Bioversity International

Key Characterization and Evaluation Descriptors: Methodologies for the Assessment of 22 Crops

Adriana Alercia




GLOBAL CROP DIVERSITY TRUST
A FOUNDATION FOR FOOD SECURITY

Bioversity International is an independent international scientific organization that seeks to improve the well-being of present and future generations of people by enhancing conservation and the deployment of agricultural biodiversity on farms and in forests. It is one of 15 centres supported by the Consultative Group on International Agricultural Research (CGIAR), an association of public and private members who support efforts to mobilize cutting-edge science to reduce hunger and poverty, improve human nutrition and health, and protect the environment. Bioversity has its headquarters in Maccarese, near Rome, Italy, with offices in more than 20 other countries worldwide. The organization operates through four programmes: Diversity for Livelihoods, Understanding and Managing Biodiversity, Global Partnerships, and Commodities for Livelihoods.

The international status of Bioversity is conferred under an Establishment Agreement which, by January 2010, had been signed by the Governments of Algeria, Australia, Belgium, Benin, Bolivia, Brazil, Burkina Faso, Burundi, Cameroon, Chile, China, Congo, Costa Rica, Côte d'Ivoire, Cuba, Cyprus, Czech Republic, Denmark, Ecuador, Egypt, Ethiopia, Ghana, Greece, Guinea, Hungary, India, Indonesia, Iran, Israel, Italy, Jordan, Kenya, Malaysia, Mali, Mauritania, Mauritius, Morocco, Norway, Oman, Pakistan, Panama, Peru, Poland, Portugal, Romania, Russia, Senegal, Slovakia, Sudan, Switzerland, Syria, Tunisia, Turkey, Uganda and Ukraine.

Financial support for Bioversity's research is provided by more than 150 donors, including governments, private foundations and international organizations. For details of donors and research activities please see Bioversity's Annual Reports, which are available in printed form on request from bioversity-publications@cgiar.org or from Bioversity's Web site (www.bioversityinternational.org).

Citation: Alercia A. 2011. Key Characterization and Evaluation Descriptors: Methodologies for the Assessment of 22 Crops. Bioversity International, Rome, Italy.

Cover photo: Courtesy of Danny Hunter, Bioversity International; Marleni Ramirez, Bioversity International and Grahame Jackson

ISBN 978-92-9043-874-8

Bioversity International
Via dei Tre Denari, 472/a
00057 Maccarese
Rome, Italy

Bioversity International is the operating name of the International Plant Genetic Resources Institute (IPGRI).

Contents

ACKNOWLEDGEMENTS

Bioversity is grateful to all the scientists and researchers who have contributed to the development of the strategic sets of 'key access and utilization descriptors for crops'. We would like to thank particularly, the Global Crop Diversity Trust (the Trust) for their financial support.

Particular recognition goes to the Crop Leaders and Core Advisory Groups from the CGIAR Centres, USDA, ECPGR and National Programmes for providing valuable scientific direction and to all the reviewers who participated in the surveys for their advice.

Special thanks are due to the various consultants working at different stages of the production process, namely: Clara Ines Quinteros, Teresa Borelli, Nadia Bergamini, Pepita Verbeek, Francesca Ercolani, Olga Spellman, Silvina Gesumaria, Barbara Rae and Ana Laura Cerutti.

Adriana Alercia coordinated and managed the entire production of this document and provided technical and scientific advice. Ms Nora Capozio prepared the cover and Ana Laura Cerutti prepared the layout.

Particular thanks go to Michael Mackay for offering encouragement and advice throughout the preparation of this publication

PREFACE

Bioversity International, with the financial support of the Global Crop Diversity Trust (the Trust) has led the development of strategic key sets of characterization and evaluation descriptors for 22 crops included in Annex I of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). These strategic sets of data standards are designed to facilitate access to and utilization of plant genetic resources information. Together with passport information, descriptors are critical to the effective sharing of evaluation data and to the efficient use of plant genetic resources. Passport, characterization and evaluation descriptors are included on the GENESYS portal, to facilitate access to information and promote the utilization of germplasm accessions.

Along with the definitions of key sets of data standards, which are also available on Bioversity's web site, the SGRP Crop Genebank Knowledge Base, the CGIAR System-wide Information Network for Genetic Resources (SINGER) and EURISCO web sites, the project also documented the standard development process, the outcome being detailed methodologies for each crop.

This activity involved the participation of over 500 crop experts from more than 200 research organizations and 85 different countries.

We hope that this document will contribute to stimulating additional characterization and evaluation activities and promote information sharing, with the ultimate outcome being more efficient management and use of plant genetic resources.

INTRODUCTION

Bioversity has produced *Key access and utilization data standards* for 22 of the crops in Annex I of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). The crops covered are, banana, barley, bean, breadfruit, cassava, chickpea, coconut, cowpea, faba bean, finger millet, grass pea, lentil, maize, pearl millet, pigeonpea, potato, rice, sorghum, sweet potato, taro, wheat and yam.

These guidelines provide the background information and objectives and give insights into the structure and elements of the methodologies developed by Bioversity to devise the crop-specific standards. They include specific methodologies for each crop and serve as a reference guide to develop further standards. Each methodology describes the development process for each key set of descriptors. The methodologies build on work previously carried out by Bioversity International and other initiatives such as the *Review of characterization standards and strategies for seven crops* accomplished as part of the SGRP Global Public Goods 2 (GPG2) project carried out by the System-wide Genetic Resources Programme (SGRP) of the Consultative Group on International Agricultural Research (CGIAR). Further input came from the Crop Strategies funded by the Trust developed by communities of crop experts often facilitated by a CGIAR centre.

The following steps underpinned each of the key sets, and are described in more detail in each specific crop methodology:

1. Information collection and reference documents

Information for the definition of the key sets was collected and compiled from individual crop descriptor lists published by Bioversity and then compared with similar definitions developed by other organizations such as the United States Department of Agriculture (USDA), the International Union for the Protection of New Varieties of Plants (UPOV), other centres of the CGIAR, and the characteristics proposed in the respective Crop Strategies. When necessary (e.g. breadfruit), other sources of information such as pre-existing descriptor lists from other internationally recognized organizations were used. Draft minimum lists were sent out to crop experts for validation, in order to assure the relevance and wide applicability of the standards.

Outputs from the SGRP Global Public Goods 2 (GPG2) project were taken into account for the following crops: banana, chickpea, maize, pigeonpea, potato, rice and sorghum.

Special attention was given to the inclusion of characters and traits relevant to biotic and abiotic stresses of particular importance in the context of climate change, such as drought, high temperatures and pests and diseases. These are expected to intensify under climate change, and are listed in the Evaluation Award Scheme on 'Enhancing the Value of Crop Diversity,' funded by the Global Crop Diversity Trust. In addition, internet searches were carried out on a crop-by-crop basis, looking for the most up-to-date information on crop characteristics and traits.

In the process of defining the first priority lists for each crop, Core Advisory Groups (CAG) and survey participants were asked to use the following criteria to select and prioritize characteristics and traits:

- Initial strategic set
- Global impact
- Importance for germplasm utilization
- Data availability
- True economic damage and wide geographical occurrence (for biotic and abiotic stresses)

2. *Preparing list of crop experts*

The lists of experts were drawn from a directory of professionals who had been involved in either the development or the review of existing Bioversity descriptors. In addition, new names were drawn from lists of experts who have taken part in crop-specific consultations for the preparation of the Crop Strategies. Particular care was taken to include experts representing CGIAR Centres, USDA, the European Cooperative Programme for Plant Genetic Resources (ECPGR) and UPOV, and a variety of organizations and different geographical regions.

The List of Experts consisted of:

(a) a Core Advisory Group composed of five experts, with at least one acting as Crop Leader and the rest acting as an Advisory Group, each representing an organization as listed above; and

(b) at least 20 reviewers or stakeholders for each crop.

3. Survey preparation and distribution

A draft survey was prepared listing the descriptors as approved in consultation with the Crop Leader. The approved draft list was sent to the identified experts, who were asked to select characteristics and traits according to the given criteria and also to consider efficient and effective utilization methods that would continue to evolve over time and thus be applicable beyond an extensive germplasm documentation system.

Deadlines were set for each crop and reminders sent out one week before the deadline and also on the deadline date. Extending the deadline to accommodate further feedback was always considered.

4. Survey analysis

Results were analysed and descriptors ranked by their average rating and importance. Survey results were then sent to the crop leader who, according to the rating results, decided which characteristics should be included in the final draft. This was then shared with the members of the Core Advisory Group for final validation.

The following documents, sharing information on the survey and its results, were prepared and sent to the Crop Leader for approval:

- Survey introduction
- Proposed descriptors to be included
- List of Core Group members and reviewers
- Summary table of survey results, highlighting the descriptors (with the highest rating) identified by survey participants
- List of additional characteristics and traits not included in the survey and suggested by reviewers.

5. Definition of the final List and Dissemination

Once the Crop Leader had confirmed the key set, the team shared the results with the CAG to validate the final list for publication.

The final lists were converted into suitable electronic formats and shared with EURISCO, the USDA Germplasm Resources Information Network (GRIN), the CGIAR System-wide Information Network for Genetic Resources (SINGER), the Generation Challenge Programme (GCP) Ontology and the developers and data providers of GENESYS, a global accession level information portal. Additionally, final standards in PDF file format were sent to Bioversity Library, the ECPGR Secretariat and the SGRP Crop Genebank Knowledge Base for publication on the internet.

Methodology for the definition of a key set of characterization and evaluation descriptors for banana (*Musa* spp.)

Information collection and preparation of the Minimum Descriptor List (MDL)

Information for the definition of a MDL for banana was drawn from the publication: 'Descriptors for Banana *(Musa* spp.)' (IPGRI/INIBAP/CIRAD 1996) and from the Addendum to the publication. The list was compared to descriptors highlighted as most important in the CGIAR SGRP Global Public Goods 2 (GPG2) 4.2.1.1 Activity, and with those for which data were available. Results were subsequently integrated and harmonized with descriptors suggested in the: 'Global Conservation Strategy for *Musa* (Banana and Plantain)' (INIBAP, 2006), particularly with regards to the inclusion of evaluation traits such as important pests and diseases. Descriptors that were awarded funds for further research by the Global Crop Diversity Trust 2008 Award Scheme 'Enhancing the Value of Crop Diversity in a World of Climate Change' (EAS) were also included.

It should be noted, however, that the definition of a Key List for this crop presented a number of challenges, mostly due to the fact that the list of most important descriptors mentioned both in 'Descriptors for Banana *(Musa* spp.)' (IPGRI/ INIBAP/CIRAD 1996) and its Addendum, as well as those resulting from the CGIAR SGRP GPG2 exercise, was significantly longer than that of other crops (64 compared to an average of 20). For this reason the Crop Leader and the Core Advisory Group took longer than usual to reach a balanced consensus on this issue, ultimately delaying the production of expected results.

Preparation of the List of Experts

Overall, 65 scientists were identified, coming from 40 countries and 45 different organizations. Reviewers were selected from centres of excellence for banana research and breeding such as USDA, ARS, the 'Centre Africain de Recherches sur Bananiers et Plantains' (CARBAP) and the Indian National Research Centre for Banana (NRCB) (see Annex I). Scientists included in the list were some of the original reviewers of 'Descriptors for Banana *(Musa* spp.)' (IPGRI/INIBAP/CIRAD 1996), as well as participants in crop-specific consultations for the definition of the 'Global Conservation Strategy for *Musa*' (Banana and Plantain) (INIBAP, 2006). Experts who submitted their comments to the CGIAR SGRP GPG2 exercise were also included, as well as researchers that were awarded funds for further research by the Trust 2008 Evaluation Award Scheme.

Following consultations with Nicolas Roux, and Stéphanie Channeliere from the Bioversity International office in Montpellier, the list was reduced dramatically to 25 key experts.

Survey preparation and distribution

To assist in the selection of a "reduced" set of traits, a comparison table was prepared to visually identify "Most important" descriptors recurring in (i) the Minimum List in the original 'Descriptors for Banana *(Musa* spp.) (IPGRI-INIBAP/CIRAD, 1996), in (ii) the results of the CGIAR SGRP GPG2 4.2.1.1 exercise, (iii) in the 'Global Conservation Strategy for *Musa* (INIBAP, 2006)' and resulting from consultations with the Bioversity office in Montpellier. This comparison exercise (visible in Annex II) subsequently led to the definition of a tentative list of key descriptors (see Annex III) that was submitted to the Montpellier office for endorsement on 12th December 2008. On 16th December the Crop Leader submitted the list of key traits to be shared among the group of experts for comments (see Annex IV). The initial eight descriptors were already validated by a group of international experts and included as reference. After lengthy discussions with Bioversity staff held during the Annual Planning week at Bioversity Headquarters in February 2009, it was felt that there was no need to include the minimum characterization descriptors since they had been already validated during the CGIAR SGRP GPG2 exercise and the subsequent meeting held in India in September 2008. Therefore, a new subgroup of scientists consisting of 16 members was defined (see Annex V).

As result of a further refinement of this list by the Crop Leader and his colleagues in the Montpellier office, 25 experts coming from 16 countries and 18 different organizations were identified (see Annex VI). Of particular note, the key set for banana is the unique crop – out of the 22 – lacking a proper survey since following instructions from the focal point, Nicolas Roux, experts were consulted through email to validate the final list of evaluation descriptors (see Annex VII).

Setting consultation deadlines

Following the decision of the Crop Leader, the survey was done through an email consultation sent out on 6th March 2009 with deadline on 20th March and, therefore a reminder was sent out on 16th March. Because of the lack of responses the deadline was postponed to 30th March 2009 and on 26th March a second reminder was sent to the experts that had not participated in the consultation until that date, to ensure that the greatest possible feedback was obtained.

Consultation analysis and refinement of Minimum list

Of the 25 experts who were identified and involved in the exercise, 12 coming from nine countries recorded their comments using the email consultation (see Annex VIII). Results from the consultation were analysed and descriptors were ranked by percentage of importance. To avoid any possible mistake in preparing the results of the survey, calculating percentages and rating averages, the responses were manually inserted in the SurveyMonkey system, making possible to obtain detailed statistical information about the consultation results (see Annex IX). Open-ended responses were also analysed and presented in Annex X. A summary of results and the revised list were then sent to the Crop Leader for final approval on 8th May 2009. As result of further consultation between the Crop Leader and *Musa* Bioversity experts, a revised and final Minimum List was approved in June 2009 (see Annex XI).

Once the core subset of characterization and evaluation standards for banana was finalised, data were transformed into Excel files for uploading into the GRIN-Global genebank data-management system being developed by USDA first, and subsequently into GENESYS, linking national, regional and international genebank databases in support of the conservation and use of plant genetic resources for food and agriculture (PGRFA). The Excel files were also provided to the CGIAR System-wide Information Network for Genetic Resources (SINGER), to EURISCO, to the Generation Challenge Programme (GCP) Ontology and to the SGRP Crop Genebank Knowledge Base partners.

Acknowledgement

Bioversity is grateful to all the scientists and researchers who have contributed to the development of the initial strategic set of 'Key access and utilization descriptors for lentil genetic resources', and to the Global Crop Diversity Trust for their financial support. Particular recognition goes to the Crop Leader, Dr Nicolas Roux who provided scientific direction. Ms Adriana Alercia provided technical expertise and guided the entire production process.

Annex I – List of experts identified for participation to the survey for the definition of a minimum set of descriptors for Banana (December, 2008)

Role	Name	Organization	Country
Crop Leader	**Roux, Nicolas**	Bioversity International	France
Core Group	Arnaud, Elizabeth	Bioversity International	France
Core Group	Channelière, Stephanie	Bioversity International	France
Core Group	Fondi, Emmanuel Ndakwe	Centre Africain de recherches sur bananiers et plantains	Cameroon
Core Group	Goenaga, Ricardo	ARS/USDA	USA
Core Group/EAS	Subbaraya, Uma	National Research Centre for Banana (NRCB)	India
Core Group	Van den Bergh, Inge	Bioversity International	France
Core Group	Vézina, Anne	Bioversity International	France
Crop Strategy Expert	Bakhiet, Salah	ARC - Agricultural Research Corporation	Sudan
Crop Strategy Expert	Bolaños Benavides, Martha Marina	Corporacíon Colombiana de Investigacíon Agropecuaria (CORPOICA-Armenia)	Colombia
Crop Strategy Expert	Chen, Chi-Hon	Taiwan Banana Research Institute (TBRI)	Taiwan
Crop Strategy Expert	Chen, Houbin	South China Agricultural University	China
Crop Strategy Expert/DL	Daniells, Jeff	Department of Primary Industries & Fisheries, Johnstone Research Station,	Australia
Crop Strategy Expert	De Oliveira e Silva, Sebastiao	EMBRAPA	Brasil
Crop Strategy Expert	de Zoysa, I. J.	Plant Genetic Resource Centre - Horticultural Crop Research and Development Institute (PGRC-HORDI)	Sri Lanka
Crop Strategy Expert	Fraser, Connie	Agricultural Research Council - Institute for Tropical and SubTropical Crops cultivar development	South Africa
Crop Strategy Expert	Gonzales Diaz, Lianet	Instituto de Investigaciones en Viandas Tropicales (INIVIT)	Cuba

Role	Name	Organization	Country
Crop Strategy Expert	Gonzalez, Miguel	Corporación Bananera Nacional S.A. (CORBANA-LA RITA)	Costa Rica
Crop Strategy Expert	Hamill, Sharon	Department of Primary Industries & Fisheries, Maroochy Research Station,	Australia
Crop Strategy Expert (GPG2)	Herradura, Lorna	Davao National Crop Research and Development Center	Philippines
Crop Strategy Expert	Hoque, Md. Abdul	BARI - Bangladesh Agricultural Research Institute	Banglades h
Crop Strategy Expert	Jamaluddin, Hawa	Horticulture Research Centre Malaysian Agricultural Research and Development Institute (MARDI)	Malaysia
Crop Strategy Expert/DL	Jenny, Christophe	CIRAD	Guadeloup e
Crop Strategy Expert	Kambuou, Rose	National Agricultural Research Institute	Papua New Guinea
Crop Strategy Expert	Kouassi, Koffi Simplice	Centre National de Recherche Agronomique (CNRA)	Cote d'Ivoire
Crop Strategy Expert	Mouketo, Ferdinand	Centre de Recherche Agronomique de Loudima (CRAL)	Congo
Crop Strategy Expert	Ngezahayo, F.	Institut de recherches agronomiques et zootechnique	Burundi
Crop Strategy Expert	Nhi, Ho Huu	Vietnam Agricultural Science Institute	Vietnam
Crop Strategy Expert	Nsabimana, Antoine	KIST - Kigali Institute of Science and Technology	Rwanda
Crop Strategy Expert	Nsemwa, Lebai T.H.	ARDI - Ministry of Agriculture Food security and cooperatives	Tanzania
Crop Strategy Expert	Onyango, Margaret	University of Hawai at Manoa	Hawaii
Crop Strategy Expert	Paofa, Janet	NARI, Laloki	Papua New Guinea

Role	Name	Organization	Country
Crop Strategy Expert	Rivera Canales, José Mauricio	Fundación Hondureña de Investigación Agrícola (FHIA)	Honduras
Crop Strategy Expert	Sutanto, Agus	Indonesian Fruit Research Institute	Indonesia
Crop Strategy Expert	Taylor, Mary	Regional Germplasm Centre, Secretariat of the Pacific Community (SPC)	Fiji
Crop Strategy Expert (GPG2)	Tenkouano, Abdou	IITA	Nigeria
Crop Strategy Expert/DL	Tomekpe, Kodjo	Centre africain de recherches sur bananiers et plantains	Cameroon
Crop Strategy Expert	Tushemereirwe, W.	National Agricultural Research Organization	Uganda
Crop Strategy Expert/DL/SRG	Van den Houwe, Ines	INIBAP Transit Center (ITC)	Belgium
Crop Strategy Expert	Xu, Lin Bing	Guangdong Academy of Agricultural Sciences, Pomology Institute,	China
GPG2	Byabachwezi, Mgenzi	Maruku Agriculture Research and Development Inst.	Tanzania
ISHS	Churchill, Alice	Federal Plant Soil and Nutrition Lab	USA
ISHS	De Beer, Zacharias Christiaan	ITSC - ARC BPIU	South Africa
GPG2	De Langhe, Edmond	TAG expert	Belgium
GPG2	Dolezel, Jaroslav	Institute of Experimental Botany, Czech Republique	Czech Republic
GPG2	Draye, Xavier	Université Catholique de Louvain	Belgium
GPG2	Heslop-Harrison, Pat	University of Leicester	UK
GPG2	Kema, Gert	University of Wageningen	The Netherland s
GPG2	Rheka, A	Division of Fruit crops, IIHR, Karnataka	India
ISHS	Smith, Mike	QDPI - Maroochy Research Station	Australia
Reviewer (DL)	Carreel, Françoise	CIRAD / UMR BGPI	France

Role	Name	Organization	Country
Reviewer (DL)	Delvaux, Bruno	CUL - Catholic University of Leuven	Belgium
Reviewer (DL)	Evers, Guy	FAO	Italy
Reviewer (DL) GPG2	Galán Saúco, Victor	ICIA - Instituto Canario de Investigaciones Agrarias	Spain
Reviewer (DL)	Goenaga, Ricardo	ARS/USDA	USA
Reviewer (DL)	Israeli, Yair	Jordan Valley Banana Experiment Station	Jordan
Reviewer (DL) GPG2	Karamura, Deborah	Bioversity International	Uganda
Reviewer (DL)	Lahav, Emmanuel	Akko Experiment Station	Israel
Reviewer (DL)	Lavigne, Christian	CIRAD FLHOR - PRAM	France
Reviewer (DL)	Lescot, Thierry	CIRAD	France
Reviewer (DL)	Ortiz, Rodomiro	CIMMYT	Mexico
Reviewer (DL)	Perrier, Xavier	CIRAD	France
New	Pocasangre, Luis	Bioversity International	Costa Rica
Reviewer (DL)	Rosales, Franklin E.	Bioversity International	Costa Rica
Reviewer (DL) GPG2	Swennen, Rony	CUL - Catholic University of Leuven	Belgium

Annex II – Summary comparison table weighing up important descriptors for Banana drawn from a number of sources[1].

Descriptor	Descr no.	Min List IPGRI-INIBAP/CIRAD 1996	GPG2	GPG2 Data avail	Crop Strategy	EAS	Most import. Montpellier
Pseudostem height [m]	(6.2.1)	*	*				*
Pigmentation of the underlying pseudostem	(6.2.6)	*	*				*
Blotches at the petiole base	(6.3.1)	*	*				*
Petiole canal leaf III	(6.3.3)	*	*				*
Petiole margins	(6.3.4)		*				*
Petiole margin colour	(6.3.6)		*				*
Edge of petiole margin	(6.3.7)		*				*
Colour of cigar leaf dorsal surface	(6.3.22)	*					*
Bunch position	(6.4.6)	*	*				*
Bunch shape	(6.4.7)		*				*
Rachis position	(6.4.12)	*	*				*
Rachis appearance	(6.4.13)	*	*				*
Male bud shape	(6.4.15)	*	*				*
Male bud size [cm]	(6.4.16)		*				*
Bract base shape	(6.5.1)		*				*
Bract apex shape	(6.5.2)	*	*				*
Bract imbrication	(6.5.3)	*	*				*
Colour of the bract internal face	(6.5.5)	*	*				*
Bract behaviour before falling	(6.5.12)	*	*				*
Compound tepal basic colour	(6.6.2)	*	*				*
Lobe colour of compound tepal	(6.6.4)	*	*				*

Descriptor	Descr no.	Min List IPGRI-INIBAP/CIRAD 1996	GPG2	GPG2 Data avail	Crop Strategy	EAS	Most import. Montpellier
Anther colour	(6.6.13)		*				*
Dominant colour of male flower	(6.6.24)		*				*
Number of fruits on second hand	(6.7.2)	*	*				*
Fruit length [cm]	(6.7.3)	*	*				*
Fruit shape (longitudinal curvature)	(6.7.4)	*	*				*
Fruit apex	(6.7.6)	*	*				*
Remains of flower relicts at fruit apex	(6.7.7)		*				*
Fruit pedicel length [mm]	(6.7.8)		*				*
Fusion of pedicels	(6.7.11)		*				*
Plant crop cycle [d]	(7.4)	*	*	*			*
Bunch weight [kg]	(7.9)	*	*	*			*
Number of hands	(7.10)	*	*	*			*
Drought	(8.2)		*	*	*	*	*
Resistance to Black Leaf streak/Black Sigatoka (*Mycosphaerella fijiensis*)	(9.1.2)	*	*	*	*		*
Resistance to Fusarium Wilt /Panama disease (*Fusarium oxysporum* f.sp. *cubense*)	(9.1.3)	*	*	*	*		*
Burrowing nematode (*Radopholus similis*)	(9.2.1)	*	*	*			*

[1]*Descriptors for Banana (Musa spp.) (IPGRI/INIBAP/CIRAD 1996) and Addendum, from the GPG2 4.2.1.1 exercise, from the Global Conservation Strategy for Musa (the Trust, 2006), from those descriptors that were granted funding for further research by the Global Crop Diversity Trust (the Trust) through the 2008 EAS awards and from consultations with the Bioversity Office in Montpellier (December 2008)*

Annex III – Tentative list of descriptors for *Musa* submitted on 12 December 2008 to the Bioversity Office in Montpellier for comments and for further resizing

First Priority

1. Pseudostem height [m]
2. Pigmentation of the underlying pseudostem
3. Blotches at the petiole base
4. Petiole canal leaf III
5. Bunch position
6. Rachis position
7. Rachis appearance
8. Male bud shape
9. Bract apex shape
10. Bract imbrication
11. Colour of the bract internal face
12. Bract behaviour before falling
13. Compound tepal basic colour
14. Lobe colour of compound tepal
15. Number of fruits on second hand
16. Fruit length [cm]
17. Fruit shape (longitudinal curvature)
18. Fruit apex
19. Plant crop cycle [d]
20. Bunch weight [kg]
21. Number of hands
22. Drought
23. Resistance to Black Leaf streak/Black Sigatoka (*Mycosphaerella fijiensis*)
24. Resistance to Fusarium Wilt /Panama disease (*Fusarium oxysporum* f.sp. *cubense*)
25. Burrowing nematode (*Radopholus similis*)

2nd Priority

26. Petiole margins
27. Petiole margin colour
28. Edge of petiole margin
29. Colour of cigar leaf dorsal surface
30. Bunch shape
31. Male bud size [cm]
32. Bract base shape
33. Anther colour
34. Dominant colour of male flower
35. Remains of flower relicts at fruit apex
36. Fruit pedicel length [mm]
37. Fusion of pedicels

Annex IV – Key set of traits for *Musa* sent by the Bioversity Office in Montpellier on 16 December 2008 to be shared with the CAG. Descriptors already validated are highlighted in yellow

1. Bunch weight [kg]
2. Number of hands
3. Plant crop cycle [d]
4. Pseudostem height [cm]
5. Drought
6. Black Leaf Streaks (Black Sigatoka)
7. Fusarium wilt (Panama disease)
8. Burrowing nematode (*Radopholus similis*)

9. Number of fruits
10. Fruit length [cm]
11. Fruit weight [g]
12. Number of living (functional) leaves at flowering
13. Number of living (functional) leaves at harvest
14. Planting to shooting
15. Pseudostem girth [cm]
16. Height of following ratoon [cm]
17. Ratoon crop cycle [d]
18. Flooding
19. High temperature
20. Low temperature
21. Mineral deficiencies
22. Winds
23. Yellow Sigatoka
24. Bugtok /Moko
25. Root lesion nematode (*Pratylenchus coffeae*)
26. Weevil borer (*Cosmopolites sordidus*)
27. *Meloidogyne* sp. (Nematodes)
28. *Helicotylenchus multicinctus* (Nematodes)

Annex V - List of experts identified for participation to the on line consultation for the validation of a key set of evaluation traits for *Musa* (12th February 2009)

Name	**Organization**	**Country**
Roux, Nicolas	Bioversity International	France
Fondi, Emmanuel Ndakwe	Centre Africain de recherches sur bananiers et plantains	Cameroon
Subbaraya, Uma	National Research Centre for Banana (NRCB)	India
Goenaga, Ricardo	ARS/USDA	USA
De Beer, Zacharias Christiaan	ITSC - ARC BPIU	South Africa
Chen, Chi-Hon	Taiwan Banana Research Institute (TBRI)	Taiwan
De Oliveira e Silva, Sebastiao	EMBRAPA	Brasil
Gonzalez, Miguel	Corporación Bananera Nacional S.A. (CORBANA-LA RITA)	Costa Rica
Herradura, Lorna	Davao National Crop Research and Development Center	Philippines
Ngezahayo, F.	Institut de recherches agronomiques et zootechnique	Burundi
Jenny, Christophe	CIRAD	Guadeloupe
Karamura, Deborah	Bioversity International	Uganda
Byabachwezi, Mgenzi	Maruku Agriculture Research and Development Inst.	Tanzania
De Langhe, Edmond	TAG expert	Belgium
Heslop-Harrison, Pat	University of Leicester	UK
Kema, Gert	University of Wageningen	The Netherlands
Rheka, A	Division of Fruit crops, IIHR, Karnataka	India

Annex VI – List of experts invited to participate in the email consultation for the validation of a Key set of evaluation traits for *Musa* (6th March 2009)

Role	Name	Organization	Country
Crop Leader	**Roux, Nicolas**	Bioversity International	France
	Aguilar, Juan Fernando	Fundación Hondureña de Investigación Agrícola (FHIA)	Honduras
	Coto, Julio Cesar	Fundación Hondureña de Investigación Agrícola (FHIA)	Honduras
	Daniells, Jeff	Department of Plant Industry & Fisheries (DPI&F)	Australia
	dela Cruz, Felipe	Institute of Plant Breeding, College of Agriculture, University of the Philippines (UPLB-IPB)	Philippines
	Fondi, Emmanuel Ndakwe	Centre Africain de recherches sur bananiers et plantains	Cameroon
	Herradura, Lorna	Davao National Crop Research and Development Center	Philippines
	Horry, Jean Pierre	CIRAD	France
	Jenny, Christophe	CIRAD	Guadeloupe
	Kambuou, Rosa	National Agricultural Research Institute (NARI)	Papua New Guinea
	Karamura, Deborah	Bioversity International	Uganda
	Lorenzen, Jim	International Institute of Tropical Agriculture	Uganda
	Mustaffa, MM	National Research Centre for Banana	India
	National Banana Research Programme	NARO-NBRP	Uganda
	Ngezahayo, Ferdinand.	Institut de recherches agronomiques et zootechnique	Burundi
	Pocasangre, Luis	Bioversity International	Costa Rica
	Rivera, Mauricio	Fundación Hondureña de Investigación Agrícola (FHIA)	Honduras
	Sandoval, Jorge	Corporación Bananera Nacional	Costa Rica
	Smith, Mike K	QDPI - Maroochy Research Station	Australia
	Subbaraya, Uma	National Research Centre for Banana (NRCB)	India
	Sutanto, Agus	Indonesian Tropical Fruit Research Institute (ITFRI)	Indonesia
	Taylor, Mary	Regional Germplasm Centre, Secretariat of the Pacific Community	Fiji
	Tomekpe, Kodjo	Centre africain de recherches sur bananiers et plantains (CARBAP)	Cameroon
	Van Nghiem, Nguyen	Fruit and Vegetable Research Institute	Vietnam

Role	Name	Organization	Country
	Vilarinhos, Alberto D.	National Cassava & Tropical Fruits Research Center	Brazil
	Vroh, Bi Irie	International Institute of Tropical Agriculture	Nigeria

Annex VII – Email consultation and its attachment submitted on 6 March 2009 by the Bioversity Office in Montpellier to share with the identified experts

Da: Roux, Nicolas (Bioversity-France)
Inviato: ven 06/03/2009 19.04
A: Christophe Jenny; Julio Cesar Coto; fondien@yahoo.com; (vila@cnpmf.embrapa.br); Jim Lorenzen; Bi Irie Vroh (B.Vroh@cgiar.org); Binita Uma Subbaraya (umabinit@yahoo.co.in); Jorge Sandoval (jsandoval@corbana.co.cr); ferdinand ngezahayo; Jeff Daniells (Jeff.Daniells@dpi.qld.gov.au); Jean-Pierre Horry; Juan Fernando Aguilar (jaguilar@fhia.org.hn); Mauricio Rivera; Kodjo TOMEKPE; nrcbdirector@sancharnet.in; Mike K Smith (Mike.Smith@dpi.qld.gov.au); LORNA HERRADURA; Felipe dela Cruz; 'Mary Taylor'; Rosa.kambuou@nari.org.pg; National Banana Research Programme; nghiemvrq@yahoo.com; bagusutanto_02@yahoo.com
Cc: Borelli, Teresa (Bioversity); Alercia, Adriana (Bioversity); Vezina, Anne (Bioversity-France); Ruas, Max (Bioversity-France); Channeliere, Stéphanie (Bioversity-France); Karamura, Deborah (Bioversity-Uganda); Molina, Agustin (Bioversity-Philippines); Pocasangre, Luis (Bioversity-Costa Rica)
Oggetto: selection of Descriptors for GIGA

Dear Colleagues,

I am seeking your assistance to achieve an important goal raised by a number of the global strategies for the conservation and utilization of various important crop species (see http://www.croptrust.org/main/strategies.php?itemid=82) supported by The Global Crop Diversity Trust. To achieve the goals raised by the Trust strategies we need to select a **key set of strategic descriptors** for *Musa* that will become the basis of the Global Information system on Germplasm Accessions (GIGA) in support of the conservation and sustainable use of PGRFA.

Completing the survey (see attachment) should not take more than 10 minutes of your valuable time. I acknowledge that you might have previously contributed your expertise to similar initiatives, however I want to emphasize that this survey is important and quite different in that it has a focus on **practical utilization**.

Your knowledge and experience in *Musa* will be invaluable in helping us identify this **initial**, strategic set of descriptors that should assist researchers to more easily **utilize** accessions held in crop diversity collections and that will have the maximum impact on identifying traits important to **crop production**.

The survey is divided into two sections. The first section presents 8 descriptors that have already been agreed upon and recently validated by *Musa* experts. The aim of this exercise is to build upon this initial set, and to select a number of additional traits that fall within the objectives outlined above.

Please consider the following factors when selecting key traits:
- Importance for germplasm utilization
- Initial strategic set
- Global impact
- Data availability
- For abiotic and biotic stresses, true economic damage and wide geographical occurrence

Please send us your respond within the next 2 weeks (i.e. by 20th March)
If you require any additional clarification please do not hesitate to contact my colleagues at Bioversity, Teresa Borelli (T.Borelli@cgiar.org) and Adriana Alercia (A.Alercia@cgiar.org) or myself.
Best wishes,
Nicolas
Nicolas Roux, PhD
Genomics and Genetic Resources, Coordinator
Commodities for Livelihoods Programme
Bioversity International
Parc Scientifique Agropolis II
34397 Montpellier Cedex 5, France
Tel.: (+33) 467.61.99.46 / 1302
Fax: (+33) 467.61.03.34
Skype: nroux_inibap
Email: n.roux@cgiar.org
www.bioversityinternational.org

Email consultation attachment:

Key access and utilization descriptors for Banana genetic resources

This list consists of an initial GIGA Project set of characterization and evaluation descriptors for Banana **utilization**. This key set of strategic descriptors, which should be significant at the global level as much as possible, along with passport data, will become the basis of the global accession level information system. This is an initial set that will facilitate access to and utilization of *Musa* accessions held in genebanks and does not exclude addition of more descriptors if data are available at a later date.

Based on the comprehensive list of 'Descriptors for Banana (*Musa spp.*)' (IPGRI-INIBAP, CIRAD, 1996), this strategic set was developed building on previous initiatives such as the SGRP Global Public Goods exercise (GPG2); consultations held during the TAG Meetings held in June 2006 and october, 2008. Finally it was discussed and validated by Bioversity Staff based at Montpellier in consultation with a Core Advisory Group led by Nicolas Roux from Bioversity International.

Biotic and abiotic stresses included in the list were chosen because of their cosmopolitan nature and global impact, since they have **wide geographic occurrence** and cause **true economic damage**. The second set of descriptors corresponds to the 'minimum descriptors' for characterization developed by the TAG panel over the years. Numbers in parentheses on the right-hand side are the corresponding descriptors numbers as published in "Descriptors for Banana (*Musa* spp.)", (http://bananas.bioversityinternational.org/content/view/26/53/lang,en/). Please tick the descriptors you feel are essential to fulfill the objectives outlined in the message joined to this survey.

Pseudostem height [m]	(6.2.1)	
Fruit length [cm]	(6.7.3)	
Plant crop cycle [d]	(7.4)	
Bunch weight [kg]	(7.9)	
Number of hands	(7.10)	
Susceptibility to drought	(8.2)	
Resistance to Black Sigatoka (*Mycosphaerella fijiensis*)	(9.1.2)	
Resistance to Fusarium Wilt (*Fusarium oxysporum* f.sp. *cubense*)	(9.1.3)	

Burrowing nematode (*Radopholus similis*)	(9.2.1)	
Pigmentation of the underlying pseudostem	(6.2.6)	
Blotches at the petiole base	(6.3.1)	
Petiole canal leaf III	(6.3.3)	
Petiole margins	(6.3.4)	
Petiole margin colour	(6.3.6)	
Edge of petiole margin	(6.3.7)	
Colour of cigar leaf dorsal surface	(6.3.22)	
Bunch position	(6.4.6)	
Bunch shape	(6.4.7)	
Rachis position	(6.4.12)	
Rachis appearance	(6.4.13)	
Male bud shape	(6.4.15)	
Male bud size [cm]	(6.4.16)	
Bract base shape	(6.5.1)	
Bract apex shape	(6.5.2)	
Bract imbrication	(6.5.3)	
Colour of the bract internal face	(6.5.5)	
Bract behaviour before falling	(6.5.12)	
Compound tepal basic colour	(6.6.2)	
Lobe colour of compound tepal	(6.6.4)	
Anther colour	(6.6.13)	
Dominant colour of male flower	(6.6.24)	
Number of fruits on second hand	(6.7.2)	
Fruit shape (longitudinal curvature)	(6.7.4)	

Fruit apex	(6.7.6)	
Remains of flower relicts at fruit apex	(6.7.7)	
Fruit pedicel length [mm]	(6.7.8)	
Fusion of pedicels	(6.7.11)	

CONTRIBUTOR

[your name]

Annex VIII – Respondents to the email consultation for the definition of a Key set of descriptors for *Musa* sent on 6th March 2009

Name	Organization	Country
Coto, Julio Cesar	Fundacion Hondurena de Investigation Agricola (FHIA)	Honduras
Fondi, Emmanuel	Centre Africain de Recherches sur bananiers et plantains	Cameroun
Subbaraya Uma Binita	National Research Centre for Banana (NRCB)	India
Lorenzen, Jim	International Institute of Tropical Agriculture	Uganda
Nabatanzi, Harriet	International Institute of Tropical Agriculture	Uganda
Nyine, Moses	International Institute of Tropical Agriculture	Uganda
Daniells, Jeff	Dept of Plant Industry & Fisheries (DPI&F)	Australia
Ngezahayo, Ferdinand	Institut de recherches agronomiques et zootechnique	Burundi
Rivera, Mauricio	Fundacion Hondurena de Investigation Agricola (FHIA)	Honduras
Kambuou, Rosa	National Agricultural Research Institute (NARI)	Papua New Guinea
Sutanto, Agus	Indonesian Tropical Fruit Research Institute (ITFRI)	Indonesia
Karamura, Deborah	Bioversity International	Uganda

Annex IX – *Musa* summary survey results ranked by rating average

Answer Options (n=12)	Rating Average
Bunch shape (6.4.7)	3.25
Fruit shape (longitudinal curvature) (6.7.4)	3.25
Remains of flower relicts at fruit apex (6.7.7)	3.25
Pigmentation of the underlying pseudostem (6.2.6)	3.00
Fruit apex (6.7.6)	3.00
Bunch position (6.4.6)	2.75
Rachis position (6.4.12)	2.50
Rachis appearance (6.4.13)	2.50
Male bud shape (6.4.15)	2.50
Bract imbrication (6.5.3)	2.50
Petiole canal leaf III (6.3.3)	2.25
Petiole margin colour (6.3.6)	2.25
Petiole margins (6.3.4)	2.00
Colour of the bract internal face (6.5.5)	2.00
Bract behaviour before falling (6.5.12)	2.00
Lobe colour of compound tepal (6.6.4)	2.00
Anther colour (6.6.13)	2.00
Fruit pedicel length [mm] (6.7.8)	2.00
Number of fruits on second hand (6.7.2)	1.92
Colour of cigar leaf dorsal surface (6.3.22)	1.75
Bract apex shape (6.5.2)	1.75
Dominant colour of male flower (6.6.24)	1.75
Fusion of pedicels (6.7.11)	1.75
Blotches at the petiole base (6.3.1)	1.50
Edge of petiole margin (6.3.7)	1.50
Male bud size [cm] (6.4.16)	1.50
Compound tepal basic colour (6.6.2)	1.50
Bract base shape (6.5.1)	0.75

Annex X – *Musa* email consultation open-ended responses

Descriptors to be added	Coto Julio Cesar	Fondi Emmanuel Ndakwe	Subbaraya Uma	Rivera Mauricio	Karamura Deborah	Sutanto Agus	Kambuou Rosa	Ngezahayo Ferdinand	N. time selected
Weevil borer (*Cosmopolites sordidus*) (9.2.4)		*	*		*			*	**4**
Peduncle hairiness (6.4.5)			*		*	*	*		**4**
Predominant taste (6.7.22)		*	*		*			*	**4**
Blotches on leaves of water suckers (6.3.23)			*			*	*		**3**
Fruit diameter [cm] 7.13	*			*			*		**3**
Leaf habit 6.1.1 (Identification of ploidy)			*		*			*	**3**
Peduncle length (6.4.1)			*		*			*	**3**
Bunch appearance (6.4.8)			*		*			*	**3**
Arrangement of ovules (6.6.26) (Identification of *acuminata* or *balbisiana*)			*		*			*	**3**
Pulp colour at maturity (6.7.19)		*	*		*				**3**
Number of fruits per hand (7.11)						*	*		**2**
Pseudostem girth [cm] (7.7)							*	*	**2**
Number of functional leaves at flowering (7.15)							*	*	**2**
Transverse section of fruit (ploidy identification) (6.7.5)			*		*				**2**
Mature fruit peel (6.7.13)			*		*				**2**
Fruits fall from hands (6.7.20)			*		*				**2**

Descriptors to be added	Coto Julio Cesar	Fondi Emmanuel Ndakwe	Subbaraya Uma	Rivera Mauricio	Karamura Deborah	Sutanto Agus	Kambuou Rosa	Ngezahayo Ferdinand	N. time selected
Presence of seed with source of pollen (6.7.23)		*	*						**2**
Fruit weight [g] (7.14)	*			*					**2**
Pseudostem colour (6.2.3)	*			*					**2**
Number of functional leaves at harvest (7.16)							*		**1**
Seed surface (6.7.24)			*						**1**
Seed shape (6.7.25)			*						**1**
Colour of free tepal (6.6.6)			*						**1**
Number of suckers (6.2.9)								*	**1**
Development of suckers (6.2.10)		*							**1**
Flesh texture 6.7.21		*							**1**
Pollen vitality [%] (6.6.15)		*							**1**
Rachis length								*	**1**
Leaf consistency (ploidy)								*	**1**
Susceptibility to BBTV (banana bunch top virus)								*	**1**
Dry matter content		*							**1**
Carbohydrate content		*							**1**
Crispness		*							**1**
Flour quality		*							**1**

Annex XI – *Musa* final Key set of characterization and evaluation descriptors with descriptors states and Contributors validated by the Crop Leader in June 2009

Pseudostem height [m] (6.2.1)

1 <2 m
2 2.1 to 2.9 m
3 >3 m

Peduncle hairiness (6.4.5)

1 Hairless
2 Slightly hairy
3 Very hairy, short hairs (similar to velvet touch)
4 Very hairy, long hairs (>2 mm)

Bunch position (6.4.6)

1 Hanging vertically
2 Slightly angled
3 Hanging at angle 45°
4 Horizontal
5 Erect

Bunch shape (6.4.7)

1 Cylindrical
2 Truncated cone shape
3 Asymmetric - Bunch axis is nearly straight
4 With a curve in the bunch axis
5 Spiral

Number of fruits on second hand (6.7.2)

1 <12
2 13-16
3 >17

Fruit length [cm] (6.7.3)

1 <15 cm
2 16- 20 cm
3 21- 25 cm
4 26- 30 cm
5 >31 cm

Fruit shape (longitudinal curvature) (6.7.4)

1 Straight (or slightly curved)
2 Straight in the distal part
3 Curved (sharp curve)
4 Curved in 'S' shape (double curvature)

Fruit apex (6.7.6)

1 Pointed
2 Lengthily pointed
3 Blunt-tipped
4 Bottle-necked
5 Rounded

Remains of flower relicts at fruit apex (6.7.7)

1 Without any floral relicts
2 Persistent style
3 Base of the style prominent
4 Persistent style and staminode

Predominant taste (6.7.22)

1 Astringent (like cooking banana)
2 Mild, slightly tasty or tasteless
3 Sweet (like Cavendish)
4 Sugary (like 'Pisang Mas')
5 Sweet and acidic (apple like)
99 Other (specify)

Plant crop cycle [d] (7.4)
From planting to harvest

Bunch weight [kg] (7.9)
Bunch stalk (peduncle) is cut above the first hand at the level of the last scar and immediately below the last hand

Number of hands (7.10)

Susceptibility to drought (8.2)

Resistance to black sigatoka (*Mycosphaerella fijiensis*) (9.1.2)

Resistance to fusarium wilt (*Fusarium oxysporum* f. sp. *cubense*) (9.1.3)
Specify VCG group if known

Resistance to burrowing nematode (*Radopholus similis*) (9.2.1)

Resistance to weevil borer (*Cosmopolites sordidus*) (9.2.4)

Contributors

Nicolas Roux, Bioversity International, France
Stephanie Channelière, Bioversity International, France

Australia
Jeff Daniells, Dept of Plant Industry & Fisheries (DPI&F)

Burundi
Ferdinand Ngezahayo, Institut de recherches agronomiques et zootechnique

Cameroun
Emmanuel Fondi, Centre Africain de Recherches sur bananiers et plantains

Honduras
Julio Cesar Coto, Fundación Hondureña de Investigación Agrícola (FHIA)
Mauricio Rivera, Fundación Hondureña de Investigación Agrícola (FHIA)

India
Uma Binita Subbaraya, National Research Centre for Banana (NRCB)

Indonesia
Agus Sutanto, Indonesian Tropical Fruit Research Institute (ITFRI)

Papua New Guinea
Rosa Kambuou, National Agricultural Research Institute (NARI)

Uganda
Deborah Karamura, Bioversity International
Jim Lorenzen, International Institute of Tropical Agriculture
Harriet Nabatanzi, International Institute of Tropical Agriculture
Moses Nyine, International Institute of Tropical Agriculture

Methodology for the definition of a key set of characterization and evaluation descriptors for barley (*Hordeum vulgare* L.)

Information collection and preparation of a Minimum Descriptor List (MDL)

Information for the definition of a key set of descriptors for barley was drawn from the publication "Descriptors for barley (*Hordeum vulgare* L.)" (IPGRI, 1994). The list was subsequently integrated and harmonized with descriptors suggested during the Crop Strategy meetings for the *ex-situ* conservation of barley, held respectively in Tunis, Tunisia (September, 2007) and Alexandria, Egypt (April, 2008). Descriptors that were awarded funds for further research by the Global Crop Diversity Trust 2008 Award Scheme 'Enhancing the Value of Crop Diversity in a World of Climate Change' (EAS), particularly traits with regard to the inclusion of characters and traits relevant to biotic and abiotic stresses for barley in the context of climate change. The initial key set of priority descriptors for barley to be sent out for comments, was selected and prepared by the Crop leader, Michael Mackay.

Preparing List of Experts

Experts were drawn from crop-specific consultations for the definition of the Crop Strategy for the *ex-situ* conservation of barley genetic resources, held respectively in Tunis, Tunisia (September, 2007) and Alexandria, Egypt (April, 2008). ECPGR experts on barley were also included to cover a representative group of geographical locations. Reviewers from the 1994 descriptors list were excluded due to their outdated contact information. Overall, 28 experts were identified, from 26 countries and 27 different organizations (see Annex I). Out of these, the Group Leader (Michael Mackay) selected a Core Advisory Group (CAG) consisting of 17 experts from the major centres of excellence for barley research and breeding to assist in the definition of a minimum set of descriptors for this crop. Core Group members were drawn from prestigious academic and scientific organizations including Montana State University, the John Innes Centre, International Center for Agricultural Research in the Dry Areas (ICARDA), the Universities of Adelaide, Saskatchewan, Okayama, the Universidad de la República del Uruguay as well as the Swedish University of Agricultural Sciences. Also included were the Leibniz Institute of Plant Genetics and Crop Plant Research (IPK), N.I. Vavilov Institute of Plant Industry (VIR), the Institute of Biology - University of Latvia, the Agricultural Research Institute Kromeriz, Ltd. and the Zhejiang Academy of Agricultural Sciences.

Survey preparation and distribution

In place of the survey, an informal letter was sent out to the 17 experts identified by Michael Mackay, (see Annex II), requesting their comments on the identified minimum set of characterization and evaluation descriptors of barley accessions to facilitate their use by researchers and asked to make any suggestions regarding any characterization and/or evaluation descriptors that were found to be relevant yet missing from the proposed Minimum List. Comments received by ten experts coming from seven countries were collected in a summary table (see Annex III), analysed and harmonised with the original descriptors list. This exercise led to the definition of a revised key set of descriptors for barley (Annex IV), which was shared among the CAG on 4 November 2008, for validation and final comments.

Input received from experts was again compiled into a comparison table (see Annex V), analysed and harmonised with the original descriptors list in consultation with the Crop Leader. This exercise led to the definition of the final key set of descriptors for barley (see Annex VI). Afterwards a final key set was prepared adding descriptor states and contributors (see Annex VII).

Once the core subset of characterization and evaluation standards for barley was finalised, data were transformed into Excel files for uploading into the GRIN-Global genebank data-management system being developed by USDA first, and subsequently into GENESYS, linking national, regional and international genebank databases in support of the conservation and use of plant genetic resources for food and agriculture (PGRFA). The Excel files were also shared with the System-wide Information Network for Genetic Resources (SINGER), the germplasm information exchange network of the Consultative Group on International Agricultural Research (CGIAR) and its partners, EURISCO, the Generation Challenge Programme (GCP) Ontology and the SGRP Crop Genebank Knowledge Base.

Acknowledgement

Bioversity is grateful to all the scientists and researchers who have contributed to the development of the strategic set of 'Key access and utilization descriptors for barley genetic resources', and to the Global Crop Diversity Trust for their financial support.

Annex I – List of experts identified for participation to the definition of a minimum set of descriptors for barley

Role	Name	Organization	Country
Core Group (Trust)	Ambrose, Michael	John Innes Centre	UK
Core Group (IBGS)	Blake, Tom	Montana State University	USA
Core Group (IBGS)	Castro, Ariel	Universidad de la República	Uruguay
Core Group (IBGS)	Eglinton, Jason	University of Adelaide	Australia
Core Group (IBGS)	Harvey, Bryan	University of Saskatchewan	Canada
Core Group	Knüpffer, Helmut	Leibniz institute of Plant Genetics and Crop Plant Research (IPK)	Germany
Core Group	Konopka, Jan	ICARDA	Syria
Core Group (IBGS)	Kovaleva, Olga	VIR, Dept. of Oat, Rye, Barley	Russia
Core Group (EPCGR)	Rashal, Isaak	Institute of Biology - University of Latvia	Latvia
Core Group (Trust)	Sato, Kazuhiro	Research Institute for Bioresources - Okayama University	Japan
Core Group (IBGS)	Spunar, Jaroslav	Agricultural Research Institute Kromeriz, Ltd.	Czech Republic
Core Group	Valkoun, Jan	Scientific Consultant	Czech Republic
Core Group (Trust)	von Bothmer, Roland	LTJ Faculty - Swedish Univ. Agric Sciences	Sweden
Core Group (IBGS)	Wang, Junmei	Zhejiang Academy of Agricultural Sciences	P.R.China
Core Group	Basudeb Sarkar	ICARDA	Syria
Core Group	Flavio Capettini	ICARDA	Syria
Core Group	Ahmed Amri	ICARDA	Syria
Survey (IBGS)	Abo El-Enein, Rashad	NVRSRP - Agricultural Research Centre	Egypt
Survey (Trust)	Elfelah, Mouldi	INRAT _ IRESA	Tunisia
Survey (Trust)	Gómez, Luz	Universidad Nacional Agraria La Molina	Peru
Survey (Trust/IBGS)	Grando, Stefania	ICARDA	Syria

Role	Name	Organization	Country
Survey (Trust)	Iorczewski, Edson	Embrapa – Brazilian Corporation for Agricultural Research	Brazil
Survey (ECPGR)	Jahoor, Ahmed	Copenhagen University - Dept of Agricultural Sciences	Denmark
Survey (ECPGR)	Maçãs, Benvindo Martins	Estação Nacional de Melhoramento de Plantas	Portugal
Survey (IBGS)	Manninen, Outi	MTT Agrifood Research Finland	Finland
Survey (ECPGR)	Molina Cano, José Luis	IRTA	Spain
Survey (Trust)	Mozafari, Javad	National Plant Gene-Bank, Seed &Plant Improvement Institute	Iran
Survey (Trust)	Ouabou, Hassan	INRA - Morocco	Morocco
Survey (Trust)	Ryabchoun, Victor K.	Yuryev Institute of Plant Production - National Centre for PGR of Ukraine	Ukraine
Survey (Trust)	Woldesemayat, Adugna	Institute of Biodiversity Conservation	Ethiopia

Annex II – Email sent by M. Mackay on August 19, 2008 to the experts of the Core Group

---

Subject: Key descriptors for access and utilization of barley genetic resources

Dear Colleague,

Firstly, please accept my greetings in my new role at Bioversity International.

Secondly, this request for your assistance is aimed at identifying some key descriptors that will assist researchers to utilize barley germplasm. These key descriptors, along with passport data, will become the foundation information to be made available to researchers in a global accession level information system. This system will provide access to some 2.5 million accessions (not all barley!) held in important genebanks worldwide.

I have identified a 'short' list of characterization descriptors below, as well as a longer list. The short list is, in my opinion, fundamental in categorizing accessions and should be helpful to utilization. The evaluation traits are those for which the Global Crop Diversity Trust (the Trust) has awarded grants to various organizations to undertake evaluation. The numbers in parentheses following the descriptors refer to the original descriptor numbers contained in the "Descriptors for Barley (*Hordeum vulgare* L.)" (IPGRI, 1994).

So, I am seeking your opinion/comment on the short list of characterization descriptors and evaluation traits as being applicable to the objectives I have outlined above. If we can agree on these key descriptors, Bioversity will include them as those barley descriptors to be available for searching in the global system. Your contribution/comment, **by 12 September 2008**, will certainly be much appreciated and acknowledged in the global system.

Should you require any further assistance, please don't hesitate to contact me by email.

Sincerely,

Michael Mackay

Proposed Minimum/Key Characterization Descriptor List

- Growth class (seasonality) (7.1.1)
- Row number/lateral florets (7.2.3)
- Spike density (7.2.4)
- Lemma awn/hood (7.2.6)
- Kernel covering (7.3.1)
- Lemma colour (7.3.3)
- Aleurone colour (7.3.5)

Proposed Evaluation Trait List: The Trust has awarded grants for the evaluation of these traits:

- Protein content (8.1.1)
- Tolerance to heat stress (9.2)
- Tolerance to drought (9.3)
- Tolerance to salinity (9.6)
- Susceptibility to powdery mildew (*Erysiphe graminis* f.sp. *hordei*) (10.2.4)
- Susceptibility to scald (*Rhynchosporium secalis*) (10.2.5)
- Susceptibility to Net blotch (*Pyrenophora teres*) (10.2.7)

Long List of Characterization Descriptors.

• Growth class (seasonality)	(7.1.1)
• Plant height [cm]	(7.1.3)
• Stem pigmentation (immature)	(7.1.4)
• Row number/lateral florets	(7.2.3)
• Spike density	(7.2.4)
• Lemma awn/hood	(7.2.6)
• Lemma awn barbs	(7.2.7)
• Glume colour	(7.2.9)
• Length of rachilla hairs	(7.2.12)
• Kernel covering	(7.3.1)
• Lemma colour	(7.3.3)
• Aleurone colour	(7.3.5)
• 1000-kernel weight [g]	(7.3.6)
• Specific gravity (Test Weight) [kg m3]	(8.1.3)
• Susceptibility to Brown rust, Dwarf leaf rust (*Puccinia hordei*)	(10.2.3)

Annex III – Comments on initial key set of descriptors for barley sent out on 19 August 2008

Descriptor no.	Descriptor name	Bryan Harvey (Canada)	Kazuhiro Sato (Japan)	Jason Eglington (Australia)	Tom Blake (USA)	Roland Von Bothmer (Sweden)	Basudeb Sarkarn (ICARDA) Syria	Flavio Cappetini (ICARDA) Syria	Ahmed Amri (ICARDA) Syria	Jan Konopka Syria
7.1.1	*Growth class (seasonality)*	OK	OK	OK	OK	OK	OK	OK	OK	OK
7.1.3	*Plant height*	Of limited value	OK	Plant height would be useful if expressed relative to a well characterized control variety.	OK	OK (**Transfer to short list**)	OK (**Transfer to short list**)	OK	OK	OK
7.1.4	*Stem pigmentation (immature)*	OK, but subject to environmental effects especially temperature	OK	OK	OK	OK	OK	OK	OK	OK
7.2.3	*Row number/lateral florets*	OK	OK	OK	OK	OK	OK	OK	OK	OK
7.2.4	*Spike density*	Can be very subjective outside of the extremes. (**Delete?**)	OK	OK	OK	OK	OK	**Delete**	OK	OK
7.2.6	*Lemma awn/hood*	OK	OK	OK	OK	OK	OK	OK	OK	OK
7.2.7	*Lemma awn barbs*	OK	OK	OK	OK	OK	OK	**Use in Minimum List**	OK	OK
7.2.9	*Glume colour*	OK, but limited value	OK	OK	OK	OK	OK	OK	OK	OK
7.2.12	*Length of rachilla hairs*	OK	OK	OK	OK	OK	OK	**Use in Minimum List**	OK	OK
7.3.1	*Kernel covering*	OK. Presumably this means hull adherence since all kernels are covered on the plant but some thresh free.	OK	OK	OK	OK	OK	OK	OK	OK
7.3.3	*Lemma colour*	OK	OK	OK	OK	OK	OK	OK	**Use in Minimum List**	OK
7.3.5	*Aleurone colour*	OK but can be very difficult to score. (**Delete**)	OK	OK	OK	OK	OK	OK	OK	Data is collected for all other traits except this one (**Delete?**)
7.3.6	*1000-kernel weight [g]*	OK	Do not have enough samples to measure 1000-kw (**Delete?**)	OK	OK	OK	**Use in Minimum List**	OK	OK	OK
8.1.1	*Protein content*	Waste of time because of the huge environmental effect (**Delete**)	Will protein content be measured by Kjeldahl? This is laborious. Also the character is quantative and not very reliable. It is nice if you evaluate this but need a good control. (**Delete**)	Environmental effects on grain protein are difficult to manage (**delete**)	OK	Tricky (**delete**)	OK	OK	OK	OK
8.1.3	*Specific gravity (Test weight) [kg m^3]*	OK **Use in short list**	Do not have enough samples to measure test weight (**Delete?**)	OK	OK	OK	**Use in short list**	OK	OK	OK
9.2	*Tolerance to heat stress*	It all depends on the method of measurement. If we can get a real measure of these traits it would be very valuable. I am sceptical however since I have found that materials claiming resistance to these stresses do not turn out to be so when we test them here. (**Delete**)	No problems of heat, drought, salinity in Japan and do not have any data on that (**Delete**)	Salinity/drought/heat stress tolerance results are too variable between environments/researchers (**Delete**)	OK	OK	OK	OK	OK	OK
9.3	*Tolerance to drought*	Same as 9.2 (**Delete**)	Same as 9.2 (**Delete**)	Same as 9.2 (**Delete**)	OK	OK	OK	OK	OK	OK

Descriptor no.	Descriptor name	Bryan Harvey (Canada)	Kazuhiro Sato (Japan)	Jason Eglington (Australia)	Tom Blake (USA)	Roland Von Bothmer (Sweden)	Basudeb Sarkarn (ICARDA) Syria	Flavio Cappetini (ICARDA) Syria	Ahmed Amri (ICARDA) Syria	Jan Konopka Syria
9.6	***Tolerance to salinity***	Same as 9.2. What kind of salinity and at what stage? (**Delete**)	Same as 9.2 (**Delete**)	Same as 9.2 (**Delete**)	OK	OK	OK	OK	OK	OK
10.2.3	***Susceptibility to Brown Rust, Dwarf leaf rust (Puccinia hordei)***	Wheat stem rust, *Septoria,* spot blotch and F*usarium* are all more important to us. (**Delete**)	No rust diseases in Japan, but serious BaYMV occurrence. (**Delete**)	OK	OK	OK	OK	OK	OK	OK
10.2.4	***Susceptibility to powdery mildew (Erysiphe graminis f.sp. hordei)***	Not a disease of concern on the great plains of North America (delete)	OK	OK	OK	OK	OK	OK	OK	OK
10.2.5	***Susceptibility to scald (Rhynchosporium secalis)***	OK	OK	OK	OK	OK	OK	OK	OK	OK
10.2.7	***Susceptibility to Net blotch (Pyrenophora teres)***	This should be split into the two types	Two types of net blotch (spot type, net type) and the resistances are different.	Net blotch should be split into spot form and net form	OK					
Other comments			Add: **grain color; earliness (heading time**,	Add: **early growth habit**; **basic vegetative phase (BVP)** and **photoperiod sensitivity**	Add: **market uses** of barley		Add: **Plant height**; **Days to flowering**; **1000 kernel weight** for characterization; Susceptibility to **spot blotc**h (*Bipolaris sorokiniana*); Susceptibility to **yellow rust** (*Puccinia striiformis* f.sp. *hordei*); **Russian wheat aphid** (*Diuraphis noxia*); **Fusarium head blight** (*Fusarium graminearum*)	Suggests removing **Spike Density** from the minimum list and including the **Length of rachilla hairs** (7.2.12) and **Lemma awn barbs** (smooth/rough).	Add: **awn length, awn color** and **lemma awn barbs** (smooth vs rough). For evaluation descriptors, we can add **reaction to barley yellow dwarf virus (BYDV)**, to **stripe disease** (*Helmintosporium gramineum*) and **yellow and leaf rusts**. Also **quality factors** (alpha amylase, Bita Glucane) to dermine the use as malting feed or food.	

Annex IV – Revised initial set of first priority descriptors for barley utilization

Growth class (seasonality)	(7.1.1)
Plant height [cm]	(7.1.3)
Row number/lateral florets	(7.2.3)
Lemma awn/hood	(7.2.6)
Lemma awn barbs	(7.2.7)
Kernel covering	(7.3.1)
Lemma colour	(7.3.3)
Susceptibility to Yellow rust (*Puccinia striiformis*)	(10.2.1)
Susceptibility to Powdery mildew (*Erysiphe graminis* f.sp. *hordei*)	(10.2.4)
Susceptibility to scald (*Rhynchosporium secalis*)	(10.2.5)
Susceptibility to Net blotch (*Pyrenophora teres*)	(10.2.7)
Susceptibility to Spot blotch (*Cochliobolus sativus*)	(10.2.8)

Annex V – Comments received on revised initial set of first priority descriptors for barley utilization

Desc no.	Descriptor name	Basudeb Sarkar (ICARDA)	Flavio Capettini (ICARDA)	Bryan Harvey (University Saskatchewan)
7.1.1	Growth class (seasonality)	OK	OK	OK
7.1.3	Plant height	OK	OK	OK
7.2.3	Row number/lateral florets	OK	OK	OK
7.2.6	Lemma awn/hood	OK	OK	OK
7.2.7	Lemma awn barbs	OK	OK	OK
7.3.1	Kernel covering	OK	OK	OK
7.3.3	Lemma colour	OK	OK	OK
10.2.1	Susceptibility to Yellow rust (*Puccinia striiformis*)	OK	OK	See comments below
10.2.4	Susceptibility to Powdery mildew (*Erysiphe graminis* f.sp. *hordei*)	OK	OK	See comments below
10.2.5	Susceptibility to scald (*Rhynchosporium secalis*)	OK	OK	See comments below
10.2.7	Susceptibility to Net blotch (*Pyrenophora teres*)	OK	OK	See comments below
10.2.8	Susceptibility to Spot blotch (*Cochliobolus sativus*)	OK	OK	See comments below
Other comments		Suggests including **susceptibility/tolerance to drought**. Increasingly important traits as we head towards climate change.	Insists on **rachilla hairs** and **endosperm color**	For the disease information to be useful it would help if the specific gene was identified or the races for which the resistance applies.

Annex VI – Final key access and utilization descriptors for barley genetic resources, defined on 19 November 2008

Numbers in parentheses on the right-hand side are the corresponding descriptors numbers as published in 'Descriptors for barley *(Hordeum vulgare* L.*)*' (IPGRI, 1994).

1.	Growth class (seasonality)	(7.1.1)
2.	Plant height [cm]	(7.1.3)
3.	Row number/lateral florets	(7.2.3)
4.	Lemma awn/hood	(7.2.6)
5.	Lemma awn barbs	(7.2.7)
6.	Length of rachilla hairs	(7.2.12)
7.	Kernel covering	(7.3.1)
8.	Lemma colour	(7.3.3)
9.	Aleurone colour	(7.3.5)
10.	Susceptibility to drought	(9.3)
11.	Susceptibility to Yellow rust (*Puccinia striiformis* f.sp. *hordei*)	(10.2.1)
12.	Susceptibility to Powdery mildew (*Erysiphe graminis* f.sp. *hordei*)	(10.2.4)
13.	Susceptibility to Scald (*Rhynchosporium secalis*)	(10.2.5)
14.	Susceptibility to Net blotch (*Pyrenophora teres*)	(10.2.7)
15.	Susceptibility to Spot blotch (*Cochliobolus sativus*)	(10.2.8)

Annex VII – Final key set of descriptors for barley genetic resources

Key access and utilization descriptors for barley genetic resources

This list consists of an initial set of characterization and evaluation descriptors for barley utilization. This key set of strategic descriptors, together with passport data, will become the basis for the global accession level information portal (GENESYS) being developed by the Bioversity-led project, Global Information on Germplasm Accessions (GIGA). It will facilitate access to and utilization of barley accessions held in genebanks and does not preclude the addition of further descriptors, should data subsequently become available.

Based on the comprehensive list of 'Descriptors for barley (*Hordeum vulgare* L.)' (IPGRI, 1994), the strategic set, listed below with the original descriptor states, was developed in consultation with a Core Advisory Group (see 'Contributors') led by Michael Mackay of Bioversity International.

Biotic and abiotic stresses included in the list were chosen because of their wide geographic occurrence and significant economic impact.

The numbers indicated in parentheses on the right-hand side are the corresponding descriptor numbers as published in 'Descriptors for Barley (*Hordeum vulgare* L.)' (IPGRI, 1994).

Growth class (seasonality) (7.1.1)

1 Winter
2 Facultative (intermediate)
3 Spring

Plant height [cm] (7.1.3)

At maturity, measured from the ground level to the top of spike excluding awns

Row number/lateral florets (7.2.3)

1 Two rowed, large or small sterile lateral florets
2 Two rowed, deficient
3 Irregular, variable lateral floret development
4 Six rowed, awnless or awnleted lateral florets
5 Six rowed, long awns on lateral florets
99 Other (specify in the **Notes** descriptor)

Lemma awn/hood (7.2.6)

1 Awnless
2 Awnleted
3 Awned
4 Sessile hoods
5 Elevated hoods

Lemma awn barbs (7.2.7)

3 Smooth (few barbs at tip)
5 Intermediate (small barbs on upper half)
7 Rough

Length of rachilla hairs (7.2.12)

1 Short
2 Long

Kernel covering (7.3.1)

Whether or not the lemma and palea adhere to the caryopsis

1 Naked grain
2 Semi-covered grain
3 Covered grain

Lemma colour (7.3.3)

1 Amber (= normal)
2 Tan/red
3 Purple
4 Black/grey
99 Other (specify in the **Notes** descriptor)

Aleurone colour (7.3.5)

(Although this trait is difficult to observe, it is used for market type classification in several countries)

1 White
2 Blue

Susceptibility to drought (9.3)

Susceptibility to Yellow rust (*Puccinia striiformis* f.sp. *hordei*) (10.2.1)

Susceptibility to Powdery mildew (*Erysiphe graminis* f.sp. *hordei*) (10.2.4)

Susceptibility to Scald (*Rynchosporium secalis*) (10.2.5)

Susceptibility to Net blotch (*Pyrenophora teres*) (10.2.7)

Susceptibility to Spot blotch (*Cochliobolus sativus*) (10.2.8)

Notes

Any additional information may be specified here, particularly that referring to the category 'Other' present in some of the descriptors above.

CONTRIBUTORS

Bioversity is grateful to all the scientists and researchers who contributed to the development of this strategic set of key access and utilization descriptors for barley genetic resources. The following Bioversity staff contributed to this exercise: Michael Mackay, who provided scientific direction, and Adriana Alercia, who provided technical expertise and guided the entire production process.

Core Advisory Group

Michael Mackay, Bioversity International, Italy
Ahmed Amri, ICARDA, Syria
Tom Blake, Montana State University, USA
Flavio Capettini, ICARDA, Syria
Jason Eglington, University of Adelaide, Australia
Bryan Harvey, University of Saskatchewan, Canada
Jan Konopka, ICARDA, Syria
Basudeb Sarkar, ICARDA, Syria
Kazuhiro Sato, Okayama University, Japan
Jan Valkoun, Czech Republic
Roland Von Bothmer, Swedish University of Agricultural Sciences, Sweden

Methodology for the definition of a key set of characterization and evaluation descriptors for bean (*Phaseolus vulgaris*)

Information collection and preparation of a Minimum Descriptor List (MDL)

Information for the definition of a key set of descriptors for bean was based on the comprehensive '*Phaseolus vulgaris* Descriptors' published by IBPGR (now Bioversity International) in 1982. The list was subsequently compared and harmonised, wherever possible, with minimum descriptors listed in 'Descriptors for *PHASEOLUS*' (USDA, ARS, GRIN), UPOV technical guidelines for French Bean (2005), 'Handbook on evaluation of *Phaseolus* Germplasm' (PHASELIEU, 2001) and 'Standard System for the Evaluation of Bean Germplasm' (CIAT, 1987). An excel table was prepared comparing descriptors mentioned in each publication and then it was shared with the Crop Leader, who selected the key set of descriptors to be included in the survey (see Annex I).

Preparation of the List of Experts

Being the original IBPGR publication too old, the list of experts was drawn from the website of the European Cooperative Programme for Plant Genetic Resources (ECPGR), and from the PHASELIEU project. Additionally, experts were identified from The World Information and Early Warning System (WIEWS) and from partners to the Phaseomics Global Initiative. Dr Daniel Debouck from the International Center for Tropical Agriculture (CIAT), Crop Leader for this exercise, was asked to examine the list and to make any additions or deletions he saw pertinent. He was also invited to select experts to join the Core Advisory Group for the definition of an initial key set of descriptors for bean. Overall 59 experts were identified, coming from 34 countries and 49 different organizations. The Core Advisory Group originally consisted of six experts coming from internationally recognized organizations such as USDA-ARS, CIAT, the Institut National de la Recherche Agronomique (INRA), the Instituto Nacional de Investigación y Tecnología Agraria (INIA) and the Misión Biológica de Galicia- CSIC – Phaselieu project and would be led by Dr Daniel Debouck (see Annex II).

Survey preparation and distribution

A draft survey on *Phaseolus* was prepared listing the descriptors as agreed after consultations with the Crop Leader (see Annex III). Once approved, the final version was uploaded into the SurveyMonkey application on internet (see Annex IV). On 20th March 2009 an email invitation with the link to the survey was sent to the identified experts. They were invited to rate the importance of the proposed characterization and evaluation descriptors for this crop and also encouraged to mention any additional trait that was found to be relevant yet missing from the proposed Minimum List, along with a substantiated justification for its inclusion. The survey deadline was set at 15th April 2009. A first reminder was sent out on 6th April 2009 and a second one on 14th April to ensure that the greatest possible feedback was obtained.

Survey analysis and refinement of Minimum List

Of the 59 experts who were identified and involved in the exercise, 25 coming from 15 countries and 22 different organizations recorded their comments using the online survey (see Annex V), four of them members of the Core Advisory Group. Results from the survey were analysed and descriptors ranked by rating average and percentage importance (see Annex VI). The summary of the survey, together with a report containing comments received by the participants (see Annex VII) was sent to the Crop Leader for further consultation and to help select a reduced set of key traits. As a way to implement the final list and to avoid any misinterpretation of some traits, Dr Debouck proposed to introduce digital images for some descriptors as seed colour, shape, pattern, and Phaseolin type. Adriana Alercia discussed the feasibility of this proposal with the developer of the Global Information Portal and an agreement was found for this inclusion once data would become available.

Afterwards a final key set was prepared adding descriptor states and then was sent again to Dr Debouck for his further validation (see Annex VIII).

The final validated document, approved also by the Core Advisory Group, and including all the contributors (see Annex IX), was proofread by an external editor and sent to the Bioversity Publication Unit for layout and online publication processes. Furthermore, the publication was shared with ECPGR Secretariat; the Generation Challenge Programme (GCP) Ontology and the SGRP Crop Genebank Knowledge Base partners. Additionally, data were converted into Excel files for uploading into the GRIN-Global genebank data-management system being developed by USDA first and subsequently into the global accession level information portal, linking national, regional and international genebank databases in support of the conservation and use of plant genetic resources for food and agriculture (PGRFA). The Excel files were also provided to the System-wide Information Network for Genetic Resources (SINGER) and to EURISCO.

Acknowledgement

Bioversity is grateful to all the scientists and researchers who have contributed to the development of the strategic set of ‘Key access and utilization descriptors for bean genetic resources’, and to the Global Crop Diversity Trust for their financial support. Particular recognition goes to the Crop Leader, Dr Daniel Debouck, for his valuable scientific direction. Ms Adriana Alercia provided technical expertise and guided the entire production process.

Annex I – Summary comparison table weighing up important descriptors for bean drawn from different sources[i]

IBPGR Desc. no.	IBPGR Descriptor name	IBPGR 1982	UPOV Descriptors	USDA/ARS/GRIN	Daniel Debouck selected 3/11/08	*Phaselieu Desriptors list*	Revised key set Debouck 21/11/08	SSE CIAT 1987
4.1.1	Leaflet length [cm]	*						
4.1.2	Plant type	*	*	*	*	*	*	**
4.2.1	Node number on main stem from base to first inflorescence	*		*				
4.2.2	Days to 50% flowering	*	*	*	*	*	*	**
4.2.3	Flower buds per inflorescence	*						
4.2.4	Flower - Colour of standard (combined with vein)	*	*	*	*	*	*	
4.2.5	Flower - Colour of wings	*	*	*	*	*	*	
4.2.6	Pod colour (combined with pattern)	*	*	*	*	*	*	
4.2.7	Pod length (to be deleted from key set)	*	*	*	*			
4.2.8	Pod cross-section	*	*					
4.2.9	Pod curvature	*						
4.2.10	Pod suture string (to be deleted from key set)	*	*	*	*			
4.2.11	Pod colour at physiological maturity	*				*		
4.2.12	Pod wall fibre	*				*		
4.2.13	Locules per pod	*		*				
4.3.1	Seed coat patterns	*	*	*	*	*	*	**
4.3.2	Seed coat darker colour	*	*	*		*		**
4.3.3	Seed coat lighter colour	*	*	*		*		**

IBPGR Desc. no.	IBPGR Descriptor name	IBPGR 1982	UPOV Descriptors	USDA/ARS/GRIN	Daniel Debouck selected 3/11/08	*Phaselieu Desriptors list*	Revised key set Debouck 21/11/08	SSE CIAT 1987
4.3.4	Brilliance of seed	*		*				**
4.3.5	Seed shape (Digital image)	*		*	*	*	*	
6.1.1	Hypocotyl length [cm]	*						
6.1.2	Hypocotyl pigmentation (to be deleted from key set)	*		*	*			
6.1.3	Emerging cotyledon colour	*		*				
6.1.4	Leaf colour of chlorophyll	*	*					
6.1.5	Leaf colour of anthocyanin	*						
6.1.6	Leaf shape	*		*		*		
6.1.7	Days to 90% pod maturity	*			*		*	
6.1.8	Leaf persistence	*						
6.1.9	Plant height [cm] (to be deleted from key set)	*			*			
6.1.10	Stem diameter [mm]	*						
6.1.11	Stem lodging	*						
6.1.12	Node number at harvest	*						
6.2.1	Flower bud size	*						
6.2.2	Size of flower bracteole	*						
6.2.3	Shape of flower bracteole	*						
6.2.4	Flower bracteole/calyx length relation	*						
6.2.5	Flower calyx/bracteole colour	*						
6.2.6	Flower wing opening	*						

IBPGR Desc. no.	IBPGR Descriptor name	IBPGR 1982	UPOV Descriptors	USDA/ARS/GRIN	Daniel Debouck selected 3/11/08	*Phaselieu Desriptors list*	Revised key set Debouck 21/11/08	SSE CIAT 1987
6.2.7	Flower style protrusion	*						
6.2.8	Racemes per plant	*						
6.2.9	Inflorescence length [mm]	*						
6.2.10	Pedicel length [mm]	*						
6.2.11	Duration of flowering	*			*		*	
6.2.12	Position of pods	*		*		*		**
6.2.13	Pod width [mm]	*						
6.2.14	Pod beak length [mm]	*	*					
6.2.15	Pod beak position	*						
6.2.16	Pod beak orientation	*						
6.2.17	Dry pod colour	*						
6.2.18	Pods per plant	*						*
6.3.1	Seeds per pod	*						*
6.3.2	Apparent seed veining	*						
6.3.3	100-Seed weight [g] (changed)	*	*	*	*	* (100-seed weight)	*	**
6.3.4	Seed volume [cm^3]	*						
6.3.5	Seed dimensions [mm]	*						
6.3.5.1	Seed length [mm]	*				*		
6.3.5.2	Seed width [mm]	*				*		
6.3.5.3	Seed height [mm]	*				*		

IBPGR Desc. no.	IBPGR Descriptor name	IBPGR 1982	UPOV Descriptors	USDA/ARS/GRIN	Daniel Debouck selected 3/11/08	*Phaselieu Desriptors list*	Revised key set Debouck 21/11/08	SSE CIAT 1987
6.3.6	Percentage seed protein [%]	*						
6.3.7	Percentage seed protein of a check variety	*						
7.1	Low temperature	*				*		
7.2	High temperature	*						
7.3	Drought	*				*		*
7.4	High Humidity	*						
7.5	Salinity	*						
7.6	Soil acidity (Low available phosphorous level)	*						*
8.1.1	*Acanthoscelides obtectus* (Say) (Bruchids)	*			*		*	**
8.1.2	*Apion godmani* (Bean pod weevil) (to be deleted)	*			*			*
8.1.3	*Aphis* spp. (Aphids)	*						*
8.1.4	*Bemisia tabaci* (Genn.) (Whitefly)	*						
8.1.5	*Caliothrips braziliensis* (Thrips)	*						
8.1.6	*Cerotoma* spp. (Leaf-feeding insects)	*						*
8.1.7	*Diabrotica* spp. (Leaf-feeding insects)	*						*
8.1.8	*Empoasca kraemeri* (Leafhopper)	*		*	*	*	*	**
8.1.9	*Heliothis* spp. (Pod borer)	*						
8.1.10	*Maruca testulalis* (Gey.) (Pod borer)	*						
8.1.11	*Zabrotes subfasciatus* (Bruchids)	*			*		*	**

IBPGR Desc. no.	IBPGR Descriptor name	IBPGR 1982	UPOV Descriptors	USDA/ARS/GRIN	Daniel Debouck selected 3/11/08	*Phaselieu Desriptors list*	Revised key set Debouck 21/11/08	SSE CIAT 1987
8.1.12	*Epinotia* spp.	*						
8.1.13	*Hedilepta indicata*	*						
8.1.14	*Meloidogyne* spp.	*						
8.1.15	*Pratylenchus* spp.	*						
8.1.16	*Polyphagot arsonemus latus* (Tarsonomid mites)	*						* White spider mite
8.1.17	*Tetranychus* spp. (Spider mites)	*						*
8.1.18	Slugs	*						
8.2.1	*Alternaria* spp. (Alternaria leaf and pod spot)	*						*
8.2.2	*Ascochyta* spp. (Ascochyta leaf spot) (to be confirmed)	*			*		*	**
8.2.3	*Botrytis cinerea* Pers. ex Fr. (Grey mold)	*				*		
8.2.4	*Cercospora* spp. (Cercospora leaf spot)	*						*
8.2.5	*Colletotrichum lindemethianum* (Anthracnose)	*		*	*		*	**
8.2.6	*Diaporthe* spp. (Diaporthe pod blight)	*						*
8.2.7	*Erysiphe polygoni* DC ex Merat. (Powdery mildew)	*						*
8.2.8	*Fusarium* spp. (Root rot)	*		* (Fusarium wilt?)				*
8.2.9	*Macrophomina phaseoli* (Maubl.) (Ashy stem blight)	*			*		*	** Charcoal rot
8.2.10	*Phoesisariopsis griseola* (Ferraris) (Angular leaf spot)	*						*

IBPGR Desc. no.	IBPGR Descriptor name	IBPGR 1982	UPOV Descriptors	USDA/ARS/GRIN	Daniel Debouck selected 3/11/08	*Phaselieu Desriptors list*	Revised key set Debouck 21/11/08	SSE CIAT 1987
8.2.11	*Phytophthora phaseoli* (Thaxter) (Downy mildew)	*						
8.2.12	*Pseudocercosporella albida* (Matta & Balliard) (White leaf spot)	*				*		**
8.2.13	*Pythium* spp. (Root rot)	*				*		**
8.2.14	*Rhizoctonia* spp. (Root rot)	*				*		**
8.2.15	*Sclerotinia sclerotiorum* (Lib.) de Bary (White mold)	*		*				*
8.2.16	*Thanatephorus cucumeris* (Frank) Dark (Web blight)	*						*
8.2.17	*Uromyces phaseoli* (Pers.) Winter (Rust)	*		*		*		**
8.3.1	*Corynebacterium flaccumfaciens* (Hedges) Dowson (Bacterial wilt)	*				*		
8.3.2	*Pseudomonas phaseolicola* (Halo blight)	*		*	*	*	*	**
8.3.3	*Pseudomonas syringae* van Hall (Bacterial brown spot)	*						*
8.3.4	*Pseudomonas tabaci* (Wolf & Foster) Stevens (Wildfire)	*						
8.3.5	*Xanthomonas phaseoli* (E.F. Sm.) Dowson (Bacterial blight)	*		*	*	*	*	**
8.4.1	Alfalfa mosaic virus	*						
8.4.2	Bean chlorotic mottle virus	*						
8.4.3	Bean common mosaic virus (BCMV)	*	*	*	*	*	*	
8.4.4	Bean curly dwarf mosaic virus	*						
8.4.5	Bean golden mosaic virus	*						
8.4.6	Bean rugose mosaic virus	*						

IBPGR Desc. no.	IBPGR Descriptor name	IBPGR 1982	UPOV Descriptors	USDA/ARS/GRIN	Daniel Debouck selected 3/11/08	*Phaselieu Desriptors list*	Revised key set Debouck 21/11/08	SSE CIAT 1987
8.4.7	Bean southern mosaic virus	*						
8.4.8	Bean summer death	*						
8.4.9	Bean yellow mosaic virus	*				*		
8.4.10	Bean yellow stipple virus	*						
8.4.11	Cucumber mosaic virus	*						
8.4.12	Curly top virus	*						
8.4.13	Euphorbia mosaic virus	*						
8.4.14	Mycoplasma diseases	*						
8.4.15	Red node (tobacco streak virus)	*						
8.4.16	*Rhynchosia* mosaic virus	*						
8.4.17	Tomato spotted wilt virus	*						
New descriptor	User category (dry bean, snap bean, green seed, green frozen seed, popping beans)						*	
	Days to 50% physiological maturity							*
	Growth habit							*
	Vegetative adaptation (vigour)							*
	Nodulation with *Rhizobium* spp.							*
	Mycovellosiella phaseoli (= *Ramularia phaseoli*) (Floury leaf spot)							*
	Cercospora castellanii (= *Cvanderysti*) (Gray leaf spot)							*
	*Phoma*sp. (Phoma red blight)							*

IBPGR Desc. no.	IBPGR Descriptor name	IBPGR 1982	UPOV Descriptors	USDA/ARS/GRIN	Daniel Debouck selected 3/11/08	*Phaselieu Desriptors list*	Revised key set Debouck 21/11/08	SSE CIAT 1987
	Chaetoseptoria wellmani(Round leaf spot)							*
	Entyloma petuniae (Entyloma leaf smut)							*
	Thielaviopsis basicola (Black root rot)							*
	Sclerotium rolfsii (Southern blight)							*
	Fusarium oxysporum f. sp. p*haseoli* (Fusarium wilt)							*
	Ophiomyia spp. (Bean flies)							*

[i] '*Phaseolus vulgaris* Descriptors' (IBPGR 1982), UPOV Technical guidelines for French Bean (2005), 'Descriptors for *PHASEOLUS*' (USDA, ARS, GRIN), 'Handbook on evaluation of *Phaseolus* Germplasm' (PHASELIEU, 2001), 'Standard System for the Evaluation of Bean Germplasm' (CIAT, 1987), traits selected and validated by Dr Debouck (CIAT).

Annex II – List of experts identified to participate to the survey

Role	Name	Organization	Country
Crop Leader	**Debouck, Daniel**	CIAT	Colombia
CAG	De la Cuadra, Celia	INIA - ECPGR	Spain
CAG	De Ron, Antonio M.	Misión Biológica de Galicia - CSIC - Phaselieu	Spain
CAG	Duc, Gerard	INRA (ECPGR)	France
CAG	Santalla, Marta	Misión Biológica de Galicia - CSIC - Phaselieu	Spain
CAG	Voysest, Oswaldo	CIAT	Colombia
CAG	Welsh, Molly	ARS/USDA	USA
ECPGR	Bettencourt, Eliseu		Italy
ECPGR	Buravtseva, T.	VIR	Russia
ECPGR	Carravedo Fantova, Miguel	Mediterranean Agronomic Institute of Zaragoza	Spain
ECPGR	Dotlacil, Ladislav	Crop Research Institute	Czech Republic
ECPGR	Hornakova, Olga	SCPV	Slovenia
ECPGR	Horvath, Lajos		Hungary
ECPGR	Kainz, Wolfgang	Austrian Agency for Health and Food Safety (AGES)	Austria
ECPGR	Kleijer, Geert	Swiss Commission for the Conservation of Cultivated Plants	Switzerland
ECPGR	Lazanyi, Janos	Debreceni Egyetem (AMTC)	Hungary
ECPGR	Lengauer, Doris	LVZ Weis	Austria
ECPGR	Manoah, Myra	Agricultural Research Organization (ARO)	Israel

Role	Name	Organization	Country
ECPGR	Ottosson, Fredrik	Nordgen	Sweden
ECPGR	Quagliotti, Luciana	Turin University	Italy
ECPGR	Russkikh, Ivan	Belarusian State University	Belorussia
ECPGR	Ryabchoun, Victor K.		Ukraine
ECPGR Rev suggd by Knuppfer	Schmidt Baerbel	IPK	Germany
ECPGR	Vanderborght, Thierry	National Botanical Garden	Belgium
ECPGR	Vorderwuelbecke, Birgit	Arche Noah	Austria
Phaseomics	Aguilar, Orlando Mario	IBBM, Universidad Nacional de La Plata	Argentina
Phaseomics	Antoun, Hani	Laval University	Canada
Phaseomics	Atkins, Craig A.	CLIMA - University of Western Australia	Australia
Phaseomics	Beebe, Stephen	CIAT	Colombia
Phaseomics	Bett, Kirstin E	Department of Plant Sciences - University of Saskatchewan	Canada
Phaseomics	Camargo, Luis E. A.	ESALQ - University of Sao Paolo	Brazil
Phaseomics	Covarrubias Robles, Alejandra Alicia	Departamento de Biologia Molecular de Plantas, Istituto UNAM	Mexico
Phaseomics	Onzere, Nelson Amugune	Department of Botany University of Nairobi	Kenya
Phaseomics	Schröder, Eduardo C.	Department of Agronomy and Soils, University of Puerto Rico	Puerto Rico
Phaseomics	Sparvoli, Francesca	IBBA - CNR	Italy

Role	Name	Organization	Country
Phaseomics	Terryn, Nancy	IPBO	Belgium
Phaseomics	Vance, Carroll P.	University of Minnesota - USDA/ARS	USA
Phaseomics	Volckaert, Guido	Catholic University of Leuven	Belgium
WIEWS	Benedikova	Research Institute of Plant Production Piestany	Slovakia
WIEWS	Feyt, Henri	CIRAD	France
WIEWS	Fundora, Z.	Banco de Germoplasma	Cuba
WIEWS	Graner, A.	IPK	Germany
WIEWS	Hýbl, Miroslav	AGRITEC, Research, Breeding and Services Ltd.	Czech Republic
WIEWS	Lawrence, Peter	Australian Plant Genetic Resource Information Service	Australia
WIEWS	Maliro, M.	Bunda College of Agriculture	Malawi
WIEWS	Mario Lobo	CORPOICA	Colombia
WIEWS	Muthamia, Zachary	National Genebank of Kenya, Crop Plant Genetic Resources Centre, Kenya Agricultural Research Institute	Kenya
WIEWS	Podyma, W.	Plant Breeding and Acclimatization Institute	Poland
WIEWS	Salazar, E.	Instituto de Investigaciones Agropecuarias, Centro Regional de Investigación La Platina	Chile
WIEWS	Stoyanova, S.	Institute for Plant Genetic Resources "K.Malkov"	Bulgaria
WIEWS	Veloso, MM	INIAP	Portugal
New Reviewer	Acosta, Jorge	INIFAP	Mexico
New Reviewer	Araya, Carlos Manuel	Escuela de Ciencias Agrarias. Universidad Nacional.	Costa Rica

Role	Name	Organization	Country
New Reviewer	Buruchara, Robin	CIAT - Africa	Uganda
New Reviewer	Hernández F., Juan Carlos	Instituto Nacional de Innovación y Trasferencia en Tecnológica Agropecuaria	Costa Rica
New Reviewer	Kelly, James	Michigan State University	USA
New Reviewer	Mwale, V.M.	Bunda College of Agriculture University of Malawi (Germplasm Directory)	Malawi
New Reviewer	Xuxiao, Zong	CAAS	China
New Reviewer	Xuzhen, Cheng	CAAS	China

Annex III - Characterization and Evaluation traits validated by Dr Daniel Debouck on 20th March 2009 and used for the survey

1.	Plant growth habit	(4.1.2)
2.	Days from sowing to 50% flowering	(4.2.2)
3.	Colour of standard flowers	(4.2.4)
4.	Colour of flower wings	(4.2.5)
5.	Pod colour	(4.2.6)
6.	Seed coat patterns	(4.3.1)
7.	Seed shape	(4.3.5)
8.	Days to 90% pod maturity	(6.1.7)
9.	Duration of flowering	(6.2.11)
10.	100-seed weight [g]	
11.	Bruchids (*Acanthoscelides obtectus*)	(8.1.1)
12.	Leafhopper (*Empoasca kraemeri*)	(8.1.8)
13.	Bruchids (*Zabrotes subfasciatus*)	(8.1.11)
14.	Ascochyta leaf spot (*Ascochyta* spp.)	(8.2.2)
15.	Ascochyta blight (*Phoma exigua* var. *diversispora* Boerema)	
16.	Anthracnose (*Colletotrichum lindemuthianum*)	(8.2.5)
17.	Ashy stem blight (*Macrophomina phaseolina*)	(8.2.9)
18.	Halo blight (*Pseudomonas syringae* pv. *phaseolicola*)	(8.3.2)
19.	Bacterial blight (*Xanthomonas campestris* pv. *phaseoli*)	(8.3.5)
20.	Bean common mosaic virus (BCMV)	(8.4.3)
21.	User category (dry bean, snap bean, green seed, popping beans)	
22.	Phaseolin type	

Annex IV – Survey to choose a key set of descriptors for bean (*Phaseolus vulgaris*)

WELCOME

Welcome to the survey for the selection of a key set of characterization and evaluation descriptors to support an international information system to enhance the utilization of germplasm held in genebanks.

Your knowledge and experience are being sought to select this initial 'key set of descriptors' of Bean accessions to identify traits important to crop production and to facilitate their use by researchers.

Your participation in it is highly appreciated. The deadline for this survey is 15th April 2009.

This key set of characterization and evaluation descriptors will be made available through a global facility for identifying sets of accessions for evaluation and use. For characterization, the aim is a key set of maximally differentiating traits that provide the most impact in discriminating between accessions. For evaluation, the aim is to focus on a few important traits for production, such as those related to biotic stresses of cosmopolitan nature.

The list presented here has been refined under the scientific direction of Dr. Daniel Debouck, from CIAT.

This survey consists of two parts:

PART I: Lists important characterization descriptors for Bean. Based on your experience, please rate the descriptors according to their importance in identifying accessions. It also allows you to indicate if any essential descriptor that can contribute to its use is missing from the minimum list presented.

PART II: Lists important evaluation descriptors for Bean. Please, rate these traits in order of importance at the global level. It also allows you to indicate if any essential trait for production is missing from the minimum list presented or indicate any that may not be very significant to global production.

We thank you in advance for investing your time and expertise in selecting this initial, key set of descriptors.

Please allow us to acknowledge your contribution by completing your full contact details below:

Name:

Organization:

Address:

City/Town:

State/Province:

ZIP/PostalCode:

Country:

Email Address

PART I: Characterization descriptors

These traits enable easy and quick discrimination between phenotypes. They are generally highly heritable, can be easily seen by the eye and are equally expressed in all environments.

*Numbers in parentheses on the right-hand side are the corresponding descriptors numbers as published in the ‘*Phaseolus vulgaris* Descriptors’ (IBPGR, 1982).

	Not important	Important	Very important
Plant growth habit (4.1.2)	j /	j /	j /
Days from sowing to 50% flowering (4.2.2)	j /	j /	j /
Colour of standard flowers (4.2.4)	j /	j /	j /
Colour of flower wings (4.2.5)	j /	j /	j /
Pod colour (4.2.6)	j /	j /	j /
Seed coat patterns (4.3.1)	j /	j /	j /
Seed shape (4.3.5)	j /	j /	j /

If you consider that an essential trait is missing from this list, please indicate it here along with a substantiated justification.

PART II: Evaluation descriptors

These descriptors include characters such as biotic stresses. They are the most interesting traits in crop improvement. Please consider the following factors relating to the trait when making your final decision: (i) Global impact, (ii) Initial strategic set, (iii) Importance for germplasm utilization, (iv) Data availability, (v) True economic damage and (vi) Wide geographical occurrence.

	Not important	Important	Very important
Days to 90% pod maturity (6.1.7)	j /	j /	j /
Duration of flowering (6.2.11)	j /	j /	j /
100-seed weight [g]	j /	j /	j /
Bruchids (*Acanthoscelides obtectus*) (8.1.1)	j /	j /	j /
Leafhopper (*Empoasca kraemeri*) (8.1.8)	j /	j /	j /
Bruchids (*Zabrotes subfasciatus*) (8.1.11)	j /	j /	j /
Ascochyta leaf spot (*Ascochyta* spp.) (8.2.2)	j /	j /	j /
Ascochyta bligth (*Phoma exigua* var. *diversispora* Boerema)	j /	j /	j /
Anthracnose (*Colletotrichum lindemuthianum*) (8.2.5)	j /	j /	j /
Ashy stem blight (*Macrophomina phaseolina*) (8.2.9)	j /	j /	j /
Halo blight (*Pseudomonas syringae* pv. *phaseolicola*) (8.3.2)	j /	j /	j /
Bacterial blight (*Xanthomonas campestris* pv. *phaseoli*) (8.3.5)	j /	j /	j /
Bean common mosaic virus (BCMV) (8.4.3)	j /	j /	j /
User category (dry beans, snap beans, green seed, and popping beans)	j /	j /	j /
Phaseolin type	j /	j /	j /

If you consider that an essential trait important for crop improvement and production is missing from this list, or, if any of the descriptors listed is not clearly useful to promote utilization, please indicate it here along with a substantiated justification.

NOTE: Please remember, this list is the starting point and will grow over time, as required.

Annex V – Respondents to the survey for the definition of a key set of descriptors for bean

Role	***Name***	***Organization***	***Country***
CAG	De Ron, Antonio M.	MBG-CSIC	Spain
CAG	Santalla Ferradas, Marta	CSIC	Spain
CAG	Voysest Voysest, Oswaldo	CIAT (retired)	USA
CAG	Welsh, Molly	USDA/ARS/WRPIS	USA
Phaseomics	Aguilar, Mario O.	IBBM, Facultad Ciencias Exactas, Universidad Nacional de La Plata	Argentina
Reviewer	Dillon, Sally	Primary Indistries and Fisheries	Australia
ECPGR	Kainz, Wolfgang	Austrian Agency for Health and Food Safety	Austria
ECPGR	Lengauer, Doris	FA 10 B, Versuchsstation für Spezialkulturen	Austria
ECPGR	Vorderwülbecke, Birgit	Arche Noah	Austria
ECPGR	Vanderborght, Thierry	National Botanic Garden of Belgium	Belgium
Reviewer	Zong, Xuxiao	Institute of Crop Science, Chinese Academy of Agricultural Sciences	China
Phaseomics	Beebe, Stephen	CIAT	Colombia
Reviewrer suggested by Knuppfer, Helmut	Schmidt, Bäerbel	IPK Genbank	Germany
Reviewer	Rana, JC	National Bureau of Plant Genetic Resources	India
ECPGR	Bettencourt, Eliseu		Italy
Phaseomics	Sparvoli, Francesca	IBBA-CNR	Italy
Phaseomics	Covarrubias, Alejandra A.	Instituto de Biotecnologia-UNAM	Mexico
Reviewer	Veloso, Maria Manuela	INRB/INIA	Portugal
WIEWS	Benedikova, Daniela	Plant Production Research Centre - Piestany	Slovak Republic
ECPGR	Ottosson, Fredrik	Nordic Genetic Resource Center	Sweden
Reviewer	Beaver, James	University of Puerto Rico	USA
Reviewer	Kelly, James D.	Michigan State University	USA
Reviewer	Osorno, Juan M.	North Dakota State University	USA
Reviewer	Urrea, Carlos A.	University of Nebraska-Lincoln	USA
Reviewer	Pastor-Corrales (Talo), Marcial A.	USDA-ARS, SGIL	USA

Annex VI – Descriptors proposed in the survey ranked by rating average and by percentage of importance

Descriptor	Rating Average
Characterization	
Plant growth habit (4.1.2)	4.92
Seed coat patterns (4.3.1)	4.92
Seed shape (4.3.5)	4.52
Colour of standard flowers (4.2.4)	3.64
Days from sowing to 50% flowering (4.2.2)	3.56
Colour of flower wings (4.2.5)	3.21
Pod colour (4.2.6)	3.13
Evaluation	
100-seed weight [g]	4.52
Bean common mosaic virus (BCMV) (8.4.3)	4.25
User category (dry beans, snap beans, green seed, and popping beans)	4.19
Anthracnose (*Colletotrichum lindemuthianum*) (8.2.5)	4.00
Bacterial blight (*Xanthomonas campestris* pv. *phaseoli*) (8.3.5)	3.90
Days to 90% pod maturity (6.1.7)	3.86
Bruchids (*Acanthoscelides obtectus*) (8.1.1)	3.47
Phaseolin type	3.32
Bruchids (*Zabrotes subfasciatus*) (8.1.11)	3.25
Halo blight (*Pseudomonas syringae* pv. *phaseolicola)* (8.3.2)	3.25
Duration of flowering (6.2.11)	2.95
Leafhopper (*Empoasca kraemeri*) (8.1.8)	2.70
Ashy stem blight (*Macrophomina phaseolina*) (8.2.9)	2.60
Ascochyta bligth (*Phoma exigua* var. *diversispora* Boerema)	2.50
Ascochyta leaf spot *(Ascochyta* spp.) (8.2.2)	2.45

Descriptor	% Importance (Very important)
Characterization	
Plant growth habit (4.1.2)	96.0
Seed coat patterns (4.3.1)	95.8
Seed shape (4.3.5)	76.0
Colour of standard flowers (4.2.4)	56.0
Colour of flower wings (4.2.5)	41.7
Days from sowing to 50% flowering (4.2.2)	40.0
Pod colour (4.2.6)	37.5
Evaluation	
100-seed weight [g]	76.2
Bean common mosaic virus (BCMV) (8.4.3)	70.0
User category (dry beans, snap beans, green seed, and popping beans)	66.7
Anthracnose (*Colletotrichum lindemuthianum*) (8.2.5)	57.1
Bacterial blight (*Xanthomonas campestris* pv. *phaseoli*) (8.3.5)	52.4
Days to 90% pod maturity (6.1.7)	50.0
Phaseolin type	36.4
Halo blight (*Pseudomonas syringae* pv. *phaseolicola)* (8.3.2)	35.0
Bruchids (*Acanthoscelides obtectus*) (8.1.1)	31.6
Bruchids (*Zabrotes subfasciatus*) (8.1.11)	20.0
Ascochyta bligth (*Phoma exigua* var. *diversispora* Boerema)	20.0
Duration of flowering (6.2.11)	19.0
Leafhopper (*Empoasca kraemeri*) (8.1.8)	15.0
Ascochyta leaf spot *(Ascochyta* spp.) (8.2.2)	10.0
Ashy stem blight (*Macrophomina phaseolina*) (8.2.9)	10.0

Annex VII - Additional descriptors proposed in the bean survey

Bean Descriptors		Name of Expert									
	N times selected	Vanderborght, Thierry	Osorno, Juan M.	Kainz, Wolfgang	Marcial A., Pastor-Corrales (Talo)	Voysest Voysest, Oswaldo	Beebe, Stephen	Beaver, James	Urrea, Carlos A.	Kelly, James D.	Veloso, Maria Manuela
Additional characterization descriptors											
Photoperiod sensitivity: Simple to evaluate (yes or no), stable across environments, and very important for breeding and introgression.	1		X								
Pod curvature (4.2.9)	1			X							
Pod suture strings (4.2.10)	1			X							
Seed colour	4	X		X			X			X	
Growth period. In the Andes for a farmer having a bean of 200 days is like having a bean a cow; they provide food (green pods, green beans and dry beans) for almost the whole year. Other type of farmers on the contrary look for early maturing beans.	1					X					
Days from sowing to 90% physiological maturity. The earlier the better to avoid early frost.	1								X		
Additional evaluation descriptors											
Plant Height (6.1.9)	1									X	
Lodging (6.1.11)	1									X	
Seed size. (6.3.5) In some market classes (greta northern), the larger the better.	1								X		
Drought (7.3)	2						X		X		
Seed-protein content	1			X							
Soil constraints (low soil P and N) probably result in the greatest yield losses.	1						X				
Soil acidity (7.6)	1						X				
Aluminum toxicity	1						X				
Nutritional value	1								X		
Angular leaf spot (8.2.10)	3				X			X		X	
White Mold (*Sclerotinia sclerotiorum*) (8.2.15)	2		X		X						
Bean Rust (8.2.17)	4		X		X			X	X		
Bean Golden Mosaic (8.4.5)	3		X			X	X				
Cucumber Mosaic Virus (CMV) (8.4.11)	1										X
Root rot (***Phytopthora, Fusarium, Phytium***) are very limiting diseases.	2								X	X	
Bean common mosaic necrosis virus (BCMNV)	1							X			

Annex VIII – Final Key set including descriptor states sent to Dr Debouck for validation on 31st July 2009

Characterization

User category

1 Dry beans
2 Snap beans
3 Green seed
4 Popping beans

Plant growth habit (4.1.2)

1 Determinate bush
2 Indeterminate bush
3 Indeterminate prostrate or vining but not climbing
4 Indeterminate climbing
5 Mixed

Seed colour

Seed coat patterns (4.3.1)

0 Absent
1 Constant mottled (*marmoratus*)
2 Striped (*striatus*)
3 Rhomboid spotted (*rhomboidius*)
4 Speckled (*punctatus*)
5 Circular mottling (*circumdatus* in *P. coccineus* & *vulgaris* x *coccineus* (hybrid)
6 Marginal colour pattern (*marginatus*)
7 Broad striped (*zebrinus*)
8 Bicolor
9 Spotted bicolour
10 Pattern around hilum (face)
99 Other (specify in descriptor **Notes**)

Seed coat darker colour (4.3.2)

When both darker and lighter colours occur the paler is always genetically related to the darker colour by a difference in a single enzyme.

1 Black
2 Brown, pale to dark
3 Maroon
4 Grey, brownish to greenish
5 Yellow to greenish yellow
6 Pale-cream to buff
7 Pure white
8 Whitish
9 White, purple tinged
10 Chlorophyll green
11 Green to olive
12 Red
13 Pink
14 Purple
99 Other (specify in descriptor **Notes**)

Seed coat lighter colour (4.3.3)

When both darker and lighter colours occur, the paler is always genetically related to the darker colour by a difference in a single enzyme. Choose from states of descriptor 4.3.2

Brilliance of seed (4.3.4)

3 Matt
5 Medium
7 Shiny

Seed shape (4.3.5)
Taken from middle of pod

1 Round
2 Oval
3 Square
4 Kidney shaped
5 Rectangular

100-seed weight [g] (6.3.3)
Weight of 100 seeds to the first decimal place at moisture content of 12-14%

Colour of standard flower (4.2.4)
In freshly opened flowers; the colours of freshly opened flowers are highly changeable after opening

1 White
2 Green
3 Lilac
4 White with lilac edge
5 White with red stripes
6 Dark lilac with purple outer edge
7 Dark lilac with purplish spots
8 Carmine red
9 Purple
99 Other (specify in descriptor **Notes**)

Days from sowing to 50% flowering (4.2.2)
Number of days from sowing to stage where 50% of plants have set flowers

Colour of flower wings (4.2.5)
In freshly opened flowers

1 White
2 Green
3 Lilac
4 White with carmine stripes
5 Strongly veined in red to dark lilac
6 Plain red to dark lilac
7 Lilac with dark lilac veins
8 Purple
99 Other specify in descriptor **Notes**)

Days to 90% pod maturity (6.1.7)
Numbers of days from emergence until 90% of pods are mature

Pod colour (4.2.6)
From fully expanded immature pod

1 Dark purple
2 Carmine red
3 Purple stripe on green
4 Carmine stripe on green
5 Pale red stripe on green
6 Dark pink (rose)
7 Normal green
8 Shiny green
9 Dull green to silver grey
10 Golden or deep yellow
11 Pale yellow to white
99 Other specify in descriptor **Notes**)

Evaluation

Phaseolin type
Drought (7.3)
Bean common mosaic virus (BCMV) (8.4.3)
Anthracnose (*Colletotrichum lindemuthianum*) (8.2.5)
Bacterial blight (*Xanthomonas campestris* pv. *phaseoli*) (8.3.5)
Bruchids (*Acanthoscelides obtectus*) (8.1.1)
Bruchids (*Zabrotes subfasciatus*) (8.1.11)
Halo blight (*Pseudomonas syringae* pv. *phaseolicola)* (8.3.2)

Annex IX – Final Key access and utilization descriptors for bean genetic resources

PLANT DATA

Use category (4.1.X)

1 Dry beans
2 Snap beans
3 Green shelled seed
4 Popping beans

Plant growth habit (4.1.2)

1 Determinate bush
2 Indeterminate bush
3 Indeterminate prostrate or vining but not climbing
4 Indeterminate climbing
5 Determinate climbing
6 Mixture

Days from sowing to 50% flowering (4.2.2)

Number of days from sowing to stage where 50% of plants have set flowers

Colour of flower standard (banner) (4.2.4)

In freshly opened flowers; the colours of freshly opened flowers are highly changeable after opening

1 White
2 Green
3 Lilac
4 White with lilac edge
5 White with red stripes
6 Dark lilac with purple outer edge
7 Dark lilac with purplish spots
8 Carmine red
9 Purple
99 Other (specify in descriptor **Notes**)

Colour of flower wings (4.2.5)

In freshly opened flowers

1 White
2 Green
3 Lilac
4 White with carmine stripes
5 Strongly veined in red to dark lilac
6 Plain red to dark lilac
7 Lilac with dark lilac veins
8 Purple
99 Other (specify in descriptor **Notes**)

Pod colour (4.2.6)

From fully expanded immature pod

1 Dark purple
2 Carmine red
3 Purple stripe on green
4 Carmine stripe on green
5 Pale red stripe on green
6 Dark pink (rose)
7 Normal green
8 Shiny green
9 Dull green to silver grey
10 Golden or deep yellow
11 Pale yellow to white
99 Other (specify in descriptor **Notes**)

Days to 90% pod maturity (6.1.7)

Numbers of days from emergence until 90% of pods are mature

SEED COLOUR

Seed coat patterns (4.3.1)

0 Absent
1 Mottled
2 Striped
3 Speckled
4 Spotted
5 Blotched
99 Other (specify in descriptor **Notes**)

Seed coat colour[1] (4.3.2)

The list of the principal colours is listed below. If the seed has more than one colour the secondary and tertiary colours are also recorded using the same colour codes as for the primary colour.

1 White
2 Cream
3 Yellow
4 Brown
5 Pink
6 Red
7 Purple
8 Black
99 Other (specify in descriptor **Notes**)

Brilliance of seed (4.3.4)

3 Dull
5 Medium
7 Shiny

[1] For mixed material separate the variants and name them accordingly by a letter after the accession number

Seed shape (4.3.5)

Taken from middle of pod

1 Round
2 Oval
3 Cuboid
4 Kidney shaped
5 Markedly truncate

100-seed weight [g] (6.3.3)

Weight of 100 seeds to the first decimal place at moisture content of 12-14%

Phaseolin type[2] (6.3.X)

The phaseolin types should be indicated by a letter e.g. T, C, S, as it has been indicated in specialized publications such as Toro O, CH Ocampo & DG Debouck. 2007. Phaseolin: variability and reference materials in wild and cultivated common bean. Annu. Rept. Bean Improvement Coop. (USA) 50: 69-70. Once the phaseolin type has been indicated by a conventional letter, then a digital image of the gel with the particular accession under study can be added.

ABIOTIC STRESSES

Drought (7.3)

BIOTIC STRESSES

Bruchids (*Acanthoscelides obtectus*) (8.1.1)

Bruchids (*Zabrotes subfasciatus*) (8.1.11)

Anthracnose (*Colletotrichum lindemuthianum*) (8.2.5)

Halo blight (*Pseudomonas syringae* pv. *phaseolicola*) (8.3.2)

Bacterial blight (*Xanthomonas campestris* pv. *phaseoli*) (8.3.5)

Bean common mosaic virus (BCMV) (8.4.3)

NOTES

Any additional information may be specified here, particularly that referring to the category '99=Other' present in some of the descriptors above.

[2] Brown JWS, Y Ma, FA Bliss & TC Hall. 1981. 'Genetic variation in the subunits of globulin-1 storage protein in French bean'. Theor. Appl. Genet. 59: 83-88

CONTRIBUTORS

CORE ADVISORY GROUP

Daniel Debouck, Centro Internacional de Agricultura Tropical (CIAT), Colombia
Antonio M. De Ron, Misión Biológica de Galicia, Consejo Superior de Investigaciones Científicas (MBG-CSIC), Spain
Marta Santalla Ferradas, Consejo Superior de Investigaciones Científicas (CSIC), Spain
Oswaldo Voysest Voysest (retired), Centro Internacional de Agricultura Tropical (CIAT), USA
Molly Welsh, United States Department of Agriculture, Agricultural Research Service, (USDA / ARS / WRPIS), USA

REVIEWERS

Argentina
O. Mario Aguilar, Instituto de Biotecnología y Biología Molecular (IBBM), Facultad Ciencias Exactas, Universidad Nacional de La Plata

Australia
Sally Dillon, Primary Industries and Fisheries

Austria
Wolfgang Kainz, Austrian Agency for Health and Food Safety (AGES)
Doris Lengauer, FA 10 B, Versuchsstation für Spezialkulturen
Birgit Vorderwülbecke, ARCHE NOAH

Belgium
Thierry Vanderborght, National Botanic Garden of Belgium

China
Zong Xuxiao, Institute of Crop Science, Chinese Academy of Agricultural Sciences (CAAS)

Colombia
Stephen Beebe, Centro Internacional de Agricultura Tropical (CIAT)

Germany
Baerbel Schmidt, Genebank Department, Leibniz Institute of Plant Genetics and Crop Plant Research (IPK)

India
JC Rana, National Bureau of Plant Genetic Resources (NBPGR)

Italy
Eliseu Bettencourt
Francesca Sparvoli, Istituto di Biologia e Biotecnologia Agraria, Consiglio Nazionale delle Ricerche (IBBA-CNR)

Mexico
Alejandra A. Covarrubias, Instituto de Biotecnologia, Universidad Nacional Autónoma de México (UNAM)

Portugal
Maria Manuela Veloso, Instituto Nacional de Recursos Biológicos, Instituto Nacional de Investigação Agrária (INRB/INIA)

Slovak Republic
Daniela Benedikova, Plant Production Research Centre – Piestany

Sweden
Fredrik Ottosson, Nordic Genetic Resource Center

USA
James Beaver, University of Puerto Rico
James D. Kelly, Michigan State University
Juan M. Osorno, North Dakota State University
Marcial A. Pastor-Corrales (Talo), United States Department of Agriculture, Agricultural Research Service, (USDA-ARS, SGIL)
Carlos A. Urrea, University of Nebraska – Lincoln

Methodology for the definition of a key set of characterization and evaluation descriptors for breadfruit (*Artocarpus altilis*)

Bioversity International

GLOBAL CROP DIVERSITY TRUST
A FOUNDATION FOR FOOD SECURITY

Information collection and preparation of a Minimum Descriptor List (MDL)

Since Bioversity has not published a Descriptors List for breadfruit, information for the definition of a MDL for this crop was drawn from the publication "Ragone, Diane. Breadfruit. *Artocarpus altilis* (Parkinson) Fosberg. Promoting the conservation and use of underutilized and neglected crops. 10." (IPK and IPGRI, 1997) and integrated with information on morphological descriptors mentioned in the website of the National Tropical Botanical Gardens (NTBG). The list was subsequently harmonized with descriptors suggested in the "*Breadfruit Conservation Strategy*"(the Trust, 2007), particularly with regards to the inclusion of evaluation traits such as yield, fruit quality and important pests and diseases for this crop.

Preparing List of Experts

The list of experts was prepared taking into account the list of participants to crop-specific consultations for the definition of the "*Breadfruit Conservation Strategy*"(the Trust, 2007), as well as participants to the Regional Workshop on Conservation and Sustainable Use of Breadfruit Genetic Resources in the Pacific held in Fiji in 2002. Breadfruit experts included in the publication "Ragone D. 2008. Regeneration Guidelines: Breadfruit." (CGIAR System- wide Genetic Resource Programme), were also included in the Core Advisory Group. Overall, 56 experts were identified, coming from 29 countries and 44 different organizations (Annex I). Out of these, a Group Leader (Diane Ragone) and a Core Advisory group consisting of five experts was selected to assist in the definition of a key set of descriptors. Experts forming the Core Advisory group were drawn from internationally recognised organizations such as USDA/ARS, the Secretariat of the Pacific Community (SPC) and the Nature Conservancy (TNC) Micronesia Program.

Survey preparation and distribution

The draft descriptors list was submitted to Dr. Diane Ragone for initial validation, but since the NTBG team was still carrying out the characterization of breadfruit accessions and was unable to make a substantiated decision on the Minimum list it was decided that a draft list (37 characterization descriptors and seven evaluation descriptors) would be sent out to identified experts for comments, to collect initial thoughts on key breadfruit descriptors recognised by other experts in different geographical areas. 56 experts were identified for survey participation, coming from 29 countries and representing 41 different organizations. The survey was uploaded into the Survey Monkey application on the internet and an email invitation sent out to experts on 14 October 2008. A link to the Survey was provided to experts, who were invited to rate the importance of the proposed characterization and evaluation descriptors for this crop. Experts were also encouraged to mention any additional trait(s) that was/were found to be relevant yet missing from the proposed List, along with a substantiated justification for its/their inclusion. The survey deadline was set at 31 October 2008. A reminder was sent out on the 22nd of October to ensure that the greatest possible feedback was obtained.

Survey analysis and refinement of Minimum List

Of the 56 experts who were identified and involved in the exercise, 15 recorded their comments using the online survey (see Annex II). Results from the Survey were analysed and descriptors ranked by rating average and percentage of importance (Annex III). A comparison table was prepared weighing up descriptors rated as very important by experts, against (i) descriptors mentioned in the NTBG website and further revised by Diane Ragone on 7 October 2008 (ii) those mentioned in the USDA/ARS descriptor list and (iii) evaluation traits mentioned in the Breadfruit Conservation Strategy (the Trust, 2007). The list was submitted to Diane Ragone on 11 December 2008 for endorsement and to help select a reduced set of key traits for this crop. She replied on 20 December. Her selection is recorded in the comparison table in Annex IV. The selected key set of traits (see Annex V), was compiled into a Word document and sent to the Core Advisory Group (CAG) for validation on 23 December 2008. At the same time Diane Ragone was contacted for advice on the formulation of descriptor states for the chosen key set of traits. Feedback was received from Diane Ragone with descriptor states on 30 December, the list was amended and sent back to Diane Ragone for final approval on 19 February 2009. Her feedback was received on the same day with comments and implemented changes. Comments received by the experts were collected, analysed and harmonised with the original descriptors list. This exercise led to the definition of the final key set of descriptors for breadfruit (Annex VI). The final version was shared, through an email sent out on 5 March 2009 (Annex VII), with the experts that contributed to the selection of the final key set of characterization and evaluation descriptors for breadfruit. Deadline for further comments was set on 13 March 2009. Comments received were included in the final key set and on 16 March 2009 the list was definitely approved by Dr Ragone, and finalized for publication (Annex VIII). On 18th March the final list was sent to the Publications Unit for editing and layout.

Once the core subset of characterization and evaluation standards for breadfruit was finalised, data were transformed into Excel files for uploading into the GRIN-Global genebank data-management system being developed by USDA, and into GENESYS, linking national, regional and international genebank databases in support of the conservation and use of plant genetic resources for food and agriculture (PGRFA). It was also shared with EURISCO, the Generation Challenge

Programme (GCP) Ontology, the System-wide Information Network for Genetic Resources (SINGER) and with the SGRP Crop Genebank Knowledge Base.

Acknowledgement

Bioversity is grateful to all the scientists and researchers who have contributed to the development of the strategic set of 'Key access and utilization descriptors for breadfruit genetic resources', and to the Global Crop Diversity Trust for their financial support. Particular recognition goes to the Crop Leader, Dr Diane Ragone for providing valuable scientific direction. Ms Adriana Alercia provided technical expertise and guided the entire production process.

Annex I – List of experts identified for participation to the Survey for the definition of a minimum set of descriptors for breadfruit

Role	Name	Institution	Country
Crop Leader	**Ragone, Diane**	National Tropical Botanical Garden	Hawaii
CAG	Zee, Francis	ARS/USDA	USA
CAG	Jackson, Grahame		
CAG/(SRG)	Coronel, Roberto		Philippines
CAG/ (SRG)	Raynor, Bill	Nature Conservancy (TNC) Micronesia Program	Micronesia
CAG/Crop Strategy	Taylor, Mary	Centre for Pacific Crops & Trees, Secretariat of the Pacific Community	Fiji
Strategy Expert	Baccus -Taylor, Gail	University of the West Indies	West Indies
Strategy Expert	Beyer, Richard	Food Science Consulting	Fiji
Strategy Expert	Biaukula, Kalisito	Ministry of Agriculture, Fisheries & Forests	Fiji
Strategy Expert	Bulai, Sairusi	Forests & Trees Programme, SPC Land Resources Division	Fiji
Strategy Expert	Conner, Nicholas	Department of Environment and Conservation	Australia
Strategy Expert	Englberger, Lois	Island Food Community of Pohnpei	Federated States of Micronesia
Strategy Expert	Gbèhounou, Gualbert	Laboratoire de Défense des Cultures/Institut National des Recherches Agricoles du Bénin	Benin
Strategy Expert	Goebel, Roger	Centre for Wet Tropics Agriculture, Department of Primary Industries and Fisheries	Australia
Strategy Expert	Golden, Kerith D	University of the West Indies	Jamaica
Strategy Expert	Halafihi, Manaia	Ministry of Agriculture, Forests and Fisheries	Tonga
Strategy Expert	Kete, Tevita	Centre for Pacific Crops & Trees, SPC Land Resources Division	Fiji
Strategy Expert	Kumar, Sant	Nature's Way Co-operative (Fiji) Ltd.	Fiji
Strategy Expert	Lebegin, Stéphane	Institut Agronomique néo-Caledonien	New Caledonia
Strategy Expert	Lorens, Adelino	Agriculture, Office of Economic Affairs, Pohnpei State Government	Federated States of Micronesia

Role	Name	Institution	Country
Strategy Expert	Maerere, Amon	Department of Crop Science & Production, Sokoine University of Agriculture	Tanzania
Strategy Expert	Masamdu, Roy	SPC Land Resources Division	Fiji
Strategy Expert	Masau, Reapi	CePaCT, Centre for Pacific Crops & Trees, SPC Land Resources Division	Fiji
Strategy Expert	Medagoda, Indrani	Fruit Division, Horticultural Crop Research & Development Institute	Sri Lanka
Strategy Expert	Montenegro Ilaoa, Emily	American Samoa Community College, Community and Natural Resources	American Samoa
Strategy Expert	Moustache, Mermedah	Crop Development and Promotion Division, Ministry of Environment and Natural Resources	Seychelles
Strategy Expert	Nauluvula, Poasa	Sigatoka Research Station, Ministry of Agriculture, Fisheries & Forests (MAF)	Fiji
Strategy Expert	Navarro, Muriel	Vanuatu Agricultural Research and Technical Centre (VARTC)	Vanuatu
Strategy Expert	Nelson-Quartey, Flora Christine	Crops Research Institute (CSIR)	Ghana
Strategy Expert	Omobuwajo, Taiwo O.	Department of Food Science & Technology, Obafemi Awolowo University	Nigeria
Strategy Expert	Padolina, Cenon	SPC Forests & Trees Programme	Fiji
Strategy Expert	Pillai, Aremogam	Ministry of Agriculture, Fisheries & Forests	Fiji
Strategy Expert	Prasad, Mere Bitu	Koronivia Research Station, MAF	Fiji
Strategy Expert	Quartermain, Alan	University of Vudal	Papua New Guinea
Strategy Expert	Redfern, Takena	Agriculture Division, Ministry of Environment, Lands & Agricultural Development	Republic of Kiribati
Strategy Expert	Roberts-Nkrumah, Laura B.	Department of Food Production, University of the West Indies	Trinidad & Tobago
Strategy Expert	Rouse-Miller, Judy	Department of Life Sciences, University of the West Indies	Trinidad & Tobago
Strategy Expert	Sankat, Clement K.	Faculty of Engineering, University of the West Indies	Trinidad & Tobago
Strategy Expert	Sisifa, Aleki	SPC Land Resources Division	Fiji
Strategy Expert	Tirimaidoka, Luke	Ministry of Agriculture, Fisheries & Forests	Fiji
Strategy Expert	Tuia, Valerie	Centre for Pacific Crops & Trees, SPC Land Resources Division	Fiji

Role	Name	Institution	Country
Strategy Expert	Tuivavalagi, Philip	Crops Development, Commercial & Export, Ministry of Agriculture	Samoa
Strategy Expert	Vave, Uatea	Extension, Ministry of Natural Resources	Tuvalua
Strategy Expert	Wiseman, James	DigitalMedia Hawaii/Pacific	USA
Strategy Expert	Woodend, John	EU-ACP Technical Centre for Agricultural and Rural Cooperation (CTA)	The Netherlands
Regional Workshop	Bule Lehi, Frazer	Department of Agriculture & Rural Development	Vanuatu
Regional Workshop	Francisco, Herman	Bureau of Agriculture Ministry of Resources & Development	Palau
Regional Workshop	Galo, Jean	Ministry of Agriculture & Lands	Solomon Islands
Regional Workshop	Kabu, Roselyn	Planting Materials Network	Solomon Islands
Regional Workshop	Natake, Tearimawa	Ministry of Environmental, Lands and Agricultural Development	Republic of Kiribati
Regional Workshop	Samuelu, Laisene	Ministry of Agriculture, Forestry, Fisheries & Meteorology	Samoa
Regional Workshop	Taufatofua, Pita	Ministry of Agriculture & Forestry	Tonga
Regional Workshop	Thomson, Lex	Secretariat of the Pacific Community	New Caledonia
Regional Workshop	Veseaga, Punapa	Department of Agriculture, Forestry and Fisheries	Niue
Regional Workshop	Wigmore, William	Ministry of Agriculture Department of Resources & Development	Cook Islands
Regional Workshop	Wright, Jacqui	(formerly at ACIAR)	Australia
Expert	Eyog-Matig, Oscar	Bioversity	Benin
Expert	Arze, Jose'	CATIE	Costa Rica
Expert	Lobo Arias, Mario	CORPOICA	Colombia
Expert	Castiñeiras, Leonor	INIFAT	Cuba
Expert	Azurdia, Cesar		Guatemala
Expert	Espitia, Miguel	Universidad de Cordoba	Colombia
Expert	Astorga, Carlos		

Annex II – Respondents to the Survey for the definition of a key set of descriptors for breadfruit sent on 14th October 2008

Name	Organization	Country
Ragone, Diane	National Tropical Botanical Garden	Hawaii, USA
Jackson, Grahame		Australia
Amagloh, Flora	CSIR-Crops Research Institute	Ghana
Baccus-Taylor, Gail	University of the West Indies	Trinidad & Tobago
Englberger, Lois	Island Food Community of Pohnpei	Federated States of Micronesia
Gbehounou, Gualbert	National Agricultural Research Institute (INRAB)	Republic of Benin
Golden, Kerith	Basic Medical Sciences UWI, Mona	Jamaica
Ilaoa, Emily M.	ASCC-CNR (Land Grant Program)	American Samoa
Julie, Lewis	MInistry of Environment, Natural Resources & Transport	Seychelles
Raynor, Bill	The Nature Conservancy	Federated States of Micronesia
Redfern, Takena	Ministry of Environment, Lands & Agricultural Development	Kiribati
Roberts-Nkrumah, Laura B.	The University of the West Indies	Trinidad and Tobago
Saena Tuia, Valerie	Secretariat of the Pacific Community	Fiji
Lebegin, Stéphane	Institut Agronomique néo-Calédonien	New Caledonia
Taufatofua, Pita	Farmer	Tonga
Taylor, Mary	Secretariat of the Pacific Community	Fiji
Zee, Francis	USDA/ARS, PBARC	USA

Annex III – Descriptors proposed in the Survey ranked by rating average and by percentage importance

Descriptor	Rating Average
NUTRITIONAL COMPONENTS	4.86
SALINITY TOLERANCE	4.69
FRUIT YIELD	4.57
FRUIT QUALITY	4.43
FRUIT ROTS *(Phytophtora*, etc.)	4.38
TRUNK ROT DISEASE (*Phellinus noxius*)	3.92
CERCOSPORA LEAF SPOT	3.08
SEED NUMBER	2.83
FRUIT FLESH COLOUR	2.57
DEGREE OF LEAF DISSECTION	2.36
FRUIT SKIN TEXTURE	2.29
LEAF LOBE NUMBER	2.14
FRUIT SHAPE	2.07
LEAF LENGTH	1.92
LEAF WIDTH	1.92
MALE FLOWER LENGTH	1.91
MALE FLOWER WIDTH	1.91
LEAF SURFACE TEXTURE	1.83
PRESENCE/ABSENCE OF LEAF HAIRS	1.69
FRUIT DIAMETER	1.64
SHAPE OF APICAL LEAF LOBE	1.64
SEED WEIGHT	1.55
SEED DIAMETER	1.55
FRUIT WEIGHT	1.50
FRUIT STALK LENGTH	1.46
FRUIT LENGTH	1.43
SEED SHAPE	1.42
FRUIT SKIN COLOUR	1.36
CORE DIAMETER OF FRUIT	1.33
LEAF VEIN COLOUR	1.27
CORE LENGTH OF FRUIT	1.25
LEAF COLOUR	1.25
LEAF MARGIN	1.25
SEED LENGTH	1.25
SHAPE OF LEAF BASE	1.18
FRUIT STALK INSERTION	1.15
FRUIT LATEX AMOUNT	1.14
SEED COAT COLOUR	1.09
FRUIT LATEX COLOUR	1.00
LEAF HAIR LOCATION	1.00
FRUIT PEDUNCLE COLLAR	0.92
LEAF HAIRS COLOUR	0.73
LEAF HAIRS LENGTH	0.64
LEAF HAIRS ORIENTATION	0.45

Descriptor	% Importance (Very important)
NUTRITIONAL COMPONENTS	92.86
SEED NUMBER	91.67
SALINITY TOLERANCE	84.62
FRUIT FLESH COLOUR	78.57
FRUIT YIELD	78.57
DEGREE OF LEAF DISSECTION	72.73
FRUIT QUALITY	71.43
FRUIT ROTS (*Phytophtora*, etc.)	69.23
FRUIT SKIN TEXTURE	64.29
LEAF LOBE NUMBER	64.29
FRUIT SHAPE	57.14
MALE FLOWER LENGTH	54.55
MALE FLOWER WIDTH	54.55
LEAF SURFACE TEXTURE	50.00
LEAF LENGTH	46.15
LEAF WIDTH	46.15
TRUNK ROT DISEASE (Phellinus noxius)	46.15
SHAPE OF APICAL LEAF LOBE	45.45
PRESENCE/ABSENCE OF LEAF HAIRS	38.46
CERCOSPORA LEAF SPOT	38.46
SEED WEIGHT	36.36
SEED DIAMETER	36.36
FRUIT DIAMETER	35.71
FRUIT WEIGHT	35.71
SEED SHAPE	33.33
FRUIT STALK LENGTH	30.77
FRUIT LENGTH	28.57
FRUIT SKIN COLOUR	28.57
LEAF VEIN COLOUR	27.27
CORE DIAMETER OF FRUIT	25.00
CORE LENGTH OF FRUIT	25.00
LEAF COLOUR	25.00
LEAF MARGIN	25.00
SEED LENGTH	25.00
FRUIT LATEX AMOUNT	21.43
SHAPE OF LEAF BASE	18.18
SEED COAT COLOUR	18.18
FRUIT LATEX COLOUR	16.67
FRUIT STALK INSERTION	15.38
LEAF HAIR LOCATION	9.09
LEAF HAIRS COLOUR	9.09
LEAF HAIRS LENGTH	9.09
FRUIT PEDUNCLE COLLAR	8.33
LEAF HAIRS ORIENTATION	0.00

Annex IV – Comparison table revised by Diane Ragone on 20 December 2008. Selected key traits for breadfruit by the NTBG scientist are recorded in the last column

Descriptor	NTGB	Revised by Diane Ragone	Survey response by % importance	ARS USDA	Crop Strategy	Key descriptors by DR 19/12/08
Average core diameter of fruit	*			*		
Average core length of fruit	*			*		
Fruit flesh colour	**	*	**	*		
Male flower length	**	*	*	*		
Male flower width	**	*	*	*		
Male flower length & width						*
Fruit diameter	*	*		*		
Fruit length	*	*		*		
Fruit shape	**	*	**	*		*
Fruit weight	*	*		*		*
Scabbing of fruit sections	*					
Latex amount	*	*		*		
Latex colour	*	*				
Shape of apical leaf lobe	*			*		
Shape of leaf base	*			*		
Leaf colour	*	*		*		
Presence/absence of leaf hair	*	*		*		
Leaf length	*	*		*		
Leaf margin	*	*		*		

Descriptor	NTGB	Revised by Diane Ragone	Survey response by % importance	ARS USDA	Crop Strategy	Key descriptors by DR 19/12/08
Leaf shape	*	*		*		
Leaf surface texture	**	*	**	*		*
Leaf flexibility	*					
Leaf vein colour	*	*		*		
Leaf width	*	*		*		
Degree of leaf dissection	**	*	**	*		*
Leaf lobe number	**	*	**	*		*
Collar neck/shape	*	*				
Fruit peduncle (stalk) diameter	*			*		
Fruit peduncle (stalk) length	*	*		*		
Peduncle (stalk) insertion	*	*		*		
Presence/absence of seeds	*			*		
Seed number	**	*	**			*
Seed coat colour	*	*		*		
Seed diameter	*	*		*		
Seed length	*	*		*		
Seed shape	*	*		*		
Seed weight	*	*		*		
Fruit skin colour	*	*		*		
Fruit skin texture	**	*	**	*		*
Nutritional components	**	*	**		*	*
Salinity tolerance	**	*	**		*	*
Fruit yield	**	*	**		*	*

Descriptor	NTGB	Revised by Diane Ragone	Survey response by % importance	ARS USDA	Crop Strategy	Key descriptors by DR 19/12/08
Susceptibility to Trunk Rot disease (*Phellinus noxius*)	*	*	*		*	*
Susceptibility to Fruit Rots (*Phytophtora, etc.*)	**	*	**			*
Susceptibility to Cercospora leaf spot	*	*	*			
Fruit quality	**	*	**			
Drought tolerance (NEW)			*			*
Size of tree (NEW)			*			
Shape of tree (NEW)			*			
Fruiting time/time of maturity (NEW)			*			*
Susceptibility to mealy bugs						*

Annex V – Key set of priority descriptors for breadfruit as revised by Diane Ragone on 23 December 2008 and sent to CAG for validation

1. Fruit weight
2. Fruit shape
3. Fruit skin texture
4. Leaf lobe number
5. Degree of leaf dissection
6. Leaf surface texture
7. Seed number
8. Male flower length & width
9. Nutritional components (Vitamins, Phosphorous, iron, etc.)
10. Fruit yield
11. Fruit rots *Phytophthora*, *Colletotrichum* (anthracnose); *Rhizopus* (soft rot)
12. Trunk rot disease (*Phellinus noxius*)
13. Susceptibility to mealy bugs
14. Salinity tolerance
15. Drought tolerance
16. Fruiting time/time of maturity

Annex VI – Key access and utilization descriptors for breadfruit genetic resources with descriptor states as defined by Dr Diane Ragone on 24 February 2009

Fruit weight [kg]
Record the average weight of at least three fruits

Fruit shape
Observe three fruits at least, and record which shape best describe them

1 Spherical
2 Broad ovoid
3 Oval
4 Oblong
5 Ellipsoid
6 Heart-shaped
7 Irregular

Fruit skin texture

1 Smooth
2 Irregularly raised, flattened sections
3 Sandpapery
4 Pebbly
5 Spiky with hard raised centre point
6 Spiny with pointed flexible tip

Leaf lobe number
Record the average number of lobes of five leaves

Degree of leaf dissection
Observe five leaves and record the predominant degree of dissection

1 Leaf entire (no dissection)
2 Leaf dissected slightly on upper half
3 Leaf moderately dissected on upper half
4 Entire leaf moderately deeply dissected
5 Leaf deeply dissected
6 Leaf deeply dissected with wide spaces between lobes

Leaf surface texture
Observe five leaves and record the texture that best describes them

1 Glossy
2 Dull

Seed number
Record the average seed number of three fruits

Male flower length [cm]
Record the average of five male inflorescences

Male flower width [cm]
Record the average of five male inflorescences

Fruiting time/time of maturity
Indicate which category listed below best describes the maturity time, and record the actual month when mature fruits are on the tree and harvestable

3 Early
5 Medium
7 Late

Month [MM]

Nutritional components
Indicate the most significant component

1 Vitamin
2 Potassium
3 Iron
4 Carbohydrate
99 Other (specify in the Notes descriptor, 10)

Fruit yield
Record the actual count of fruits on tree and/or harvested. If resources are not available, the following codes could be used

3 Low
5 Medium
7 High

Biotic stress susceptibility

Fruit rot (*Phytophthora* sp.)
Anthracnose (*Colletotrichum* sp.)
Soft rot (*Rhizopus* sp.)
Trunk rot (*Phellinus noxius*)
Mealybug (*Icerya aegyptiaca*)

Abiotic stress susceptibility

Salinity
Drought

Annex VII – Email to breadfruit experts to share final version of the Breadfruit descriptors sent on 5 March 2009

From: Alercia, Adriana (Bioversity)
Sent: Thursday, March 05, 2009 2:20 PM
To: 'ragone@ntbg.org'; 'francis.zee@ars.usda.gov'; 'gjackson@zip.com.au'; 'braynor@tnc.org'; 'maryt@spc.int'; 'recoronel1939@yahoo.com'; gbaccust@eng.uwi.tt; nutrition@mail.fm; ldcstrig@bow.intnet.bj; kerith.golden@uwimona.edu.jm; kerrigold@cwjamaica.com; lebegin@iac.nc; emily_ilaoa@yahoo.com; pgr@seychelles.net; floraamagloh@yahoo.com; macktaken79@yahoo.com; lroberts-nkrumah@fsa.uwi.tt; valeriet@spc.int; pttofua@yahoo.com.au
Cc: Bergamini, Nadia (Bioversity)
Subject: RE: Key access and utilization descriptors for Breadfruit genetic resources - FINAL LIST

Dear Breadfruit experts,

You will be pleased to know that we have reached the final phase and have defined the Key access and utilization descriptors for Breadfruit genetic resources.

I would like to thank you all for contributing to the development of this List, particularly to Dr Diane Ragone, who provided scientific direction and to Grahame Jackson for his substantial contribution. We have implemented and harmonized almost all comments received from you on 'essential' descriptors descriptors, as this is just the first step in an evolving process.

As a brief reminder, the purpose of the exercise was to identify some key descriptors that will assist researchers to more effectively utilize breadfruit germplasm. These key descriptors, along with passport data, will become the foundation information to be made available to researchers in a global accession level information system.

Now, we wish to share this final version with you, please find it herewith attached. This List will go now to editing and layout processes and will be sent to relevant experts for its uploading in GRIN-Global and ALIS (Accession Level Information System).

We hope that this Key strategic set will become an important standard for breadfruit genetic resources documentation, since it is the result of a review of many years of fieldwork by scientists and field practitioners, like you. As you will see from the 'Contributors' section, your valuable contribution, that has certainly been much appreciated, is acknowledged.

Best regards,

Adriana

Annex VIII – Final Key access and utilization descriptors for Breadfruit genetic resources as defined on 16 March 2009

Key access and utilization descriptors for breadfruit genetic resources

This list consists of an initial Global Information on Germplasm Accessions (GIGA) Project set of characterization and evaluation descriptors for breadfruit. It contains those, which, along with passport data, will become the basis of a global information system for this crop, and facilitate access to and utilization of breadfruit held in genebanks. It does not exclude other descriptors at a later date.

The list is based on the publication "*Ragone, Diane. Breadfruit. Artocarpus altilis (Parkinson) Fosberg. Promoting the conservation and use of underutilized and neglected crops. 10*" (IPK and IPGRI, 1997), with additional descriptors drawn from work at the National Tropical Botanical Gardens (NTBG). The list was subsequently integrated with evaluation traits, such as yield, fruit quality and reaction to important pests and diseases, as suggested in the "Breadfruit Conservation Strategy"(the Trust, 2007). The list was harmonized, wherever possible, with descriptors developed by USDA, ARS, National Genetic Resources Program. *Germplasm Resources Information Network - (GRIN)*.

Biotic and abiotic stresses are included in the list. They have been chosen because of their cosmopolitan nature and global impact, since they have wide geographic occurrence and cause economic damage.

The key set of access and utilization descriptors was defined in consultation with a Core Advisory Group (see 'Contributors') led by Dr Diane Ragone from the NTBG, and is listed below with the descriptor states.

Fruit weight [kg]
Record the average weight of at least three fruits

Fruit shape
Observe three fruits at least, and record which shape best describe them

1 Spherical
2 Broad ovoid
3 Oval
4 Oblong
5 Ellipsoid
6 Heart-shaped
7 Irregular

Fruit skin texture

1 Smooth
2 Irregularly raised, flattened sections
3 Sandpapery
4 Pebbly
5 Spiky with hard raised centre point
6 Spiny with pointed flexible tip

Fruit flesh colour
1 White
2 Cream
3 Light yellow
4 Yellow
5 Dark yellow

Leaf lobe number
Record the average number of lobes of five leaves

Degree of leaf dissection
Observe five leaves and record the predominant degree of dissection
1 Leaf entire (no dissection)
2 Leaf dissected slightly on upper half
3 Leaf moderately dissected on upper half
4 Entire leaf moderately deeply dissected
5 Leaf deeply dissected
6 Leaf deeply dissected with wide spaces between lobes

Leaf surface texture
Observe five leaves and record the texture that best describes them
1 Glossy
2 Dull

Seed number
Record the average seed number of three fruits

Male flower length [cm]
Record the average of five male inflorescences

Male flower width [cm]
Record the average of five male inflorescences

Fruiting time/time of maturity
Indicate which category listed below best describes the maturity time, and record the actual month when mature fruits are on the tree and harvestable
3 Early
5 Medium
7 Late

Month [MM]

Nutritional components
Indicate the most significant component
1 Vitamin
2 Potassium
3 Iron
4 Carbohydrate
5 Carotenoid content
99 Other (specify in the Notes descriptor)

Fruit yield

Record the actual count of fruits on tree and/or harvested. If resources are not available, the following codes could be used

3 Low
5 Medium
7 High

Biotic stress susceptibility

Fruit rot (*Phytophthora* sp.)
Anthracnose (*Colletotrichum* sp.)
Soft rot (*Rhizopus* sp.)
Trunk rot (*Phellinus noxius*)
Mealybug (*Icerya aegyptiaca*)

Abiotic stress susceptibility

Salinity
Drought

Notes

Specify here any additional information particularly that referring to the category '99=Other' present in some of the descriptors above.

CONTRIBUTORS

Bioversity is grateful to all the scientists and researchers who contributed to the definition of this strategic set of Descriptors for Breadfruit, particularly to Dr D. Ragone who provided scientific direction. Adriana Alercia provided technical expertise and guided the entire production process.

Core Advisory Group

Diane Ragone, National Tropical Botanical Garden, Hawaii, USA
Grahame Jackson, 24 Alt Street, Queens Park, NSW 2022, Australia
Bill Raynor, The Nature Conservancy (TNC), Federated States of Micronesia
Mary Taylor, Secretariat of the Pacific Community, Fiji
Francis Zee, USDA,ARS, PBARC, USA

Reviewers

American Samoa

Emily M. Ilaoa, American Samoa Community College (ASCC)-Community and Natural Resources (CNR) (Land Grant Program)

Benin

Gualbert Gbèhounou, National Agricultural Research Institute (INRAB)

Federated States of Micronesia

Lois Englberger, Island Food Community of Pohnpei

Fiji

Valerie Saena Tuia, Secretariat of the Pacific Community

Ghana

Flora Amagloh, Crops Research Institute (CSIR)

Jamaica
Kerith Golden, Basic Medical Sciences UWI

New Caledonia
Stéphane Lebegin, Institut Agronomique néo-Calédonien

Republic of Kiribati
Takena Redfern, Ministry of Environment, Lands & Agricultural Development

Seychelles
Julie Lewis, Ministry of Environment and Natural Resources & Transport

Tonga
Pita Taufatofua, Farmer

Trinidad and Tobago
Laura B. Roberts-Nkrumah, University of the West Indies
Gail Baccus-Taylor, University of the West Indies

Methodology for the definition of a key set of characterization and evaluation descriptors for cassava (*Manihot esculenta*)

Information collection and preparation of a Minimum Descriptor List (MDL)

Information for the definition of a MDL for cassava was drawn from *Genetic Resources for cassava and wild relatives* (IBPGR, 1983 - Appendix VII), which was modified following advice from Dr. Daniel Debouck from CIAT, Colombia. The list included in the publication was further compared with the List of cassava descriptors published by EMBRAPA (June, 1998) and integrated and harmonized with descriptors suggested during the *Manihot* Genetic Resources meeting held in Cali, Colombia, from 30 April to 2 May 2008. Important evaluation traits, such as pests and diseases and abiotic stresses, were added to the original descriptors list.

Preparing List of Experts

Since the original draft was too old, the list of experts was drawn from the list of reviewers to the draft version of "*Descriptors for Cassava*". Participants to the *Manihot* Genetic Resources meeting described above were also included as experts in the Survey. Overall, 37 experts were identified, coming from nine countries and 17 different organizations. Out of these, a Group Leader (Daniel Debouck) and a Core Advisory group (CAG) consisting of nine experts (see Annex I) was selected to assist in the definition of a minimum set of descriptors for Cassava. Experts forming the CAG were selected from centres of excellence for cassava research and breeding such as EMBRAPA, IITA, CIAT, Cornell University, INIA, INIVIT, the Khon Kaen Field Crop Research Centre and the National Root Crop Research Institute.

Survey preparation and distribution – 1st phase

A draft survey on cassava was prepared listing the descriptors as approved by consultations with the Crop Leader. Once approved, the final draft of the survey was uploaded into the Survey Monkey application on the internet and an email invitation sent out to the list of identified experts on 10 April 2008. A link to the Survey was provided to experts, who were invited to rate the importance of the proposed characterization and evaluation descriptors (81 descriptors) for this crop. Experts were also encouraged to mention any additional trait that was found to be relevant yet missing from the proposed list of descriptors, along with a substantiated justification for its inclusion. The survey deadline was set at 29th of April 2008. A reminder was sent out on the 22nd of April to ensure that the greatest possible feedback was obtained. (See Annex II).

Survey analysis – 1st phase

Of the 40 experts who were identified and involved in the exercise, 26, coming from seven countries, recorded their comments using the online survey (see Annex III). At the same time the descriptors list was circulated among participants to the "Mini-Workshop on Minimum Cassava Descriptors" held on the 2nd of May 2008 in Cali, Colombia within the above-mentioned *Manihot* Genetic Resources meeting.

Survey 2nd phase

Responses obtained from the survey were harmonized with comments received during the mini-workshop. Results from the Survey were analysed and descriptors ranked by rating average and percentage of importance (see Annex IV). The first 24 descriptors of the ranking exercise were selected as the traits to be included in the final draft of the Minimum descriptor list, which was subsequently circulated by email for comments among the Crop leader (Daniel Debouck) and the nine experts composing the CAG on 23 July 2008. Of these, four replied with comments (see Annex V) that were streamlined and harmonised to create a new Minimum List (see Annex VI). A summary of results and the revised list were then sent to the Crop Leader for final approval on 6 October 2008, who in turn consulted with the CAG again on 10 October for the finalization of the minimum list. A question arose regarding the inclusion of "Resistance to Salinity" in the Minimum List. The CAG was contacted once more on 20 November to confirm the rating of salinity. Five members of the CAG responded, confirming that "salinity" did not meet the criteria for a "very important" descriptor, based on the fact that it is not broadly important across the world. Thus, in consultation with the crop leader, salinity was removed from the Minimum List.

Furthermore, Dr. John Beeching, from the Department of Biology & Biochemistry of the University of Bath, was contacted to ensure that the standard method for determining post-harvest physiological deterioration (PPD) developed by Wheatley and quoted in the final key set of descriptors for Cassava was adequate and up-to-date. Dr. Beeching replied that it was indeed suitable since it is the most versatile, economic and rapid method for assessing PPD to date.

The revised and final Minimum list was approved on 7 November 2008 and is presented in Annex VII. Afterwards a final key set was prepared adding descriptor states and contributors (see Annex VIII).

Once the core subset of characterization and evaluation standards for cassava was finalised, data were transformed into Excel files for uploading into the GRIN-Global genebank data-management system being developed by USDA, and subsequently into GENESYS, linking national, regional and international genebank databases in support of the conservation and use of plant genetic resources for food and agriculture (PGRFA). The Excel files will also be used for the System-wide Information Network for Genetic Resources (SINGER), the germplasm information exchange network of the Consultative Group on International Agricultural Research (CGIAR) and EURISCO. The final publications were also shared with the SGRP Crop Genebank Knowledge Base and the Generation Challenge Programme (CGP) Ontology partners.

Acknowledgement

Bioversity is grateful to all the scientists and researchers who have contributed to the development of the strategic set of 'Key access and utilization descriptors for cassava genetic resources', and to the Global Crop Diversity Trust for their financial support. Special thanks go to Drs. Daniel Debouck and Xavier Scheldeman for providing valuable scientific direction and to Adriana Alercia for guiding the entire production process.

Annex I – List of experts identified for participation to the Survey for the definition of a minimum set of descriptors for cassava

Role	Name	Organization	Country
Crop leader	**Debouck, Daniel**	CIAT	Colombia
Core Group	Cunha Alves, Alfredo Augusto	EMBRAPA/CNPMF	Brazil
Core Group	Dumet, Dominique	IITA	Nigeria
Core Group	Eke-Okoro, O.N.	National Root Crops Research Institute	Nigeria
Core Group	Hershey, Clair	Cornell University	USA
Core Group	Hunter, Danny	Bioversity International	Italy
Core Group	Morante, Nelson	CIAT	Colombia
Core Group	Ríos Lobo, Llermé	INIA	Peru
Core Group	Rodríguez Morales, Sergio J.	INIVIT	Cuba
Core Group	Sarawat, Peaingpen	Khon Kaen Field Crop Research Center	Thailand
Core Group	Scheldeman, Xavier	Bioversity International	Colombia
Manihot Workshop	Carvalho, Luiz	EMBRAPA - Cenargen	Brazil
Manihot Workshop	Ceballos, Hernan	CIAT	Colombia
Manihot Workshop	Cuervo, Maritza	CIAT	Colombia
Manihot Workshop	Fukuda, Wania	EMBRAPA/CNPMF	Brazil
Manihot Workshop	Ilona, Paul	IITA	Nigeria
Manihot Workshop	Mafla, Graciela	CIAT	Colombia
Manihot Workshop	Ocampo Nahar, César Humberto	CIAT	Colombia
New	Aranzales, Ericson	CIAT	Colombia

Role	Name	Organization	Country
New	Beeching, John	University of Bath	UK
New	Boonseng, Opas	Rayong Field Crops Research Center	Thailand
New	Calle Calle, Fernando	CIAT	Colombia
New	Dias, Miguel	EMBRAPA	Brazil
New	Dixon, Alfred	IITA	Nigeria
New	Fregene, Martin	CIAT	Colombia
New	Howeler, Reinhardt	CIAT	Thailand
New	Hurtado, Paula	CIAT	Colombia
New	Iglesias, Carlos	Weaver Popcorn Company	USA
New	Kulayasilapin, Pinit	Prachinburi Field Crop Experiment Station	Thailand
New	Lemos de Carvalho, Paulo Cesar	Universidade Federal do Reconcavo da Bahia	Brazil
New	Limsila, Atchara	Rayong Field Crops Research Center	Thailand
New	Lopez Montes, Antonio	CORPOICA - Corporacion Centro de Investigaciones Agropecuarias	Colombia
New	Malipan, Anon	Lopburi Service Center for Crops and Production	Thailand
New	Mejia, Kember	Instituto de Investigaciones de la Amazonia peruana	Peru
New	Nassar, Nagib	Universidad de Brasilia	Brazil
New	Oyatomi, Olaniyi Ajewole	IITA	Nigeria
New	Pérez, Juan Carlos	CIAT	Colombia
New	Pinedo, Julio	Universidad Nacional de la Amazonía peruana (UNAP)	Peru
New	Sias Costa, Ivo Roberto	EMBRAPA - Cenargen	Brazil
New	Silva Santos, Vanderlei	EMBRAPA/CENARGEN	Brazil
New	Villagomez Castillo, Vidal	Universidad Nacional Agraria La Molina	Peru

Annex II – Minimum set of Descriptors for cassava - Survey to Crop Expert Group

---

WELCOME

Welcome to the survey to participate in the definition of a minimum set of characterization and evaluation descriptors to support the global system of information on germplasm conservation and use.

You have been identified as an expert on Cassava, hence our request to help us in the identification of the Cassava minimum set of descriptors.

The objective of this activity is to identify those descriptors that are essential to be recorded as they represent those traits that the users of germplasm are looking for. They have been taken from a draft revision of Descriptor List for Cassava (Manihot esculenta) [1] produced in 2000, and following scientific advice from Dr Daniel Debouck (CIAT). That is, for characterization, we should be aiming at a minimum set of maximally differentiating traits for the identification of the crop. For evaluation, we aim for a minimum set of characters important for breeders (e.g. yield, protein content, stem chlorophyll content, Fusarium, drought). It is hoped that a minimum set of characterization and evaluation data, available for most ex situ conserved material, will allow a better comparability between genebanks which should facilitate the identification of interesting material and an increased use of conserved material. An enhanced use of the conserved germplasm will allow an easier and better justification of the costs involved in ex situ conservation.

This survey should not take longer than 15 minutes. Your participation in it is highly appreciated.

The Deadline for this survey is June 30.

We thank you in advance for investing your time to provide us your input into the development of this minimum set.

This survey consists of three parts:

- PART I (listed as 2 and 3): Deals with the selection of the most important characterization and evaluation descriptors out of the Draft “Descriptors for Cassava as developed in 2000 and Descriptores de Yuca p157-179.

- PART II (listed as 4): Is an open question which allows you to indicate those standards that are missing in the minimum current list and which measurement/determination would promote the use of the material.

- PART III (listed as 5): We would ask you to provide some additional contacts (emails) of persons which you consider as experts in Cassava and which could help to validate the final list of minimum descriptors.

[1] IBPGR. 1983. Appendix VII of Genetic Resources of Cassava and Wild relatives.

2. PART I: Characterization Descriptors

These enable an easy and quick discrimination between phenotypes. They are generally highly heritable, can be easily seen by the eye and are equally expressed in all environments.

1. Please rate the importance of the following Plant Descriptors related to VEGETATIVE characters for the identification of the crop.

	NOT Important	IMPORTANT	VERY Important
1. Plant height (cm)	NOT Important	IMPORTANT	VERY Important
2. Plant type	NOT Important	IMPORTANT	VERY Important
3. Stem colour	NOT Important	IMPORTANT	VERY Important
4. Growth habit of young stem	NOT Important	IMPORTANT	VERY Important
5. Number of branching levels	NOT Important	IMPORTANT	VERY Important
6. Branching angle	NOT Important	IMPORTANT	VERY Important
7. Height of the first apical branch (cm)	NOT Important	IMPORTANT	VERY Important
8. Number of weeks from planting to first apical branching	NOT Important	IMPORTANT	VERY Important
9. Colour of unexpanded apical leaves	NOT Important	IMPORTANT	VERY Important
10. Colour of first fully expanded leaf	NOT Important	IMPORTANT	VERY Important
11. Number of leaf lobes	NOT Important	IMPORTANT	VERY Important
12. Shape of central lobe	NOT Important	IMPORTANT	VERY Important

	NOT Important	IMPORTANT	VERY Important
13. Length of central lobe (cm)	NOT Important	IMPORTANT	VERY Important
14. Width of central lobe (cm)	NOT Important	IMPORTANT	VERY Important
15. Leaf vein colour	NOT Important	IMPORTANT	VERY Important
16. Petiole length	NOT Important	IMPORTANT	VERY Important
17. Petiole colour	NOT Important	IMPORTANT	VERY Important
18. Distribution of anthocyanin pigmentation in petiole	NOT Important	IMPORTANT	VERY Important
19. Angle of petiole insertion	NOT Important	IMPORTANT	VERY Important
20. Prominence of leaf scars	NOT Important	IMPORTANT	VERY Important
21. Pubescence of young leaves	NOT Important	IMPORTANT	VERY Important
22. Length of stipules	NOT Important	IMPORTANT	VERY Important
23. Margin of stipules	NOT Important	IMPORTANT	VERY Important
24. Storage root surface colour	NOT Important	IMPORTANT	VERY Important
25. Storage root pulp colour	NOT Important	IMPORTANT	VERY Important
26. Hydrocyanic acid content (HCN)(mg/kg)	NOT Important	IMPORTANT	VERY Important
27. Storage root peduncle	NOT Important	IMPORTANT	VERY Important
28. Storage root shape	NOT Important	IMPORTANT	VERY Important

	NOT Important	IMPORTANT	VERY Important
29. Storage root constrictions	NOT Important	IMPORTANT	VERY Important
30. Roots growth attitude	NOT Important	IMPORTANT	VERY Important
31. Storage root surface texture	NOT Important	IMPORTANT	VERY Important
32. Storage root length	NOT Important	IMPORTANT	VERY Important
33. Storage root diameter	NOT Important	IMPORTANT	VERY Important
34. Colour of outer surface of storage root cortex	NOT Important	IMPORTANT	VERY Important

2. Please rate the importance of the following Plant Descriptors related to INFLORESCENCE and FRUIT characters for the identification of the crop.

	NOT Important	IMPORTANT	VERY Important
1. Absence/presence of flowers	NOT Important	IMPORTANT	VERY Important
2. Colour of sepals	NOT Important	IMPORTANT	VERY Important
3. Colour of disc	NOT Important	IMPORTANT	VERY Important
4. Colour of stigma	NOT Important	IMPORTANT	VERY Important
5. Colour of ovary	NOT Important	IMPORTANT	VERY Important
6. Colour of anthers	NOT Important	IMPORTANT	VERY Important
7. Length of sepal (mm)	NOT Important	IMPORTANT	VERY Important
8. Width of sepal (mm)	NOT Important	IMPORTANT	VERY Important

	NOT Important	IMPORTANT	VERY Important
9. Absence/presence of female flowers without staminoids	NOT Important	IMPORTANT	VERY Important
10. Absence/presence of pollen	NOT Important	IMPORTANT	VERY Important
11. Absence/presence of fruit set	NOT Important	IMPORTANT	VERY Important
12. Length of fruit capsule (mm)	NOT Important	IMPORTANT	VERY Important
13. Diameter of fruit capsule (mm)	NOT Important	IMPORTANT	VERY Important
14. Texture of fruit exocarp	NOT Important	IMPORTANT	VERY Important

3. Please rate the importance of the following Plant Descriptors related to SEED characters for the identification of the crop.

	NOT Important	IMPORTANT	VERY Important
1. 100-Seed weight	NOT Important	IMPORTANT	VERY Important
2. Main colour of seed	NOT Important	IMPORTANT	VERY Important
3. Secondary colour of seed	NOT Important	IMPORTANT	VERY Important
4. Colour of seed caruncle	NOT Important	IMPORTANT	VERY Important

Minimum set of Descriptors for cassava - Survey to Crop Expert Group

3. PART I: Evaluation Descriptors

This type of descriptors includes characters such as yield, agronomic performance, stress susceptibilities and biochemical and cytological traits. They are the most interesting traits in crop improvement.

1. Please rate the importance of the following plant descriptors related to vegetative characters for the current breeding programmes and for the foreseeable future.

	NOT Important	IMPORTANT	VERY Important
1. Germination of stakes (%)	NOT Important	IMPORTANT	VERY Important
2. Initial vigour	NOT Important	IMPORTANT	VERY Important
3. Number of weeks from planting to second apical branching	NOT Important	IMPORTANT	VERY Important
4. Total fresh weight of foliage and stems per plant (FW kg)	NOT Important	IMPORTANT	VERY Important
5. Total fresh weight of storage roots per plant (FW kg)	NOT Important	IMPORTANT	VERY Important
6. Storage root dry matter percentage (DM, %)	NOT Important	IMPORTANT	VERY Important
7. Fibre content (%)	NOT Important	IMPORTANT	VERY Important
8. Number of storage roots per plant	NOT Important	IMPORTANT	VERY Important
9. Ease of root periderm (outer skin) removal	NOT Important	IMPORTANT	VERY Important

	NOT Important	IMPORTANT	VERY Important
10.Ease of root cortex (inner skin) removal	NOT Important	IMPORTANT	VERY Important
11.Amount of rotted storage roots per plant	NOT Important	IMPORTANT	VERY Important
12.Commercial roots (%)	NOT Important	IMPORTANT	VERY Important
13.Post-harvest deterioration	NOT Important	IMPORTANT	VERY Important
14.Harvest index	NOT Important	IMPORTANT	VERY Important
15.Earliness proportion	NOT Important	IMPORTANT	VERY Important

2. Please rate the importance of the following Abiotic Stress Susceptibility Descriptors FOR THE CURRENT BREEDING PROGRAMME AND FOR THE FORESSEABLE FUTURE.

	NOT Important	IMPORTANT	VERY Important
1. Reaction to low temperature	NOT Important	IMPORTANT	VERY Important
2. Reaction to high temperature	NOT Important	IMPORTANT	VERY Important
3. Reaction to drought	NOT Important	IMPORTANT	VERY Important
4. Reaction to high soil moisture	NOT Important	IMPORTANT	VERY Important
5. Reaction to low ambient relative humidity	NOT Important	IMPORTANT	VERY Important
6. Reaction to soil salinity	NOT Important	IMPORTANT	VERY Important

	NOT Important	IMPORTANT	VERY Important
7. Reaction to low pH	NOT Important	IMPORTANT	VERY Important
8. Reaction to low phosphorous	NOT Important	IMPORTANT	VERY Important

3. Please rate the importance of the following Biotic Stress Susceptibilities FOR THE CURRENT BREEDING PROGRAMME AND FOR THE FORESSEABLE FUTURE.

	NOT Important	IMPORTANT	VERY Important
1. Cassava bacterial blight	NOT Important	IMPORTANT	VERY Important
2. Cassava common mosaic virus disease (CMVD)	NOT Important	IMPORTANT	VERY Important
3. African cassava mosaic virus	NOT Important	IMPORTANT	VERY Important
4. Cassava frog skin disease	NOT Important	IMPORTANT	VERY Important
5. Cassava mites	NOT Important	IMPORTANT	VERY Important
6. Whiteflies	NOT Important	IMPORTANT	VERY Important

4. PART II: Additional Characterization and Evaluation Descriptors

Which additional characterization and evaluation standards do you consider essential to be included in the list of minimum standards above to promote the use of ex situ conserved material.

1. Please add any CHARACTERIZATION DESCRIPTOR you consider essential for the identification of the crop that is missing and indicate how the descriptor should be recorded, the conditions under which the observation is made (i.e. growth stage, sample selection, specific parts to be measured, etc.) and provide the unit of measurement/scales of values, when relevant.

2. Please add any EVALUATION DESCRIPTOR you consider essential for crop improvement that is missing and indicate how the descriptor should be recorded, the conditions under which the observation is made (i.e. growth stage, sample selection, specific parts to be measured, etc.) and provide the unit of measurement/scales of values, when relevant.

Annex III – Respondents to the survey for the selection of a Minimum Set of Descriptors for Cassava

Name	Organization	Country
Boonseng, Opas	Rayong Field Crops Research Center	Thailand
Calle Calle, Fernando	CIAT	Colombia
Carvalho, Luiz	EMBRAPA - Cenargen	Brazil
Ceballos, Hernan	CIAT	Colombia
Cuervo, Maritza	CIAT	Colombia
Cunha Alves, Alfredo Augusto	EMBRAPA/CNPMF	Brazil
Debouck, Daniel	CIAT	Colombia
Dumet, Dominique	IITA	Nigeria
Eke-Okoro, O.N.	National Root Crops Research Institute	Nigeria
Fukuda, Wania	EMBRAPA/CNPMF	Brazil
Hershey, Clair	Cornell University	USA
Howeler, Reinhardt	CIAT	Thailand
Hurtado, Paula	CIAT	Colombia
Iglesias, Carlos	Weaver Popcorn Company	USA
Ilona, Paul	IITA	Nigeria
Kulayasilapin, Pinit	Prachinburi Field Crop Experiment Station	Thailand
Mafla, Graciela	CIAT	Colombia

Name	Organization	Country
Malipan, Anon	Lopburi Service Center for Crops and Production	Thailand
Mejia, Kember	Instituto de Investigaciones de la Amazonia peruana	Peru
Morante, Nelson	CIAT	Colombia
Ocampo Nahar, César Humberto	CIAT	Colombia
Oyatomi, Olaniyi Ajewole	IITA	Nigeria
Ríos Lobos, Llermé	INIA	Peru
Rodríguez Morales, Sergio J.	INIVIT	Cuba
Sarawat, Peaingpen	Khon Kaen Field Crop Research Center	Thailand
Sias Costa, Ivo Roberto	EMBRAPA - Cenargen	Brazil

Annex IV – Descriptors ranked by rating average and by percentage importance

Ranked by rating average			Ranked by % importance	
No	Descriptor name	Rating average	Descriptor name	% Importance
1	Storage root pulp colour	2,9	Storage root pulp colour	95,2
2	African cassava mosaic virus	2,7	African cassava mosaic virus	81,0
3	Storage root dry matter percentage (DM, %)	2,7	Storage root dry matter percentage (DM, %)	81,0
4	Storage root surface colour	2,6	Storage root surface colour	76,2
5	Reaction to drought	2,4	Reaction to drought	71,4
6	Cassava bacterial blight	2,4	Cassava bacterial blight	66,7
7	Germination of stakes (%)	2,4	Germination of stakes (%)	66,7
8	Total fresh weight of storage roots per plant (FW kg)	2,4	Total fresh weight of storage roots per plant (FW kg)	66,7
9	Whiteflies	2,2	Whiteflies	57,1
10	Absence/presence of flowers	2,1	Absence/presence of flowers	57,1
11	Cassava common mosaic virus disease (CMVD)	2,1	Cassava common mosaic virus disease (CMVD)	57,1
12	Harvest index	2,1	Harvest index	57,1
13	Initial vigour	2,1	Initial vigour*	52,4
14	Stem colour	2,0	Stem colour	57,1
15	Colour of first fully expanded leaf	2,0	Colour of first fully expanded leaf*	52,4
16	Hydrocyanic acid content (HCN)(mg/kg)	2,0	Hydrocyanic acid content (HCN)(mg/kg)*	52,4
17	Colour of unexpanded apical leaves*	2,0	Colour of unexpanded apical leaves*	57,1
18	Pubescence of young leaves	2,0	Pubescence of young leaves	52,4
19	Petiole colour	1,9	Petiole colour	52,4
20	Reaction to high soil moisture	1,9	Reaction to high soil moisture	47,6
21	Cassava mites	1,9	Cassava mites	42,9
22	Post-harvest deterioration	1,9	Post-harvest deterioration	42,9
23	Reaction to soil salinity	1,8	Reaction to soil salinity*	38,1
24	Number of storage roots per plant	1,8	Number of storage roots per plant*	38,1
25	Reaction to low pH	1,8	Reaction to low pH*	38,1
26	Earliness proportion	1,8	Earliness proportion*	42,9
27	Cassava frog skin disease	1,8	Cassava frog skin disease*	42,9
28	Absence/presence of pollen	1,7	Absence/presence of pollen*	47,6
29	Colour of outer surface of storage root cortex	1,7	Colour of outer surface of storage root cortex*	42,9
30	Shape of central lobe	1,7	Shape of central lobe	42,9
32	Growth habit of young stem	1,7	Growth habit of young stem	42,9
33	Total fresh weight of foliage and stems per plant (FW kg)	1,7	Total fresh weight of foliage and stems per plant (FW kg)	38,1
34	Absence/presence of fruit set	1,6	Absence/presence of fruit set	38,1
35	100-Seed weight	1,6	100-Seed weight	38,1

Ranked by rating average = The Rating Average is a weighted average per column. Each rating scale choice (column header) is assigned a value from left to right starting at "1". A sum is made of the weighted values of the no. of respondents who picked the rating Very Important. Then the Weighted Value Calculation is divided by the Sum of Respondents. For more info http://www.surveymonkey.com/HelpCenter/Answer.aspx?HelpID=89

Ranked by % importance = Percentage importance was calculated by multiplying the no. of people that considered the descriptor very important by 100, and dividing the result by the no. of experts that took part in the survey (i.e.21)

N.B. Descriptors followed by an asterisk (*) in the second table show that they have either decreased or increased in importance when rating average is used as reference.

Annex V – CAG responses to the identified set of Minimum descriptors for cassava, following the ranking exercise

Name	Organization	Country	Characterization descriptors to be added	Characterization descriptors to be deleted	Evaluation descriptors to be added	Evaluation descriptors to be deleted
Debouck, Daniel	CIAT	Colombia		-Germination of stakes -Initial Vigour		
Eke-Okoro, O.N.	National Root Crops Research Institute	Nigeria	• Distribution of Anthocyanin Pigmentation • Angle of branching • Total fresh weight of storage roots per plant (FW kg) – Marketable and Unmarketable		• Storage root size • Reaction to salinity • Reaction to low temperatures • Reaction to low soil moisture	
Hershey, Claire	Cornell University	USA	• Color of internal surface of stem epidermis • Color of stem sub-epidermis • Shape of central lobe	-Germination of stakes - Weight of roots - Absence/presence of flowers - HCN	• Reaction to local soil constraints (specify) • Reaction to locally important pests and diseases (specify)," • Locally important quality traits (eg. poundability, farinha trait) **Move Total fresh wt of storage roots: Germination of stakes; HCN content to Evaluation Traits**	
Ríos Lobos, Llermé	INIA	Peru	• Colour of inner surface of storage root cortex • Colour of flower disc • Shape of central leaf lobe • Storage root peduncle • Storage root shape • Texture of storage root surface * Suggests listing descriptors from 22 to 26 under a single descriptor (Susceptibility to diseases)	• Colour of first fully expanded apical leaf • Pubescence of young leaves	List under a single descriptor "Susceptibility to diseases (specify)"• African cassava mosaic virus (ACMV) • Cassava bacterial blight • Cassava common mosaic virus (CsCMV) • Cassava mites • Cassava frog skin disease (FSD) • Whiteflies	• Post-harvest deterioration

Annex VI – Identified key set of descriptors from the Survey

Characterization descriptors

1. Storage root pulp colour
2. Storage root surface colour
3. Germination of stakes (%)
4. Total fresh weight of storage roots per plant (FW kg)
5. Absence/presence of flowers
6. Stem colour
7. Colour of first fully expanded leaf
8. Hydrocyanic acid content (HCN)(mg/kg)
9. Colour of unexpanded apical leaves
10. Pubescence of young leaves
11. Petiole colour
12. Colour of outer surface of storage root cortex

Evaluation descriptors

13. Storage root dry matter percentage (DM, %)
14. Harvest index
15. Initial vigour
16. Post-harvest deterioration
17. Reaction to drought
18. Reaction to high soil moisture
19. African cassava mosaic virus (ACMV)
20. Cassava bacterial blight
21. Cassava common mosaic virus (CsCMV)
22. Cassava mites
23. Cassava frog skin disease (FSD)
24. Whiteflies

Annex VII – Final validated key set of descriptors for access and utilization of cassava genetic resources

Characterization descriptors

1. Storage root pulp colour
2. Storage root surface colour
3. Stem colour
4. Colour of first fully expanded leaf
5. Shape of central lobe
6. Colour of unexpanded apical leaves
7. Pubescence of young leaves
8. Petiole colour
9. Colour of outer surface of storage root cortex

Evaluation descriptors

10. Storage root dry matter percentage (DM %)
11. Total fresh weight of storage roots per plant (FW kg)
12. Hydrocyanic acid content (HCN)(mg/kg)
13. Harvest index
14. Post-harvest deterioration
15. Reaction to drought
16. Reaction to high soil moisture
17. African cassava mosaic virus (ACMV)
18. Cassava bacterial blight
19. Cassava common mosaic virus (CsCMV)
20. Cassava mites
21. Cassava frog skin disease (FSD)
22. Whiteflies
23. Cassava Brown Streak Virus (CBSD)

Annex VIII – Final key set of descriptors for cassava genetic resources obtained after validation

Key access and utilization descriptors for cassava genetic resources

This list consists of an initial set of characterization and evaluation descriptors for cassava utilization. This key set of strategic descriptors, together with passport data, will become the basis for the global accession level information portal (GENESYS) being developed by the Bioversity-led project, Global Information on Germplasm Accessions (GIGA). It will facilitate access to and utilization of cassava accessions held in genebanks and does not preclude the addition of further descriptors, should data subsequently become available.

Based on the comprehensive list of descriptors contained in 'Genetic Resources for cassava and wild relatives' (IBPGR, 1983, Appendix VII), this strategic set, listed below with the original descriptor states, was developed in consultation with cassava experts worldwide, and further refined by a Core Advisory Group (see 'Contributors') led by Dr Daniel Debouck of CIAT.

Biotic and abiotic stresses included in the list were chosen because of their wide geographic occurrence and significant economic impact.

Storage root pulp colour

Observed immediately after being cut open

1 White or cream
2 Yellow
3 Pink
99 Other (specify in the **Notes** descriptor)

Storage root surface colour

1 White
2 Cream
3 Light brown
4 Dark brown
99 Other (specify in the **Notes** descriptor)

Stem colour

Observed between 50–100 cm from ground level

1 Silver green
2 Light brown or orange
3 Dark brown
99 Other (specify in the **Notes** descriptor)

Colour of first fully expanded leaf

3 Light green
5 Dark green
7 Green–purple
9 Purple

Shape of central lobe

1 Oblanceolate
2 Linear
3 Elliptic
4 Pandurate (obovate with pair of basal lobes)
5 Lanceolate
99 Other (specify in the **Notes** descriptor)

Colour of unexpanded apical leaves

3 Light green
5 Dark green
7 Green–purple
9 Purple
99 Other (specify in the **Notes** descriptor)

Pubescence of young leaves

Newly formed leaves in the transitional stage

3 Sparse
5 Intermediate
7 Dense

Petiole colour

1 Light green
2 Dark green
3 Green–purple
4 Purple
99 Other (specify in the **Notes** descriptor)

Colour of outer surface of storage root cortex

1 White or cream
2 Yellow
3 Pink
4 Purple
99 Other (specify in the **Notes** descriptor)

Storage root dry matter percentage (DM %)

Total fresh weight of storage roots per plant (FW kg)

Recorded on 10 plants

Hydrocyanic acid content (HCN) [mg/kg]

3 Low (sweet)
7 High (bitter)

Harvest index

Fresh storage root weight (5)/total plant weight (4 + 5)

Post-harvest deterioration
Qualitative evaluation of physiological deterioration[1]

3 Low
5 Medium
7 High

Reaction to drought (7.3)

Reaction to high soil moisture (7.4)

African Cassava Mosaic Virus (ACMV)

Cassava Bacterial Blight (CBB)

Cassava Common Mosaic Virus (CsCMV)

Cassava mites

Cassava Frogskin Disease (CFSD)

Whiteflies

Cassava Brown Streak Virus Disease (CBSD)

Notes
Any additional information may be specified here, particularly that referring to the category 'Other' present in some of the descriptors above.

[1] Use quantitative method described by Wheatley C. et al. (1985), Post-harvest deterioration of cassava roots, in Cock JH and Reyes JA, editors, Cassava: Research, Production and Utilization. UNDP-CIAT, Cali, Colombia, pp 655–671. Or specify method used in the NOTES descriptor.

CONTRIBUTORS

Bioversity is grateful to all the scientists and researchers who contributed to the development of this strategic set of key access and utilization descriptors for cassava, and in particular to the participants in the 'Mini-Workshop on Minimum Cassava Descriptors' held on 2 May 2008 in Cali, Colombia. Special thanks go to Drs. Daniel Debouck and Xavier Sheldeman for providing scientific direction, and to Adriana Alercia for providing technical expertise and guiding the entire production process.

Core Advisory Group

Daniel Debouck, CIAT, Colombia
Alfredo Augusto Cunha Alves, EMBRAPA, Brazil
Dominique Dumet, IITA, Nigeria
O.N. Eke-Okoro, National Root Crops Research Institute, Nigeria
Clair Hershey, Cornell University, USA
Danny Hunter, Bioversity International, Italy
Nelson Morante, CIAT, Colombia
Llermé Ríos Lobo, INIA, Peru
Sergio J. Rodríguez Morales, INIVIT, Cuba
Peaingpen Sarawat, Khon Kaen Field Crop Research Centre, Thailand
Xavier Scheldeman, Bioversity, Colombia

Reviewers

Brazil

Luiz Carvalho, EMBRAPA
Miguel Dias, EMBRAPA/CPAA
Wania Fukuda, EMBRAPA
Paulo Cesar Lemos de Carvalho, Universidade Federal do Reconcavo da Bahia
Nagib Nassar, Universidad de Brasilia
Ivo Roberto Sias Costa, EMBRAPA/CENARGEN
Vanderlei Silva Santos, EMBRAPA/CNPMF

Colombia

Fernando Calle Calle, CIAT
Hernan Ceballos, CIAT
Maritza Cuervo, CIAT
Paula Hurtado, CIAT
Graciela Mafla, CIAT
César Humberto Ocampo Nahar, CIAT

Nigeria

Alfred Dixon, IITA
Paul Ilona, IITA
Olaniyi Ajewole Oyatomi, IITA

Peru

Kember Mejia, Instituto de Investigaciones de la Amazonía peruana
Julio Pinedo, Universidad Nacional de la Amazonía peruana (UNAP)
Vidal Villagomez Castillo, Universidad Nacional Agraria La Molina

Thailand
Opas Boonseng, Rayong Field Crops Research Centre
Reinhardt Howeler, CIAT
Pinit Kulayasilapin, Prachinburi Field Crop Experiment Station
Atchara Limsila, Rayong Field Crops Research Centre
Anon Malipan, Lopburi Service Centre for Crops and Production

United Kingdom
John Beeching, Department of Biology & Biochemistry, University of Bath

USA
Carlos Iglesias, Weaver Popcorn Company

Methodology for the definition of a key set of characterization and evaluation descriptors for chickpea (*Cicer arietinum* L.)

Information collection and preparation of the Minimum Descriptor List (MDL)

Information for the definition of a MDL for chickpea (*Cicer arietinum* L.) was drawn from the publication 'Descriptors for Chickpea (*Cicer arietinum* L.)' (IBPGR/ICRISAT/ICARDA, 1993). A comparison table was prepared comparing these descriptors to important descriptors mentioned in the draft document 'Global Strategy for the Ex Situ Conservation of Chickpea (Cicer L.)' (the Trust, December 2008); and to descriptors that were awarded funds for further research by the Global Crop Diversity Trust 2008 Award Scheme 'Enhancing the Value of Crop Diversity in a World of Climate Change' (EAS). These were further weighed against Descriptors for CHICKPEA (USDA, ARS, GRIN); 'Guidelines for the conduct of tests for Distinctness, Uniformity and Stability' (UPOV, 2005) and important descriptors resulting from the SGRP Global Public Goods, Phase 2 (GPG2), Activity 4.2.1.1. Particular attention was given to those descriptors for which data were available.

Descriptors were integrated and harmonized to produce an initial minimum set to be submitted to the Crop Leader for approval. During a crop-specific consultation held at the National Bureau of Plant Genetic Resources (NBPGR), India in June 2009, a minimum and a long list covering diagnosis and breeding traits were discussed (see Annex I). From the comparison table discussed during the meeting, a list of descriptors which were considered important for utilization were included in the key set of descriptors, that would be proposed through the survey.

Preparation of the List of Experts

The list of experts was prepared using various sources. It includes experts drawn from the original descriptor list and participants in crop-specific consultations for the definition of the 'Global Strategy for the *Ex Situ* Conservation of Chickpea (*Cicer* L.)' (the Trust, December 2008). The list was further integrated with experts from the ECPGR Network, from the Trust Evaluation Awards Scheme (EAS) and the Status Regeneration Guidelines, as well as experts drawn from FAO WIEWS, Directory of Germplasm collections, and those identified during the crop-specific meeting held at NBPGR. An internet search was also performed to integrate this list and obtain the greatest number of comments. Jan Konopka, from the International Center for Agricultural Research in the Dry Areas (ICARDA), was first contacted to supply names of experts who could be involved in this exercise and review the comparison table. ICARDA experts proposed were Ken Street, Amri Ahmed, Malhotra Rajendra and Mohammed Imtiaz and were invited to act as the Crop Advisory Group (CAG). During her visit to India, the coordinator of the exercise, Ms Adriana Alercia collaborated with renown expert, M.C. Kharkwal of IARI Genetics (India) and in consultation with Prem N. Mathur, it was agreed that he would act as Crop Leader together with M. Imtiaz (ICARDA, Syria).

Overall, 54 experts were identified, coming from 22 countries and 38 different organizations (see Annex II). Out of these, Mohammed Imtiaz (ICARDA) and M.C. Kharkwal (IARI) were selected as Crop Leaders and a Core Advisory Group consisting of 10 experts was identified to assist in the definition of a minimum set of descriptors, which was subsequently circulated for validation among the wider group of experts.

Survey preparation and distribution

A draft survey on chickpea was prepared listing the descriptors as approved by consultations with the Crop Leaders and the CAG (see Annex III). Once approved, the final draft of the survey was uploaded into the SurveyMonkey application on the internet (see Annex IV) and sent out to the list of identified experts in July 2009. Experts were invited to validate the initial 'Minimum set of descriptors' of chickpea accessions to facilitate their use by researchers and asked to make any suggestions regarding any characterization and/or evaluation descriptors that were found to be relevant yet missing from the proposed Minimum List. The survey deadline was set at 20 August 2009. A reminder was sent out before the deadline to ensure that the greatest possible feedback was obtained.

Survey analysis and refinement of the Minimum List

Of the 54 experts who were identified and involved in the exercise, 32 from 16 countries and 21 organizations recorded their comments using the online survey (see Annex V). Results from the consultation were analyzed and descriptors were ranked by rating average and percentage of importance (see Annex VI). Descriptors having a wide consensus amongst experts were highlighted in bold typeface. These summary results listed by ranking and percentage of responses of the survey, together with a report containing comments as open-ended questions received from the participants (see Annex VII) were sent to the Core Advisory Group inviting experts to select descriptors that should be included in the Minimum List by indicating them with an 'X' in the relevant column. Advice provided by Dr Imtiaz was followed along with the CAG survey responses and survey percentage results, because other Core Advisory members, although participating to the survey, did not answer in spite of the reminders. As a result, a first final list was defined and subsequently proposed to members of the CAG for their validation and comments (see Annex VIII). Many replies were received and sparked off an interesting debate, which was summarized listing the discussed descriptors, along with relevant comments (see Annex IX), and sent again to the Core Advisory Group.

In early April 2009, the first priority set for utilization, with the addition of a few more descriptors and one descriptor for deletion, as suggested by the CAG and approved by the Crop Leaders, was again shared with the CAG for further refinement and their final approval (see Annex X). Dr Hari D. Upahdyaya of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT, India) was added as Crop Leader due to the substantial scientific advice provided during the last phase.

Definition of a final key set of descriptors for chickpea

The final key set approved by the Crop Leaders and the CAG, including all the contributors (see Annex XI), was proofread by an external editor and sent to the Bioversity Publications Unit for layout and on-line publication processes. Furthermore, the publication was shared with the ECPGR Secretariat; the Generation Challenge Programme (GCP) Ontology and the SGRP Crop Genebank Knowledge Base partners. Additionally, data were converted into Excel files for uploading into the GRIN-Global genebank data-management system being developed by USDA, and into the global accession level information portal (GENESYS). The Excel files were also disseminated to the System-wide Information Network for Genetic Resources (SINGER) and to EURISCO.

Acknowledgement

Bioversity is grateful to all the scientists and researchers who contributed to the development of the strategic set of key access and utilization descriptors for chickpea genetic resources, and to the Global Crop Diversity Trust for their financial support. Particular recognition goes to the Crop Leaders, Mohammed Imtiaz, M.C. Kharkwal and Dr H. Updadhyaya for providing valuable scientific direction. Ms Adriana Alercia provided technical expertise and guided the entire production process.

Annex I – Comparison table weighing up important descriptors for chickpea drawn from different sources[1]

Desc. no.	Descriptor name	IBPGR/ ICRISAT/ ICARDA 1993 (1)	Evaluation Awards (2)	Strategy (3)	UPOV (4)	USDA (5)	GPG2 Imp traits (6)	GPG2 Top 10 (7)	Data avail. ICRISAT (8)	Long List (9)	NBPGR 09 MIN (GR utilization) (10)	ICARDA (Imtiaz) MIN x use (11)
4.1.1	Plant pigmentation	*				*	*			*	*	*
4.1.2	Plant hairiness	*								*		
4.1.3	Leaf type	*				*	*			*	*	*
4.1.4	Number of leaflets per leaf	*				*	*			*		
4.2.1	Days to 50% flowering	*			* (80%)	*	*	*	*	*	*	*
4.2.2	Days to maturity	*			*		*	*	*	*	*	*
4.2.3	Number of seeds per pod	*			*	*	*	*	*	*	*	*
4.2.4	Flower colour	*			*	*				*	*	*
4.2.5	Number of flowers and pods per peduncle	*				*	*			*	*	*
4.2.6	Pod length [mm]	*			*	*				*		
4.2.7	Pod dehiscence	*				*				To be deleted. Not important and difficult		
4.2.8	Number of pods per plant	*				*	*	*	*	*	*	*
4.3.1	Seed shape	*			*	*	*			*		*
4.3.2	Seed testa texture	*				*	*			*		
4.3.3	Seed colour	*			*	*	*			*	*	*
4.3.4	Absence/presence of minute black dots	*				*				*		
4.3.5	100-Seed weight [g]	*			* (not 100)	*	*	*	*	*	*	*
6.1.1	Growth habit	*			*	*	*			*	*	*
6.1.2	Leaflet length [mm]	*			*					*		
6.1.3	Leaf area [cm^2]	*								Redundant, to be deleted since there is leaf length		
6.1.4	Number of branches	*					*			To be deleted		
6.1.4.1	Number of primary branches	*				*			*	*	*	*
6.1.4.2	Number of secondary branches	*							*	*	*	
6.1.4.3	Apical primary	*				*			*	To be deleted		
6.1.4.4	Apical secondary	*								To be deleted		
6.1.4.5	Tertiary	*							*	To be deleted		
6.1.5	Plant canopy height (at maturity)	*			*	*	*	*	*	*	*	*
6.1.6	Plant canopy width [cm]	*				*	*		*	To be deleted		
6.2.1	Flower duration	*							*	To be deleted and difficult to record		
6.2.2	Yield	*										

6.2.2.1	Biological yield per plant [g]	*						*		*		*
6.2.2.2	Grain yield per plant [g]	*				*		*	*	*	*	*
6.3.1.1	Protein content [% DW]	*	*			*			*	*		*
6.3.1.2	Dhal milling [%]	*								*		
6.3.1.3	Cooking time	*								*		
6.3.1.4	Cookability of dry seeds	*							*	Delete		
7.1	Reactions to low Temperature	*								*		
7.1.1	Seedling emergence	*								*		
7.1.2	Susceptibility to cold (whole plant)	*				*			*	Delete		*
7.1.3	Frost damage	*				*	*			*		*
7.2	Reactions to high temperature (Heat)	*				*			*	*	*	*
7.3	Reactions to Aluminium toxicity	*								*		
7.4	Reaction to low Iron	*					*			*		
7.5	Reaction to drought	*		*		*	*	*	*	*	*	*
7.6	Reaction to low seedbed moisture conditions	*								Delete		
New	Reaction to salt stress									*		*
7.7	Reaction to Alkaline soils	*								Delete		
8.1.1	*Alternaria alternata* (Fr.) Kiessler (Alternaria blight)	*					*			*		
8.1.2	*Ascochyta rabiei* (Pass.) Labr. (Ascochyta blight)	*	*	*		*	*		*	*	*	*
8.1.3	*Botrytis cinerea* Pers. ex Fr. (Grey mould)	*					*		*	*	*	*
8.1.4	*Fusarium oxysporum* Schlecht. (Fusarium wilt)	*		*		*	*	*	*	*	*	*
8.1.5	*Phytophthora megasperma* Drechs. (Phytophthora blight)	*							*	*		*
8.1.6	*Uromyces ciceris-arietini* (Grogn.) Jacz & Beyer (Rust)	*								*		
8.2.1	*Pythium ultimum* Trow. (Damping off)	*				*				*		
8.2.2	*Stemphylium sarciniforme* (Cav.) Wilts. (Stemphylium blight)	*								*		
8.2.3	*Xanthomonas cassiae* Kulkarni *et al.* (Seedling rot)	*								*		*
8.3.1	*Fusarium solani* (Mart.) Sacc. (Root rot)	*				*	*			*	*	*
8.3.2	*Operculella padwickii* Kheswalla (Foot rot)	*								*		

8.3.3	*Rhizoctonia bataticola* (Taub.) Butler (Dry root rot)	*					*			*		*
8.3.4	*Sclerotinia sclerotiorum* (Lib.) de Bary (Stem rot)	*								*		*
8.3.5	*Sclerotium rolfsii* Sacc. (Collar rot)	*					*		*	*		*
8.4.1	Bean (pea) leafroll virus (Luteovirus) (Chickpea stunt)	*					*			*		*
8.5.1	*Metopina ciceri* Disney (Nodule damaging flies)	*								*		
8.5.2	*Agrotis ipsilon* Hufnagel. etc. (Cutworm)	*								*		
8.5.3	*Liriomyza cicerina* (Rondani) (Leaf miner)	*					*		*	*		*
8.5.4	*Aphis craccivora* (Koch) (Aphids)	*								*		
8.6.1	*Helicoverpa armigera* (Hübner) (Pod borer)	*					*		*	*		*
8.7.1	*Callosobruchus chinensis* (L.) (Storage bruchid beetle)	*								*		
8.8.1	*Meloidogyne incognita*; *M.javanica; M. aritiellia* (Rootknot nematode)	*					*			*		*
8.8.2	*Pratylenchus thornei*; *P. zeae* Graham (Root lesion nematode)	*								*		*
8.8.3	*Heterodera ciceri* (Vovlas, Greco and Di Vito*) (*Cyst nematode)	*					*			*		*
	Nitrogen fixing ability									*		
	Amino Acid content								*	Not required		
	Seed size					*			*	*		*
	Salinity tolerance/Stress to soil salinity						*		*	Already added		
	Stress to Zinc						*			*		*
	Colletotrichum blight						*			*		

[1] (1) 'Descriptors for Chickpea (C*icer arietinum* L.)' (IBPGR, ICRISAT and ICARDA, 1993);
(2) Evaluation Award Scheme 2008 (EAS);
(3) Global Strategy for the *Ex Situ* Conservation of Chickpea (*Cicer* L.), Draft, July 2008;
(4) UPOV technical guidelines for Chick-Pea (2005);
(5) 'Descriptors for CHICKPEA' (USDA, ARS, GRIN);
(6) Important traits from the GPG2 exercise;
(7) Top ten traits from the GPG2 exercise;
(8) 'Core Collection of Chickpea as a Means to Enhance Utilization of Genetic Resources in Crop Improvement' (ICRISAT);
(9) Long list of traits identified during the crop-specific meeting at NBPGR (June 2009);
(10) Minimum list of traits identified during the crop-specific meeting at NBPGR (June 2009);
(11) Dr Imtiaz's choice of descriptors.

Annex II – List of experts identified to participate in the survey

Role/Source	*Name*	*Organization*	*Country*
Crop Leader (suggested by Ken Street)	**Imtiaz, Mohammed**	ICARDA	Syria
Crop Leader	**Kharkwal, M.C.**	Indian Agricultural Research Institute (IARI, Genetics)	India
CAG	Boulineau, Francois	GEVES (UPOV)	France
CAG	Coyne, Clare	USDA, ARS. Washington State University	USA
CAG (contact from ENEA chickpea congress)	Crinò, Paola	ENEA	Italy
CAG	Dua, Ram Prakash	NBPGR (Under utilized plants division)	India
CAG	Duc, Gérard	INRA (ECPGR)	France
CAG (suggested at ontology workshop)	Gaur, P.	ICRISAT	India
CAG	Haque, Mamtazul	Bangladesh Agricultural Research Institute	Bangladesh
CAG (suggested by H. Knüpffer, IPK)	Kotter, Matthias	IPK Genebank Department Leibniz Institute	Germany
CAG	Malhotra, Rajinder	ICARDA	Syria
CAG	Updadhyaya, H.	ICRISAT	India
Internet	Abbo, Shahal	Hebrew University of Jerusalem	Israel
Crop Strategy	Abdelguerfi, Aissa	Institut National Agronomique (INA)	Algeria
SINGER survey	Amri, Ahmed	Head GRU (ICARDA)	Syria
WIEWS	Benediková, Daniela	Research Institute of Plant Production Piestany	Slovak Republic
Internet	Berger, Jens D.	CSIRO Plant Industry	Australia
Internet (Plant pathologist)	Buchwaldt, Lone	Agriculture and Agri-Food Canada	Canada
Internet	Bulyntsev, Sergey	Curator Chickpea VIR	Russian Federation
Internet	Chaturvedi, S.K.	Indian Institute for Pulses Research	India
Internet (Plant pathologist)	Chen, Weidong	ARS/USDA	USA
Journal	Croser, Janine	Centres for Legumes in Mediterranean Agriculture (CLIMA)	Australia
Contact from ENEA chickpea congress	De la Rosa, Lucia	INIA	Spain
Internet	Diederichsen, Axel	Agriculture and Agri-Food Canada	Canada
NBPGR	Dwivedi, Narendra Kumar	NBPGR (Regional Station - Jodhpur)	India
WIEWS	Fundora, Z.	Banco de Germplasma	Cuba
Directory of Germplasm (Nutritionist)	Garzon-Tiznado, J.A.	Instituto Nacional de Investigaciones Agrícolas	Mexico

WIEWS	Hýbl, Miroslav	Agritech	Czech Republic
Internet (Plant pathologist)	Jiménez-Díaz, Rafael M.	IAS-CSIC	Spain
Internet (Plant geneticist)	Kahl, Gunter	Plant Molecular Biology, Biozentrum	Germany
Internet	Khan, Tanveer	Western Australian Department of Agriculture and Food, Dryland Research Institute	Australia
Reviewer	Kumar, J.	IARI, Genetics	India
Reviewer	Mishra, S.K.	NBPGR	India
Internet	McMurray, Larn	South Australian Research and Development Institute (SARDI)	Australia
Purdue website	Mohamed, Ali I.	Virginia State University	USA
Directory of Germplasm	Moreno, Maria T.	Centro de Investigación y Desarrollo Agrario Alameda del Obispo	Spain
Internet (Plant pathologist)	Muehlbauer, Frederick J.	USDA/ARS Washington State University	USA
NBPGR (Project Coordinator)	Nizar, M Abdul	NBPGR	India
Internet	Pandey, R.L.	Indira Gandhi Agricultural University	India
ECPGR	Pereira, Maria da Graça	Estação Nacional de Melhoramento de Plantas	Portugal
Directory of Germplasm	Pratibha, Brahmi	NBPGR	India
Crop Strategy	Redden, Bob	Department of Primary Industries Victoria	Australia
SINGER Survey (Genebank data manager)	Reddy, M. Thimma	ICRISAT	India
ICRISAT	Sharma, Kiran	ICRISAT (Principal scientist chickpea genetic engineering)	India
ICRISAT Legumes pathology	Sharma, Mamta	ICRISAT	India
Reviewer	Sharma, S.K.	ICAR, NBPGR	India
Journal	Siddique, K.H.M.	Institute of Agriculture-University of Western Australia	Australia
Purdue website	Slinkard, Al	University of Saskatchewan	Canada
Crop Strategy/WIEWS	Tan, Ayfer	Aegean Agricultural Research Institute (AARI)	Turkey
Internet	Toker, Cengiz	Department of Field Crops, Faculty of Agriculture, Akdeniz University	Turkey
Internet	Van der Maesen, L.J.G.	Wageningen Agricultural University	The Netherlands
Internet (Plant pathologist)	Vovlas, Nicola	Istituto per la Protezione delle Piante, C.N.R.	Italy
SRG/WIEWS	Yadav, Shyam S.	Retired	Papua New Guinea
EAS/Crop Strategy	Zahoor, Ahmad	Pakistan Agricultural Research Council	Pakistan

Annex III - First priority set of descriptors for chickpea identified by Dr Imtiaz in July 2009, to be inserted in the survey

1.	**Plant pigmentation**	(4.1.1)
2.	**Leaf type**	(4.1.3)
3.	**Days to 50% flowering**	(4.2.1)
4.	**Days to maturity**	(4.2.2)
5.	**Number of seeds per pod**	(4.2.3)
6.	**Flower colour**	(4.2.4)
7.	**Number of flowers and pods per peduncle**	(4.2.5)
8.	**Number of pods per plant**	(4.2.8)
9.	**Seed shape**	(4.3.1)
10.	**Seed colour**	(4.3.3)
11.	**100-Seed weight** [g]	(4.3.5)
12.	**Seed size**	(4.3.X)
13.	**Growth habit**	(6.1.1)
14.	**Number of primary branches**	(6.1.4.1)
15.	**Plant canopy height** (at maturity)	(6.1.5)
16.	**Biological yield per plant** [g]	(6.2.2.1)
17.	**Grain yield per plant** [g]	(6.2.2.2)
18.	**Protein content** [% DW]	(6.3.1.1)
19.	**Susceptibility to cold** (whole plant)	(7.1.2)
20.	**Frost damage**	(7.1.3)
21.	**Stress to Zinc**	(7.X)
22.	**Reactions to high temperature** (Heat)	(7.2)
23.	**Reaction to drought**	(7.5)
24.	**Reaction to salt stress**	(7.X)
25.	**Ascochyta blight** (*Ascochyta rabiei*)	(8.1.2)
26.	**Grey mould** (*Botrytis cinerea*)	(8.1.3)
27.	**Fusarium wilt** (*Fusarium oxysporum*)	(8.1.4)
28.	**Phytophthora blight** (*Phytophthora megasperma*)	(8.1.5)
29.	**Seedling rot** (*Xanthomonas cassiae*)	(8.2.3)
30.	**Root rot** (*Fusarium solani*)	(8.3.1)
31.	**Dry root rot** (*Rhizoctonia bataticola*)	(8.3.3)
32.	**Stem rot** (*Sclerotinia sclerotiorum*)	(8.3.4)
33.	**Collar rot** (*Sclerotium rolfsii*)	(8.3.5)
34.	**Chickpea stunt** (Bean (pea) leafroll virus)	(8.4.1)
35.	**Leaf miner** (*Liriomyza cicerina*)	(8.5.3)
36.	**Pod borer** (*Helicoverpa armigera*)	(8.6.1)
37.	**Rootknot nematode** (*Meloidogyne incognita; M. javanica; M. aritiellia*)	(8.8.1)
38.	**Root lesion nematode** (*Pratylenchus thornei; P. zeae*)	(8.8.2)
39.	**Cyst nematode** (*Heterodera ciceri*)	(8.8.3)

Annex IV – Survey to choose a key set of descriptors for chickpea utilization

WELCOME

Welcome to the survey for the selection of a key set of characterization and evaluation descriptors for chickpea to support an international information system to enhance the utilization of germplasm held in genebanks.

Your knowledge and experience are being sought to define an initial **'key set'** of descriptors that identify traits important to crop production and facilitate the use of accessions.

Your participation in it is highly appreciated. The deadline for this survey is **20 August 2009**.

This key set of descriptors will be made available through a global portal for identifying sets of accessions for evaluation and use. For characterization, the aim is a key set of maximally differentiating traits that provide the most impact in discriminating between accessions. For evaluation, the aim is to focus on a few important traits for production, such as those related to abiotic or biotic stresses of cosmopolitan nature.

This survey consists of two parts:

- PART I: Characterization descriptors.

- PART II: Evaluation descriptors.

We thank you in advance for investing your time and expertise in selecting the set of descriptors.

* **Please allow us to acknowledge your contribution by completing your full contact details below:**

Name:

Position:

Organization:

Country:

Email:

PART I: Characterization descriptors

These traits enable easy and quick discrimination between phenotypes. They are generally highly heritable, can be easily seen by the eye and are equally expressed in all environments.

Based on your experience, please rate the descriptors according to their importance. It also allows you to indicate if any essential descriptor that can contribute to its use is missing from the minimum list presented.

*Numbers in parentheses on the right-hand side are the corresponding descriptors numbers as published in the IBPGR/ICRISAT/ICARDA publication 'Descriptors for Chickpea' (1993).
*Descriptors with numbers ending in 'X' are new descriptors that were added during the revision of the original publication.

	Not important	Important	Very important
Plant pigmentation (4.1.1)	◯	◯	◯
Leaf type (4.1.3)	◯	◯	◯
Days to 50% flowering (4.2.1)	◯	◯	◯
Days to maturity (4.2.2)	◯	◯	◯
Number of seeds per pod (4.2.3)	◯	◯	◯
Flower colour (4.2.4)	◯	◯	◯
Number of flowers and pods per peduncle (4.2.5)	◯	◯	◯
Number of pods per plant (4.2.8)	◯	◯	◯
Seed shape (4.3.1)	◯	◯	◯
Seed colour (4.3.3)	◯	◯	◯
100-Seed weight [g] (4.3.5)	◯	◯	◯
Seed size (4.3.X)	◯	◯	◯

If you consider that an essential trait is missing from this list, please indicate it here along with a substantiated justification.

PART II: Evaluation descriptors

These descriptors include characters such as biotic and abiotic stresses. They are the most interesting traits in crop improvement. Please consider the following factors relating to the trait when making your final decision: (i) Global impact, (ii) Initial strategic set, (iii) Importance for germplasm utilization, (iv) Data availability, (v) True economic damage and (vi) Wide geographical occurrence.

Please, rate these traits in order of importance at the global level. It also allows you to indicate if any essential trait for production is missing from the minimum list presented or indicate any that may not be very significant to global production.

	Not Important	Important	Very important
Growth habit (6.1.1)	○	○	○
Number of primary branches (6.1.4.1)	○	○	○
Plant height (at maturity) (6.1.5)	○	○	○
Biological yield per plant [g] (6.2.2.1)	○	○	○
Grain yield per plant [g] (6.2.2.2)	○	○	○
Protein content [% DW] (6.3.1.1)	○	○	○
Susceptibility to cold (whole plant) (7.1.2)	○	○	○
Frost damage (7.1.3)	○	○	○
Stress to Zinc (7.X)	○	○	○
Reactions to high temperature (Heat) (7.2)	○	○	○
Reaction to drought (7.5)	○	○	○
Reaction to salt stress (7.X)	○	○	○
Ascochyta blight (*Ascochyta rabiei*) (8.1.2)	○	○	○
Grey mould (*Botrytis cinerea*) (8.1.3)	○	○	○
Fusarium wilt (*Fusarium oxysporum*) (8.1.4)	○	○	○
Phytophthora blight (*Phytophthora megasperma*) (8.1.5)	○	○	○
Seedling rot (*Xanthomonas cassiae*) (8.2.3)	○	○	○
Root rot (*Fusarium solani*) (8.3.1)	○	○	○
Dry root rot (*Rhizoctonia bataticola*) (8.3.3)	○	○	○
Stem rot (*Sclerotinia sclerotiorum*) (8.3.4)	○	○	○
Collar rot (*Sclerotium rolfsii*) (8.3.5)	○	○	○
Chickpea stunt (Bean (pea) leafroll virus) (8.4.1)	○	○	○
Leaf miner (*Liriomyza cicerina*) (8.5.3)	○	○	○
Pod borer (*Helicoverpa armigera*) (8.6.1)	○	○	○
Rootknot nematode (*Meloidogyne incognita*; *M. javanica; M. aritiellia*) (8.8.1)	○	○	○
Root lesion nematode (*Pratylenchus thornei*; *P. zeae*) (8.8.2)	○	○	○
Cyst nematode (*Heterodera ciceri*) (8.8.3)	○	○	○

If you consider that an essential trait important for crop improvement and production is missing from the list above, please indicate it here along with a substantiated justification.

Annex V – List of respondents to the survey

Role	*Name*	*Position*	*Organization*	*Country*
Crop Leader	**Kharkwal, M.C.**		Indian Agricultural Research Institute (IARI, Genetics)	India
Crop Leader	**Imtiaz, Muhammad**		International Center for Agricultural Research in the Dry Areas (ICARDA)	Syria
CAG	Bharadwaj, C.	Senior Scientist	Indian Agricultural Research Institute (IARI)	India
CAG	Boulineau, François	Directeur d'unité	Groupe d'Etude et de contrôle des Variétés et des Semences (GEVES)	France
CAG	Coyne, Clarice J.	Curator/Geneticist	United States Department of Agriculture, Agricultural Research Service (USDA-ARS)	USA
CAG	Crinò, Paola	Scientist	Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile (ENEA)	Italy
CAG	Dua, R.P.	Principal Scientist and Coordinator AICRP (UUC)	National Bureau of Plant Genetic Resources (NBPGR)	India
CAG	Haque, Mamtazul	Chief Scientific Officer	Bangladesh Agricultural Research Institute	Bangladesh
CAG	Lohwasser, Ulrike		Leibniz Institute of Plant Genetics and Crop Plant Research (IPK) Department of Genebank, Research Group Resources Genetics and Reproduction	Germany
CAG	Pandravada, S.R.	Senior Scientist	National Bureau of Plant Genetic Resources (NBPGR), Regional Station, Hyderabad	India
CAG	Upadhyaya, Hari D.	Principal Scientist and Head Gene Bank	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	India
Reviewer	Abbo, Shahal	Lecturer	Hebrew University of Jerusalem	Israel
Reviewer	Antalíková, Gabriela	Curator of Chickpea	Plant Production Research Centre, Research Institute of Plant Production (PPRC, RIPP) Piešťany	Slovak Republic
Reviewer	Diederichsen, Axel	Curator	Plant Gene Resources of Canada, Agriculture and Agri-Food Canada	Canada
Reviewer	Garzón-Tiznado, José Antonio	Researcher-Professor	Universidad Autónoma De Sinaloa	Mexico
Reviewer	Gowda, C.L.L.		International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	India
Reviewer	Jiménez-Díaz, Rafael M.	Professor of Plant Pathology	University of Córdoba	Spain
Reviewer	Khan, Tanveer	Principal Research Officer	Department of Agriculture and Food	Australia
Reviewer	Kumar, Jitendra	Principal scientist	Indian Agricultural Research Institute (IARI)	India
Reviewer	Mishra, S.K.	Head, Germplasm Evaluation Division	National Bureau of Plant Genetic Resources (NBPGR)	India
Reviewer	Muehlbauer, Fred	Research Geneticist (retired)	United States Department of Agriculture, Agricultural Research Service (USDA-ARS)	USA

Reviewer	Redden, Bob	Curator, Australian Temperate Field Crops Collection	Department of Primary Industries Victoria	Australia
Reviewer	Reddy, M. Thimma	Scientific Associate	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	India
Reviewer	Shagarodsky Scull, Tomás	Researcher and curator of chickpea collection	Instituto de Investigaciones Fundamentales en la Agricultura Tropical (INIFAT)	Cuba
Reviewer	Sharma, Mamta	Scientist	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	India
Reviewer	Sharma, Shivali		International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	India
Reviewer	Siddique, Kadambot	Professor and Director	The University of Western Australia	Australia
Reviewer	Singh, Sube		International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	India
Reviewer	Taran, Bunyamin	Chickpea Breeder/Assist. prof	Crop Development Centre, University of Saskatchewan	Canada
Reviewer	van der Maesen, L.J.G.	Prof. of Plant Taxonomy	Wageningen University	The Netherlands
Reviewer	Yadav, Shyam Singh	Ex. Principal Chickpea Breeder	Indian Agricultural Research Institute (IARI)	India
Reviewer	Zahoor, Ahmad	Senior Director	National Agricultural Research Centre (NARC)	Pakistan

Annex VI – List of descriptors proposed in the survey, ranked by rating average and percentage of importance, and sent to the Core Advisory Group for their selection

Descriptor	Rating Average	Your selection
Characterization		
100-Seed weight [g] (4.3.5)	**4.75**	
Days to maturity (4.2.2)	**4.50**	
Seed colour (4.3.3)	**4.50**	
Days to 50% flowering (4.2.1)	**4.33**	
Seed shape (4.3.1)	**3.96**	
Flower colour (4.2.4)	**3.71**	
Seed size (4.3.X)	**3.63**	
Number of seeds per pod (4.2.3)	**3.42**	
Number of flowers and pods per peduncle (4.2.5)	3.13	
Plant pigmentation (4.1.1)	3.00	
Number of pods per plant (4.2.8)	3.00	
Leaf type (4.1.3)	2.83	
Evaluation		
Reaction to drought (7.5)	**4.43**	
Ascochyta blight (*Ascochyta rabiei*)	**4.42**	
Fusarium wilt (*Fusarium oxysporum*) (8.1.4)	**4.38**	
Growth habit (6.1.1)	**4.25**	
Grain yield per plant [g] (6.2.2.2)	**4.25**	
Pod borer (*Helicoverpa armigera*) (8.6.1)	**4.17**	
Reaction to salt stress (7.X)	**3.74**	
Plant height (at maturity) (6.1.5)	3.63	
Reactions to high temperature (Heat) (7.2)	3.63	
Grey mould (*Botrytis cinerea*) (8.1.3)	**3.58**	
Protein content [% DW] (6.3.1.1)	3.54	
Dry root rot (*Rhizoctonia bataticola*) (8.3.3)	3.38	
Root rot (*Fusarium solani*) (8.3.1)	3.29	

Descriptor	% Important	% Very important
Characterization		
100-Seed weight [g] (4.3.5)	**12.5% (3)**	**87.5% (21)**
Days to 50% flowering (4.2.1)	**12.5% (3)**	**79.2% (19)**
Days to maturity (4.2.2)	**25.0% (6)**	**75.0% (18)**
Seed colour (4.3.3)	**25.0% (6)**	**75.0% (18)**
Seed shape (4.3.1)	**20.8% (5)**	**66.7% (16)**
Flower colour (4.2.4)	**33.3% (8)**	**54.2% (13)**
Seed size (4.3.X)	**37.5% (9)**	**50.0% (12)**
Number of pods per plant (4.2.8)	**16.7% (4)**	**50.0% (12)**
Number of seeds per pod (4.2.3)	37.5% (9)	45.8% (11)
Number of flowers and pods per peduncle (4.2.5)	41.7% (10)	37.5% (9)
Plant pigmentation (4.1.1)	56.5% (13)	26.1% (6)
Leaf type (4.1.3)	66.7% (16)	16.7% (4)
Evaluation		
Ascochyta blight (*Ascochyta rabiei*) (8.1.2)	**8.3% (2)**	**83.3% (20)**
Reaction to drought (7.5)	**17.4% (4)**	**78.3% (18)**
Fusarium wilt (*Fusarium oxysporum*) (8.1.4)	**20.8% (5)**	**75.0% (18)**
Grain yield per plant [g] (6.2.2.2)	**16.7% (4)**	**75.0% (18)**
Pod borer (*Helicoverpa armigera*) (8.6.1)	**20.8% (5)**	**70.8% (17)**
Growth habit (6.1.1)	**37.5% (9)**	**62.5% (15)**
Reaction to salt stress (7.X)	**30.4% (7)**	**56.5% (13)**
Grey mould (*Botrytis cinerea*) (8.1.3)	**29.2% (7)**	**54.2% (13)**
Protein content [% DW] (6.3.1.1)	41.7% (10)	45.8% (11)
Plant height (at maturity) (6.1.5)	58.3% (14)	37.5% (9)
Reactions to high temperature (Heat) (7.2)	58.3% (14)	37.5% (9)
Dry root rot (*Rhizoctonia bataticola*) (8.3.3)	50.0% (12)	37.5% (9)
Susceptibility to cold (whole plant) (7.1.2)	45.8% (11)	37.5% (9)

Susceptibility to cold (whole plant) (7.1.2)	3.25	
Rootknot nematode (*Meloidogyne incognita; M. javanica; M. aritiellia*) (8.8.1)	3.13	
Biological yield per plant [g] (6.2.2.1)	3.00	
Stem rot (*Sclerotinia sclerotiorum*) (8.3.4)	3.00	
Collar rot (*Sclerotium rolfsii*) (8.3.5)	3.00	
Number of primary branches (6.1.4.1)	2.96	
Frost damage (7.1.3)	2.96	
Chickpea stunt (Bean (pea) leafroll virus)	2.71	
Seedling rot (*Xanthomonas cassiae*) (8.2.3)	2.68	
Root lesion nematode (*Pratylenchus thornei; P. zeae*) (8.8.2)	2.68	
Phytophthora blight (*Phytophthora megasperma*) (8.1.5)	2.65	
Leaf miner (*Liriomyza cicerina*) (8.5.3)	2.61	
Cyst nematode (*Heterodera ciceri*) (8.8.3)	2.46	
Stress to Zinc (7.X)	1.54	

Biological yield per plant [g] (6.2.2.1)	37.5% (9)	37.5% (9)
Root rot (*Fusarium solani*) (8.3.1)	54.2% (13)	33.3% (8)
Number of primary branches (6.1.4.1)	50.0% (12)	29.2% (7)
Frost damage (7.1.3)	50.0% (12)	29.2% (7)
Chickpea stunt (Bean (pea) leafroll virus) (8.4.1)	41.7% (10)	29.2% (7)
Collar rot (*Sclerotium rolfsii*) (8.3.5)	56.5% (13)	26.1% (6)
Rootknot nematode (*Meloidogyne incognita; M. javanica; M. aritiellia*) (8.8.1)	62.5% (15)	25.0% (6)
Stem rot (*Sclerotinia sclerotiorum*) (8.3.4)	58.3% (14)	25.0% (6)
Phytophthora blight (*Phytophthora megasperma*) (8.1.5)	52.2% (12)	21.7% (5)
Seedling rot (*Xanthomonas cassiae*) (8.2.3)	59.1% (13)	18.2% (4)
Root lesion nematode (*Pratylenchus thornei; P. zeae*) (8.8.2)	59.1% (13)	18.2% (4)
Cyst nematode (*Heterodera ciceri*) (8.8.3)	54.2% (13)	16.7% (4)
Leaf miner (*Liriomyza cicerina*) (8.5.3)	65.2% (15)	13.0% (3)
Stress to Zinc (7.X)	37.5% (9)	8.3% (2)

Annex VII – Additional descriptors included in the open-ended section of the survey

Chickpea Descriptor	Name of expert								
	N. times selected	B. Redden (Dep. of Primary Industries Victoria, Australia)	J. Kumar (IARI, India)	R.P. Dua (NBPGR, India)	A. Diederichsen (Agriculture and Agri-Food Canada)	S.S. Yadav (IARI, India)	P. Crinò (ENEA, Italy)	T. Shagarodsky Scull (INIFAT, Cuba)	G. Antalíková (PPRC-RIPP Piešťany, Slovakia)
Additional characterization traits (VI= Very Important)		VI	VI	VI	VI	VI	VI	VI	VI
Plant hairiness (4.1.2), wide diversity of major types: none, pubescent, very hairy	1	X							
Testa texture (4.3.2) is very important to differentiate the genotypes with respect to seed surface	3		**X** Seed roughness (smooth, rough, tuberculated)	X		**X** Seed type like rough seeded, smooth seeded may be included			
Cotyledon colour in mature seeds (green-olive; orange-red; or yellow. An important and stable trait	1				X				
Weight of seed per plant (g)									X
Number of seed per plant									X
Additional evaluation traits									
Resistant to store pests particularly the Bruchids	1			X					
Lodging should be rated	1				X				
In our case the most important pests in Cuba are *Heliothis virescens* and *Spodoptera* spp.	1							X	
Comments:									
Quality traits and anti-nutritional traits may be identified and included. This crop need worldwide attention on these traits for human consumption						X			
The importance of each pathogen depends on the environment where chickpea is grown							X		
Plant pigmentation should be clarified e.g. foliage pigment or stem pigment etc. Some varieties are dark green and some are light green colour like kabuli types are light green and desi types are dark green colour						X			

Annex VIII – First list of descriptors for chickpea drawn from Dr Imtiaz's selection, from the survey and CAG's feedback, and sent to the Core Advisory Group for validation

First priority set of descriptors for chickpea

1.	**Days to 50% flowering**	(4.2.1)
2.	**Days to maturity**	(4.2.2)
3.	**Number of seeds per pod**	(4.2.3)
4.	**Flower colour**	(4.2.4)
5.	**Number of pods per plant**	(4.2.8)
6.	**Seed shape**	(4.3.1)
7.	**Seed colour**	(4.3.3)
8.	**100-Seed weight** [g]	(4.3.5)
9.	**Seed size**	(4.3.X)
10.	**Growth habit**	(6.1.1)
11.	**Grain yield per plant** [g]	(6.2.2.2)
12.	**Protein content** [%DW]	(6.3.1.1)
13.	**Reaction to drought**	(7.5)
14.	**Reaction to salt stress**	(7.X)
15.	**Ascochyta blight** (*Ascochyta rabiei*)	(8.1.2)
16.	**Grey mould** (*Botrytis cinerea*)	(8.1.3)
17.	**Fusarium wilt** (*Fusarium oxysporum*)	(8.1.4)
18.	**Pod borer** (*Helicoverpa armigera*)	(8.6.1)

Additional trait suggested:

19.	**Testa texture**	(4.3.2)

Annex IX – Attachment containing summary background information about the debate on some additional descriptors suggested and submitted to CAG

CHICKPEA

1. Plant height:
- Important for mechanical harvesting;
- No descriptor is included to quantify the accessions especially in terms of growth parameters which are also important phenotypic indicators of the productivity of a genotype to some extent;
- It is necessary as a key descriptor;
- Indicated as most important descriptor for breeding in GPG2 results (managed by ICRISAT);
- **Survey rating** (n=24):

Plant height (at maturity) (6.1.5)	**Not important** 4.2% (1)	**Important** **58.3% (14)**	**Very important** 37.5% (9)	3.63	24

2. Testa texture:
- Very important to differentiate the genotypes with respect to seed surface;
- Seed roughness (smooth, rough, tuberculated);
- It is necessary as a key descriptor
- **Survey rating:** Not rated since not included in the survey, but suggested as additional descriptor by 5 experts;
- Indicated as most important descriptor for diagnosis in GPG2 results (managed by ICRISAT).

3. Number of primary branches:
- Important phenotypic indicator of the productivity of a genotype, to some extent;
- Indicated as most important descriptor for breeding in GPG2 results (managed by ICRISAT);
- **Survey rating** (n=24):

Number of primary branches (6.1.4.1)	**Not important** 20.8% (5)	**Important** **50.0% (12)**	**Very important** 29.2% (7)	2.96	24

4. Leaf Type
- Suggested by ICARDA and NPBGR scientists;
- Indicated as most important descriptor for breeding in GPG2 activity (managed by ICRISAT);
- It is not so important because most of the cultivated chickpeas are multipinnate;
- **Survey rating** (n=24):

Leaf type (4.1.3)	**Not important** 16.7% (4)	**Important** **66.7% (16)**	**Very important** 16.7% (4)	2.83	24

ANNEX X – Chickpea descriptors list proposed to the CAG (10/2) n=24

(Blue face= added; Red face= deleted)

Plant pigmentation (4.1.1)
Days to 50% flowering (4.2.1)
Days to maturity (4.2.2)
Number of seeds per pod (4.2.3)
Flower colour (4.2.4)
Number of pods per plant (4.2.8)
Seed shape (4.3.1)
Testa texture (4.3.2)
Seed colour (4.3.3)
100-Seed weight [g] (4.3.5)
~~**Seed size (4.3.X) –**~~ **TO BE DELETED: 100-seed weight is conveniently used as a measure of seed size and therefore the latter could be deleted.**
Growth habit (6.1.1)
Number of primary branches (6.1.4.1)
Plant height (at maturity) (6.1.5)
Grain yield per plant [g] (6.2.2.2)
Protein content [%DW] (6.3.1.1)
Reaction to drought (7.5)
Reaction to salt stress (7.X)
Ascochyta blight (*Ascochyta rabiei*) (8.1.2)
Grey mould (*Botrytis cinerea*) (8.1.3)
Fusarium wilt (*Fusarium oxysporum*) (8.1.4)
Pod borer (*Helicoverpa armigera*) (8.6.1)

ANNEX XI – Final key set of descriptors for chickpea genetic resources

Key access and utilization descriptors for chickpea genetic resources

This list consists of an initial set of characterization and evaluation descriptors for chickpea (*Cicer arietinum* L.) genetic resources utilization. This strategic set of descriptors, together with passport data, will become the basis for the global accession level information portal being developed by Bioversity International with the financial support of the Global Crop Diversity Trust (the Trust). It will facilitate access to and utilization of chickpea accessions held in genebanks and does not preclude the addition of further descriptors, should data subsequently become available.

Based on the comprehensive list 'Descriptors for Chickpea (*Cicer arietinum* L.)' published by ICRISAT, ICARDA and IBPGR (now Bioversity International) in 1993, the list builds on the results of the SGRP Global Public Goods Activity 4.2.1.1, particularly with regard to those descriptors highlighted as the most important diagnostic and breeding traits. It was subsequently compared and harmonized with a number of sources such as the UPOV technical guidelines for Chick-Pea (2005), 'Descriptors for CHICKPEA' (USDA, ARS, GRIN), 'Core Collection of Chickpea as a Means to Enhance Utilization of Genetic Resources in Crop Improvement' (ICRISAT-website), 'Global Strategy for the *Ex situ* Conservation of Chickpea (*Cicer* L.)' (the Trust, 2008), as well as with those descriptors that were awarded funds for further research by the Trust in 2008 Evaluation Awards Scheme (EAS). This list was further refined during a meeting held at the National Bureau of Plant Genetic Resources (NBPGR, India) in June 2009. Several scientists from NBPGR and the Indian Agricultural Research Institute (IARI) participated.

A worldwide distribution of experts was involved in an online survey to define a first priority set of descriptors to describe, to access and to utilize chickpea genetic resources. This key set was afterwards validated by a Core Advisory Group (see 'Contributors') led by Dr M. Imtiaz of the International Center for Agricultural Research in the Dry Areas (ICARDA), Dr M.C. Kharkwal of the Indian Agricultural Research Institute (IARI) and Dr Hari D. Upadhyaya of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

Biotic and abiotic stresses included in the list were chosen because of their wide geographic occurrence and significant economic impact at a global level.

Numbers in parentheses on the right-hand side are the corresponding descriptor numbers listed in the 1993 publication. Descriptors with numbers ending in 'letters' are either modified or are new descriptors that were added during the development of the list below.

PLANT DATA

Stem/foliage pigmentation (4.1.1)

Observed before flowering. Indicate whether the pigmentation is on stems or leaves in the descriptors **Notes**

1 No anthocyanin (light green)
3 No anthocyanin (green)
5 Low anthocyanin (partly light purple)
7 High anthocyanin (predominantly purple)
9 Highly purple

Days to 50% flowering (4.2.1)

Number of days from sowing (or first rain sufficient for germination under rainfed conditions) until 50% of the plants have started to flower

Days to maturity (4.2.2)

Number of days from sowing (or first rain sufficient for germination under rainfed conditions) until 90% of the pods have matured and turned yellow

Number of seeds per pod (4.2.3)

Average number of 10 pods each from five representative plants. At maturity

Flower colour (4.2.4)

In most cases pink and blue flowers have veins of a darker shade in the flag, while the tip of the keel is also darker. The classes are ranges rather than only the shades of the reference colours. Royal Horticultural Society (RHS) colour codes are given in parentheses beside descriptor states

1 Blue (violet-blue group 97B)
2 Light blue (violet-blue group 97C)
3 Dark pink (red-purple group 64D)
4 Pink (red-purple group 63D)
5 Light pink (red-purple group 69C)
6 White (white group 155D)
7 White-pink striped (white group 155D, red-purple group 63D)

Number of pods per plant (4.2.8)

Average number of pods taken from five representative plants. At maturity

Seed shape (4.3.1)

1 Angular, ram's head (most desi cultivars)
2 Irregular rounded, owl's head (most kabuli cultivars)
3 Pea-shaped, smooth round (intermediate types)

Seed testa texture (4.3.2)

1 Rough (pea-shaped)
2 Smooth
3 Tuberculated (sticky surface)

Seed colour (4.3.3)

Royal Horticultural Society (RHS) colour codes are given in parentheses beside descriptor states

1 Black (black group 202A, 202B; brown group 200A)
2 Brown (greyed-orange group 177B)
3 Light brown (greyed-orange group 177C)
4 Dark brown (greyed-orange group 177A)
5 Reddish brown (greyed-orange group 166C)
6 Greyish brown (brown group 200D)
7 Salmon brown (greyed-orange group 165C)
8 Grey (greyed-green group 196A)
9 Brown beige (greyed-orange group 173D)
10 Beige (greyed-orange group 165D)
11 Yellow (greyed-orange group 164B)
12 Light yellow (greyed-orange group 164C)
13 Yellow brown (greyed-orange group 165C)
14 Orange yellow (greyed-orange group 168D)
15 Orange (greyed-orange group 168C)
16 Yellow beige (orange-white group 159C)
17 Ivory white (orange-white group 159C)
18 Green (greyed-green group 191A; grey group 201A; greyed-orange group 166B)
19 Light green (greyed-green group 193B)
20 Variegated
21 Black brown mosaic (black group 202A; greyed-orange group 177E)

100-seed weight [g] (4.3.5)

Measured at 10% (air-dry) moisture content

Growth habit (6.1.1)

The angle of the branches from the vertical axis at the pod filling stage

1 Prostrate (branches flat on the ground, >80°)
2 Spreading (61-80° from vertical)
3 Semi-spreading (26-60° from vertical)
4 Semi-erect (16-25° from vertical)
5 Erect (0-15° from vertical)

Number of primary branches (6.1.4.1)

Average number of basal primary branches per plant taken from five representative plants

Plant canopy height [cm] (6.1.5)

Average canopy height of five representative plants. Recorded at maturity

Seed yield per plant [kg ha^{-1}] (6.2.2.2)

Seed protein content [% DW] (6.3.1.1)

Whole seed crude protein using the dye-binding method or automatic protein analyzer

ABIOTIC STRESSES

Reaction to drought (7.5)

Reaction to salinity (7.X)

BIOTIC STRESSES

Ascochyta blight *(Ascochyta rabiei)* (8.1.2)

Grey mould *(Botrytis cinerea)* (8.1.3)

Fusarium wilt *(Fusarium oxysporum* f. sp. *ciceri)* (8.1.4)

Pod borer (*Helicoverpa armigera*) (8.6.1)

NOTES

Any additional information may be specified here, particularly that referring to the category '99=Other' present in some of the descriptors above.

CONTRIBUTORS

Bioversity is grateful to all the scientists and researchers who have contributed to the development of this strategic set of 'Key access and utilization descriptors for chickpea genetic resources', and in particular to Dr M. Imtiaz (ICARDA), Dr M.C. Kharkwal (IARI) and Dr Hari D. Upadhyaya (ICRISAT) for providing valuable scientific direction. Ms Adriana Alercia (Bioversity International) provided technical expertise and guided the entire production process.

CORE ADVISORY GROUP

Muhammad Imtiaz, International Center for Agricultural Research in the Dry Areas (ICARDA), Syria
M.C. Kharkwal, Division of Genetics, Indian Agricultural Research Institute (IARI), India
Hari D. Upadhyaya, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India
C. Bharadwaj, Division of Genetics, Indian Agricultural Research Institute (IARI), India
François Boulineau, Groupe d'Etude et de contrôle des Variétés et des Semences (GEVES), France
Clarice J. Coyne, United States Department of Agriculture, Agricultural Research Service (USDA, ARS), USA
Paola Crinò, Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile (ENEA), Italy
R.P. Dua, Indian Council of Agricultural Research (ICAR), India
Matthias Kotter, Leibniz Institute of Plant Genetics and Crop Plant Research (IPK), Germany
Ulrike Lohwasser, Leibniz Institute of Plant Genetics and Crop Plant Research (IPK) Department of Genebank, Research Group Resources Genetics and Reproduction, Germany
S.R. Pandravada, National Bureau of Plant Genetic Resources (NBPGR), Regional Station, Hyderabad, India

REVIEWERS

Australia

Tanveer Khan, Department of Agriculture and Food
Bob Redden, Department of Primary Industries Victoria
Kadambot Siddique, The University of Western Australia

Bangladesh

Mamtazul Haque, Bangladesh Agricultural Research Institute

Canada

Axel Diederichsen, Plant Gene Resources of Canada, Agriculture and Agri-Food Canada
Bunyamin Taran, Crop Development Centre, University of Saskatchewan

Cuba

Tomás Shagarodsky Scull, Instituto de Investigaciones Fundamentales en la Agricultura Tropical (INIFAT)

India

C.L.L. Gowda, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
Jitendra Kumar, Indian Agricultural Research Institute (IARI)
S.K. Mishra, National Bureau of Plant Genetic Resources (NBPGR)
M. Thimma Reddy, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
Mamta Sharma, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
Shivali Sharma, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
Sube Singh, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
Shyam Singh Yadav, Indian Agricultural Research Institute (IARI)

Israel

Shahal Abbo, Hebrew University of Jerusalem

Mexico

José Antonio Garzón-Tiznado, Universidad Autónoma De Sinaloa

Pakistan

Ahmad Zahoor, National Agricultural Research Centre (NARC)

Slovak Republic

Gabriela Antalíková, Plant Production Research Centre, Research Institute of Plant Production (PPRC, RIPP) Piešťany

Spain

Rafael M. Jiménez-Díaz, University of Córdoba

The Netherlands

L.J.G. van der Maesen, Wageningen University

USA

Fred Muehlbauer, United States Department of Agriculture, Agricultural Research Service (USDA, ARS)

Methodology for the definition of a key set of characterization and evaluation descriptors for coconut (*Cocos nucifera* L.)

Bioversity International

GLOBAL CROP DIVERSITY TRUST
A FOUNDATION FOR FOOD SECURITY

Information collection and preparation of a Minimum Descriptor List (MDL)

Information for the definition of a MDL for coconut was drawn from the publication 'Descriptors for Coconut' (IPGRI, 1995) and from the 'Minimum List of Descriptors for Coconut' (Bioversity, 2007). The original lists were compared to characteristics and traits suggested in the 'Global Conservation Strategy for *Cocos nucifera*' (the Trust, 2008) and to the outcomes of the survey carried out in 2007 among coconut experts for the definition of the minimum set of descriptors for this crop. Important evaluation traits, such as main pests and diseases for coconut, were added to the minimum list, including traits that were awarded funds for further research by the Global Crop Diversity Trust 2008 Award Scheme, 'Enhancing the Value of Crop Diversity in a World of Climate Change' (EAS).

Preparing List of Experts

Experts were drawn from crop-specific consultations for the definition of the 'Global Conservation Strategy for *Cocos nucifera*' (the Trust, 2008) and from the original Bioversity publication. Overall, 47 experts were identified, coming from 23 countries and 29 different organizations (see Annex I). Out of these a Core Advisory Group consisting of six experts was selected to assist in the definition of a key set of descriptors for coconut utilization. Members of the Core Advisory Group were selected from important organizations and research centres focusing on coconut conservation, such as the Centre de coopération internationale en recherche agronomique pour le développement (CIRAD) and the Philippine Coconut Authority.

Survey preparation and distribution

The 'Minimum List of Descriptors for Coconut' (Bioversity, 2007) was compared to descriptors suggested in the 'Global Conservation Strategy for *Cocos nucifera*' (the Trust, 2008) and to results from the consultation carried out in July 2008 for the definition of essential evaluation descriptors for this crop. Since the Minimum List published in 2007 already contained characterization and evaluation traits agreed upon by internationally recognized coconut experts, it was decided that the survey should refer to the 'Minimum List of Descriptors for Coconut '(Bioversity, 2007), and seek expert advice only on the important biotic and abiotic stresses in the context of climate change, such as resistance to main pests and diseases (see Annex II). The survey would additionally include comments received from Dr. M. Dollet (CIRAD) on biotic stresses and from Dr. A. Prades (CIRAD) on descriptors included in sections 15 to 18. Consensus on this decision was sought from Maria Luz George (Bioversity) and Chantal Hamelin (CIRAD).

Once approved, the final text was uploaded into the SurveyMonkey web application (see Annex III) and sent out on 24th February 2009 to the list of identified experts. They were invited to rate the list of biotic and abiotic stresses provided, and asked to suggest important evaluation descriptors that were found to be relevant yet missing from the proposed Minimum List. The survey deadline was set at 20th March. A reminder was sent out on 10th March and a second reminder was sent on 16th March to ensure that the greatest possible feedback was obtained.

Survey analysis

Of the 47 experts who were identified and involved in the exercise, 20, coming from 15 countries, recorded their comments using the online survey (see Annex IV). Results from the survey were analyzed and descriptors ranked by rating average and percentage of importance (see Annex V). The summary of the survey, together with a report containing comments received by the participants (see Annex VI) was sent to the Core Advisory Group for further consultation and to help select a reduced set of key traits for this crop. CIRAD scientists, after analyzing the results of the survey, proposed six key traits for biotic and abiotic stresses affecting coconut (see Annex VII). These identified traits, together with characterization and evaluation data already defined in the 'Minimum List of Descriptors for Coconut' (Bioversity, 2007), were grouped together (see Annex VIII) to create a new document compliant with the Germplasm Information on Genebank Accessions project terms of reference.

Once the core subset of characterization and evaluation standards for Coconut was finalised, data were transformed into Excel files for uploading into the GRIN-Global genebank data-management system being developed by USDA, to EURISCO and into the Global Accession Level Information Portal (GENESYS), linking national, regional and international genebank databases in support of the conservation and use of plant genetic resources for food and agriculture (PGRFA). The Excel files were also provided to the System-wide Information Network for Genetic Resources (SINGER), the SGRP Crop Genebank Knowledge Base, and the Generation Challenge Programme (GCP) Ontology partners.

Acknowledgement

Bioversity is grateful to all the scientists and researchers who contributed to the development of the strategic set of 'Key access and utilization descriptors for coconut genetic resources', and in particular to the valuable scientific direction provided by CIRAD scientists. Special recognition goes to the Global Crop Diversity Trust for their financial support. Ms Adriana Alercia provided technical expertise and guided the entire production process.

Annex I – List of experts identified for participation to the survey for the definition of a key set of evaluation descriptors for Coconut

Role	Name	Organization	Country
Core Group	George, Maria Luz	Bioversity International	Malaysia
Core Group	Hamelin, Chantal	CIRAD	France
Core Group	Baudouin, Luc	CIRAD	France
Core Group	Harries, Hugh C.	Consultant	UK
Core Group	Labouisse, Jean-Pierre	CIRAD	France
Core Group (EAS)	Perera, A.A. Lalith	Coconut Research Institute (CRI)	Sri Lanka
Core Group	Santos, Gerardo A.	PCA	Philippines
Crop Strategy Expert	Faure, M.	Cocoa & Coconut Insitute of PNG	Papua New Guinea
Crop Strategy Expert	Jayasekara, C.	Coconut Research Insitute	Sri Lanka
Crop Strategy Expert	Rajagopal, V.	India Central Plantation Crops Research Institute (CPCRI)	India
Crop Strategy Expert	Rillo, E.	Philippine Coconut Authority (PCA-ARC)	Philippines
Crop Strategy Expert/Reviewer (MDL)	Konan Konan, Jean Louis	Centre Nationale de Recherche Agronomique (CNRA)	Ivory Coast
Crop Strategy Expert/Reviewer (MDL)	Kullaya, Alois	Mikocheni Agricultural Reserach Institute (MARI)	Tanzania
Crop Strategy Expert/Reviewer (MDL)	Novarianto, Hengky	Indonesian Coconut and Palmae Research Institute (ICOPRI) Mapanget	Indonesia
Reviewer (MDL)	Alfiler, Ambrosio Raul	Philippine Coconut Authority (PCA) Albay Research Center, Banao Guinobatan, Albay	Philippines
Reviewer (MDL)	Aragao, Wilson	Empresa Brasileira de Pesquisa Agropecuária Centro de Pesquisa Agropecuária dos Tabuleiros Costeiros (EMBRAPA/CPATC) Av Beira Mar, 3250, Aracaju/SE	Brazil
Reviewer (MDL)	Carpio, Carlos	Philippine Coconut Authority (PCA) Albay Research Center, Banao Guinobatan, Albay Elliptical Rd, Diliman, Quezon City	Philippines
Reviewer (MDL)	Castillo Gonzalez, Ramon Artemio	Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP)	Mexico
Reviewer (MDL)	Chellapa, Jayabose	Central Plantation Crops Research Institute (CPCRI)	India
Reviewer (MDL)	Engelmann, Florent	Institut de Recherche pour le Développement (IRD)	France
Reviewer (MDL)	Halafihi, Mana'ia	Ministry of Agriculture and Food Forests and Fisheries	Tonga

Role	Name	Organization	Country
Reviewer (MDL)	Hua, Chen	Coconut Research Institute Chinese Academy of Tropical Agriculture Sciences (CRI-CATAS)	China
Reviewer (MDL)	Islam, Nazirul	Bangladesh Agricultural Research Inst (BARI)	Bangladesh
Reviewer (MDL)	Jerard Bosco, B. Augustine	Central Plantation Crops Research Institute (CPCRI)	India
Reviewer (MDL)	Kete, Tevita N.	Secretariat of the Pacific Community (SPC)	Fiji
Reviewer (MDL)	Khaleque Mian, Md Abdul	Bangabandhu Sheikh Mujibur Rahman Agricultural University Department of Genetics and Plant Breeding	Bangladesh
Reviewer (MDL)	Kumar, Vijendra	Wainigata Research Station Ministry of Agriculture, Sugar and Land Resettlement	Fiji
Reviewer (MDL)	Le Thuy, Nguyen Thi	Oil Plant Institute of Vietnam (OPI)	Vietnam
Reviewer (MDL)	Liangqiu, Chen	Coconut Research Institute Chinese Academy of Tropical Agriculture Sciences (CRI-CATAS)	China
Reviewer (MDL)	Longxiang, Tang	Coconut Research Institute Chinese Academy of Tropical Agriculture Sciences (CRI-CATAS)	China
Reviewer (MDL)	Manohar, Erlene	Philippine Coconut Authority (PCA)	Philippines
Reviewer (MDL)	Mooleedhar, Vish	Research Division Ministry of Agriculture Central Experiment Station	Trinidad & Tobago
Reviewer (MDL)	Nair, Velayudhan	Central Plantation Crops Research Institute (CPCRI)	India
Reviewer (MDL)	Nampoothiri, Unnikrishnan K.	M S Swaminathan Research Foundation	India
Reviewer (MDL)	Nipah, Joseph O.	Oil Palm Research Institute (OPRI)	Ghana
Reviewer (MDL)	Niral, V.	Central Plantation Crops Research Institute (CPCRI)	India
Reviewer (MDL)	Odewale, Joshua O.	Nigerian Inst for Oil Palm Research (NIFOR)	Nigeria
Reviewer (MDL)	Okolo, Edmund	Nigerian Institute for Oil Palm Research	Nigeria
Reviewer (MDL)	Ovasuru, Tore	Kokonas Industri Koporesan (KIK)	Papua New Guinea
Reviewer (MDL)	Perera, Chandrika	Coconut Research Institute (CRI)	Sri Lanka
Reviewer (MDL)	Rivera, Ramon	Philippine Coconut Authority Zamboanga Research Center (PCA-ZRC)	Philippines
Reviewer (MDL)	Sileye, Tiata	Vanuatu Agriculture and Technical Center (VARTC)	Republic of Vanuatu
Reviewer (MDL)	Solangi, Abdul Hameed	Plant Genetic Resources Conservation and Management	Pakistan
Reviewer (MDL)	Thomas, G.	Central Plantation Crops Research Institute (CPCRI)	India

Role	Name	Organization	Country
Reviewer (MDL)	Tuivavalagi, Philip	Ministry of Agriculture and Fisheries Samoa (MAF)	Samoa
Reviewer (MDL)	Wai Fong, W. Au	Department of Agriculture (DOA)	Malaysia
Reviewer (MDL)	Zhiguo, Dong	Coconut Research Institute Chinese Academy of Tropical Agriculture Sciences (CRI-CATAS)	China

Annex II – Key traits relating to biotic and abiotic stresses affecting Coconut proposed in the survey sent out on 24th February 2009

Biotic stress susceptibility

Bud rot (*Phytophthora* spp.)	(8.1.2)
Stem bleeding (*Ceratocystis paradoxa*; *Chalara paradoxa*)	(8.1.9)
Lixa pequena (*Catacauma torrendiella*)	(8.1.11)
Queima das folhas (*Botryodiplodia theobromae*)	(8.1.12)
Lixa grande (*Coccostroma palmicola*)	(8.1.13)
Coconut foliar decay virus (CFDV)	(8.2.1)
Coconut cadang-cadang viroid (CCCVd)	(8.2.2)
Red ring nematode (*Bursaphelenchus cocophilus*)	(8.4.1)
Hartrot (*Phytomonas* sp.)	(8.5.1)
Kerala root wilt	(8.6.1)
Kalimantan wilt	
Lethal yellowing*	(8.6.1)
Coconut hispine beetle (*Brontispa longissima*)	
Rhinoceros beetle (*Oryctes rhinoceros*)	(8.7.34)

Abiotic stress susceptibility

Reaction to salinity	(7.1)
Reaction to waterlogging	(7.2)
Reaction to drought	(7.3)
Reaction to low temperature	(7.4)
Reaction to mineral deficiencies	(7.5)
Reaction to mineral toxicitie	(7.6)
Reaction to pH	(7.7)

* Also called in other countries as Cape Saint Paul Wilt Disease (CSPW), Kaincopé Disease, Awka Disease, Kribi Disease, Lethal Disease

Annex III – Survey for the selection of key traits relating to biotic and abiotic stresses affecting Coconut

WELCOME

Welcome to the survey for the selection of a key set of evaluation traits relating to biotic and abiotic stresses affecting *Cocos nucifera*.

This survey should take no longer than 15 minutes. Your participation in it is highly appreciated. The deadline for this survey is 20 March 2009.

Information for the definition of this key set was drawn from the publication "Descriptors for Coconut" (IPGRI, 1995), and builds on work carried out by Bioversity in 2007, in collaboration with CIRAD and other international organizations, for the definition of a key set of morphometric descriptors for categorizing accessions and leading to the effective utilization of Coconut germplasm.

Today your knowledge and experience are being sought to select an additional set of descriptors related to important biotic and abiotic stresses for this crop. A number of these have been identified by the Global Crop Diversity Trust as requiring further research into their importance.

The survey consists of two parts:
PART I: Lists important biotic stresses for *Cocos nucifera*. You are kindly asked to rate these stresses in order of global impact. You may also indicate any essential descriptor that you believe is missing from the list and that can contribute to the effective use of Coconut germplasm.

PART II: Lists important abiotic stresses for *Cocos nucifera*. You are kindly asked to rate these stresses in order of importance at the global level. You may also indicate any essential descriptor that you believe is missing from the list and that can contribute to the effective use of Coconut germplasm.
Thank you in advance for investing your time and expertise in this exercise.

Please allow us to acknowledge your contribution by completing your full contact details below:
Name:
Position:
Institute:
Address:
City/Town:
Country:
Email:
Phone:
Fax:

PART I: Susceptibility to biotic stresses

Please rate the importance of the following traits relating to susceptibility to BIOTIC stresses, bearing in mind current breeding programmes and future production and use of Coconut germplasm at the global level.

*Numbers in parentheses on the right-hand side are the corresponding descriptors numbers as published in the IPGRI publication 'Descriptors for Coconut'(1995).

	Not important	Important	Very important
BUD ROT (*Phytophthora* spp.) (8.1.2)	j /	j /	j /
KALIMANTAN WILT	j /	j /	j /
STEM BLEEDING (*Ceratocystis paradoxa*; *Chalara paradoxa*) (8.1.9)	j /	j /	j /
LIXA PEQUENA (*Catacauma torrendiella*) (8.1.11)	j /	j /	j /
QUEIMA DAS FOLHAS (*Botryodiplodia theobromae*) (8.1.12)	j /	j /	j /
LIXA GRANDE (*Coccostroma palmicola*) (8.1.13)	j /	j /	j /
COCONUT FOLIAR DECAY VIRUS (CFDV) (8.2.1)	j /	j /	j /
COCONUT CADANG-CADANG VIROID (CCCVd) (8.2.2)	j /	j /	j /
RED RING NEMATODE (*Bursaphelenchus* cocophilus) (8.4.1)	j /	j /	j /
HARTROT (*Phytomonas* sp.) (8.5.1)	j /	j /	j /
KERALA ROOT WILT (8.6.1)	j /	j /	j /
LETHAL YELLOWING* (8.6.1)	j /	j /	j /
COCONUT HISPINE BEETLE (*Brontispa longissima* Gestro) (8.7.29)	j /	j /	j /
RHINOCEROS BEETLE (*Oryctes rhinoceros*) (8.7.34)	j /	j /	j /

*Also known, in other countries, as Cape Saint Paul Wilt Disease (CSPW), Kaincopé Disease, Awka Disease, Kribi Disease, Lethal Disease.

If you consider that an essential trait is missing from this list, or, if any of the descriptors listed is not clearly useful to promote utilization, please indicate it here along with a substantiated justification.

PART II: Susceptibility to abiotic stresses

Please rate the importance of the following traits relating to susceptibility to ABIOTIC stresses, bearing in mind current breeding programmes and future production and use of Coconut germplasm at the global level.

*Numbers in parentheses on the right-hand side are the corresponding descriptors numbers as published in the IPGRI publication 'Descriptors for Coconut'(1995).

	Not Important	Important	Very important
SALINITY (7.1)	j /	j /	j /
WATERLOGGING (7.2)	j /	j /	j /
DROUGHT (7.3)	j /	j /	j /
LOW TEMPERATURE (7.4)	j /	j /	j /
MINERAL DEFICIENCIES (7.5)	j /	j /	j /
MINERAL TOXICITIES (7.6)	j /	j /	j /
PH (7.7)	j /	j /	j /

/

If you consider that an essential trait is missing from this list, or, if any of the descriptors listed is not clearly useful to promote utilization, please indicate it here along with a substantiated justification.

NOTE: Please remember, this list is the starting point and will grow over time, as required.

THANK YOU VERY MUCH FOR YOUR PARTICIPATION.

Annex IV – Respondents to the survey

Role	Name	Organization	Country
Crop Leader	**George, Maria Luz C.**	Bioversity International	Malaysia
Core Group (MDL)	Baudouin, Luc	CIRAD	France
Core Group (MDL)	Harries, Hugh C.	Royal Botanic Gardens, Kew	UK
Core Group (MDL)	Labouisse, Jean-Pierre	CIRAD	France
Core Group (MDL)	Santos Alora, Gerardo	PCA	Philippines
Crop Strategy Expert/Reviewer (MDL)	Novarianto, Hengky	Indonesian Coconut and Palmae Research Institute	Indonesia
Reviewer (MDL)	Castillo Gonzalez, Ramon	Instituto Nacional de Investigaciones Forestales Agricolas y Pecuarias (INIFAP)	Mexico
Reviewer (MDL)	Chellapa, Jayabose	Central Plantation Crops Research Institute	India
Reviewer (MDL)	Halafihi, Mana'ia	Ministry of Agriculture and Food, Forests and Fisheries	Tonga
Reviewer (MDL)	Jerard, Augustine B.	Central Plantation Crops Research Institute (CPCRI)	India
Reviewer (MDL)	Longxiang, Tang	Coconut Research Institute of Chinese Academy of Tropical Agriculture Sciences (CRICATAS)	China
Reviewer (MDL)	Nazirul, Islam	Horticulture Research Centrer	Bangladesh
Reviewer (MDL)	Niral, V.	C.P.C.R.I	India
Reviewer (MDL)	Odewale, Joshua Olusesan	Nigerian Inst for Oil Palm Research (NIFOR)	Nigeria
Reviewer (MDL)	Perera, S. A. C. N.	Coconut Research Institute of Sri Lanka	Sri Lanka
Reviewer (MDL)	Rivera, Limosinero Ramon	Philippine Coconut Authority-Zamboanga Research Center	Philippines
Reviewer (MDL)	Sileye, Tiata	VARTC	Vanuatu
Reviewer (MDL)	Solangi, Abdul Hameed	Coastal Agricultural Research station, PARC	Pakistan
Reviewer (MDL)	Tevita, Kete N.	Secretariat of the Pacific Community	Fiji
Reviewer (MDL)	Zhiguo, Dong	Coconut Research Institute	China

Annex V – Descriptors listed in the Coconut survey ranked by rating average and by percentage of importance

Descriptor	Rating Average
Susceptibility to biotic stresses	
LETHAL YELLOWING* (8.6.1)	4.11
COCONUT FOLIAR DECAY VIRUS (CFDV) (8.2.1)	3.65
BUD ROT (*Phytophthora* spp.) (8.1.2)	3.59
RHINOCEROS BEETLE (*Oryctes rhinoceros*) (8.7.34)	3.37
COCONUT CADANG-CADANG VIROID (CCCVd) (8.2.2)	2.81
COCONUT HISPINE BEETLE (*Brontispa longissima* Gestro) (8.7.29)	2.60
KERALA ROOT WILT (8.6.1)	2.47
STEM BLEEDING (*Ceratocystis paradoxa*; *Chalara paradoxa*) (8.1.9)	2.44
RED RING NEMATODE (*Bursaphelenchus cocophilus*) (8.4.1)	2.31
HARTROT (*Phytomonas* sp.) (8.5.1)	2.13
KALIMANTAN WILT	1.94
LIXA PEQUENA (*Catacauma torrendiella*) (8.1.11)	1.21
QUEIMA DAS FOLHAS (*Botryodiplodia theobromae*) (8.1.12)	1.13
LIXA GRANDE (*Coccostroma palmicola*) (8.1.13)	1.07
Susceptibility to abiotic stresses	
DROUGHT (7.3)	4.50
WATERLOGGING (7.2)	3.28
MINERAL DEFICIENCIES (7.5)	3.00
PH (7.7)	2.82
LOW TEMPERATURE (7.4)	2.79
MINERAL TOXICITIES (7.6)	2.63
SALINITY (7.1)	2.00

Descriptor	% Importance (Very important)
Susceptibility to biotic stresses	
LETHAL YELLOWING* (8.6.1)	72.2
BUD ROT (*Phytophthora* spp.) (8.1.2)	47.1
RHINOCEROS BEETLE (*Oryctes rhinoceros*) (8.7.34)	42.1
COCONUT FOLIAR DECAY VIRUS (CFDV) (8.2.1)	41.2
COCONUT CADANG-CADANG VIROID (CCCVd) (8.2.2)	37.5
KERALA ROOT WILT (8.6.1)	33.3
RED RING NEMATODE (*Bursaphelenchus cocophilus*) (8.4.1)	31.3
COCONUT HISPINE BEETLE (*Brontispa longissima* Gestro) (8.7.29)	25.0
STEM BLEEDING (*Ceratocystis paradoxa*; *Chalara paradoxa*) (8.1.9)	18.8
KALIMANTAN WILT	12.5
HARTROT (*Phytomonas* sp.) (8.5.1)	12.5
LIXA PEQUENA (*Catacauma torrendiella*) (8.1.11)	7.1
QUEIMA DAS FOLHAS (*Botryodiplodia theobromae*) (8.1.12)	6.7
LIXA GRANDE (*Coccostroma palmicola*) (8.1.13)	0.0
Susceptibility to abiotic stresses	
DROUGHT (7.3)	75.0
MINERAL DEFICIENCIES (7.5)	31.6
WATERLOGGING (7.2)	22.2
LOW TEMPERATURE (7.4)	21.1
MINERAL TOXICITIES (7.6)	18.8
PH (7.7)	17.6
SALINITY (7.1)	16.7

Annex VI – Additional descriptors proposed in the Coconut survey results

Coconut Descriptor	Name of expert									
	Chellapa, J.	Labouisse, J-P	Harries, H.C.	Halafihi, M.	Rivera, Ramon L.	Jerard Bosco, B. Augustine	Ramon Castillo, Gonzalez	Odewale, Joshua O.	Baudouin, Luc	Nazirul Islam, Md.
Red weevil of coconut (*Opisina arenosella*)	X									
Palm weevil (*Rhyncophorus* spp.)			X				X			
Stick insects (*Graeffea crouani*)				X						
Fruit mite (*Eriopyhes/Aceria)* For a substantiated justification, see Hewitt, W.B. & L. Chiarappa, L. (eds) (1977) Plant Health and Quarantine Problems Arising in International Genetic Resources Transfer; pp. 125-136. CBC Press Cleveland, USA.			X			X				
We have **Socorro wilt** in the Philippines although very localized.					X					
Pre mature nut fall, this usually happens in Nigeria from six months of fruit development to the eleventh month. It can reduce fruit production to abou10%								X		
Monocot weeds usually traps over 75% of nutrient that ought to be available to the coconut and can reduce production by more than 50%.								X		
Fruit bug (*Amblypelta* & *Pseudotheraptus)*			X							
Red palm mite (*Raoelia Indica*)									X	
Coconut mite (*E. guerreronis*) cause 80% surface area are damaged, accompanied by great distortion and reduction in nut **size**, Yield reduces up to 80%										X
Resistance to strong winds (Cyclone). Windstorm tolerance - see Marty, G., le Guen, V. & Fournial, T.(1986) Cyclone effects on coconut plantations in Vanuatu. Oleagineux 41 (2) 268-269.		X	X	X			X			

Annex VII – Coconut Key set of evaluation descriptors validated by CIRAD scientists after SurveyMonkey analysis on 16th April 2009

Biotic

Bud rot (*Phytophthora* spp.)	(8.1.2)
Lethal yellowing	(8.6.1)
Coconut foliar decay virus (CFDV)	(8.2.1)
Rhinoceros beetle (*Oryctes rhinoceros*)	(8.7.34)

Abiotic

Drought	(7.3)
Resistance to strong winds	(7.X)

Annex VIII - Key access and utilization descriptors for Coconut genetic resources and Contributors

PLANT DATA

Stem morphology

Measurements should be done at six and ten years after planting

Stem girth at 20 cm above soil level [cm] (4.5.1)

Stem girth at 1.5 m height [cm] (4.5.2)

Stem height [cm] (4.5.4)
Measured from ground to oldest green leaf

Date [YYYYMMDD] (4.5.4.1)

Height [cm] (4.5.4.2)

Height between 11 leaf scars (ten internodes) [cm] (4.5.9)
Measure starting from 1.5 m from ground surface

Inflorescence traits

Pollination behaviour (1.14)

1 Predominantly self-pollinated (generally dwarf varieties)
2 Intermediate
3 Predominantly out-crossing (generally tall varieties)

Number of female flowers (4.8.13)

Number of spikelets (4.8.X)

Fruit

Fruit colour of immature fruit (4.9.3)

1 Yellow
2 Yellow-red (Pale orange)
3 Red-yellow (Orange)
4 Red
5 Red-green (Copper)
6 Green-red (Bronze)
7 Green
8 Green-yellow (Pale-green)
9 Yellow-green (Greenish yellow)
10 Red-yellow-green (Brown)

Fruit polar section shape (4.9.10)

1 Round
2 Egg-shaped
3 Pear-shaped
4 Elliptic

Nut (fruit without husk) appearance and shape (4.9.15)

1 Pointed
2 Ovoid
3 Almost round
4 Oblate

Fruit component analysis (FCA)

Fruit weight [g] (4.10.1)
Whole fruit

Husk weight [g] (4.10.Xa)

Nut weight [g] (4.10.2)
Fruit without husk

Shell weight [g] (4.10.4)
Nut without water and without endosperm

Water weight [g] (4.10.Xb)

Endosperm weight [g] (4.10.Xc)

Endosperm thickness [mm] (4.11.1)
Measured on the equator of the nut

Yield

Date observations began [YYYYMMDD] (4.12.1)

Date observations ended [YYYYMMDD] (4.12.2)

Number of bunches per palm per year (4.12.4)

Number of fruits harvested per palm per year (4.12.5)

Copra weight per nut [g] (4.12.7)
Calculated as: copra (g) = dry endosperm (g) * 100 / 94

Dry meat oil content [%] (4.13.1)
Based on weight of oil extracted / total dry weight of the sample × 100
(Soxhlet Method to be used)

Abiotic stresses

Drought (7.3)

Strong winds (7.X)

Coded on a 1-9 resistance scale, as follows:

1 Very low
3 Low
5 Intermediate
7 High
9 Very high

Biotic stresses

Bud rot (*Phytophthora* spp.) (8.1.2)

Coconut foliar decay virus (CFDV) (8.2.1)

Lethal yellowing (8.6.1)

Rhinoceros beetle (*Oryctes rhinoceros*) (8.7.34)

Notes

Any additional information may be specified here, including possible deviations from the Stantech Manual methods.

CONTRIBUTORS

Core Advisory Group

Luc Baudouin, Centre de Cooperation Internationale en Recherche Agronomique pour le Developpement (CIRAD), France
Maria Luz George, Bioversity International, Malaysia
Chantal Hamelin, CIRAD, France
Hugh C. Harries, UK
Jean-Pierre Labouisse, CIRAD, France
Gerardo Santos Alora, PCA, Philippines

Reviewers

Bangladesh

Islam Nazirul, Horticulture Research Centre

China
Tang Longxiang, Coconut Research Institute
Dong Zhiguo, Coconut Research Institute

Fiji
Kete Tevita, Secretariat of the Pacific Community

France
Michel Dollet, CIRAD
Alexia Prades, CIRAD

India
Augustine Jerard Bosco, Central Plantation Crops Research Institute
Jayabose Chellapa, Central Plantation Crops Research Institute
V. Niral, Central Plantation Crops Research Institute

Indonesia
Hengky Novarianto, Indonesian Coconut and Palm Research Institute

Mexico
Ramon Artemio Castillo Gonzalez, Instituto Nacional de Investigaciones Forestales, Agricolas y Pecuarias

Nigeria
Joshua Odewale, Nigerian Institute for Oil Palm Research

Pakistan
Abdul Hameed Solangi, Coastal Agricultural Research Station

Philippines
Ramon Rivera Limosinero, Philippine Coconut Authority-Zamboanga Research Centre

Sri Lanka
Chandrika Perera, Coconut Research Institute

Tonga
Mana'ia Halafihi, Ministry of Agriculture and Food, Forests and Fisheries

Vanuatu
Tiata Sileye, Agriculture and Technical Centrer

Bioversity International

Methodology for the definition of a key set of characterization and evaluation descriptors for cowpea [*Vigna unguiculata* (L.) Walp.]

GLOBAL CROP DIVERSITY TRUST
A FOUNDATION FOR FOOD SECURITY

Information collection and preparation of the Minimum Descriptor List (MDL)

Information for the definition of a Minimum Descriptor List for cowpea was based on the publication 'Descriptors for Cowpea' published by IBPGR (now Bioversity International) in 1983. The comprehensive descriptors list included in this publication was compared to characteristics and traits mentioned in a number of other sources such as Descriptors for VIGNA (USDA, ARS, GRIN), Descriptors for Characterization and Evaluation of Cowpea (National Institute of Agrobiological Sciences, NIAS, Genebank of Japan) as well as those drawn from the article 'Cowpea [*Vigna unguiculata* (L.) Walp.] core collection defined by geographical, agronomical and botanical descriptors' (V. Mahalakshmi, Q. Ng, M. Lawson and R. Ortiz, Plant Genetic Resources: Characterization and Utilization, Vol. 5, Issue 3, pp. 113-119, NIAB, 2007). An Excel table was prepared comparing descriptors mentioned in each list. The table was then refined during a crop-specific meeting held at the National Bureau of Plant Genetic Resources (NBPGR) in India in June 2009, that involved several scientists from NBPGR and the Indian Agricultural Research Institute (IARI). The consultation resulted in the definition of a preliminary key set of descriptors for cowpea (see Annex I).

Preparation of the List of Experts

As the original publication was too old to be used for this purpose, the List of Experts was prepared taking into account different sources such as the European Cooperative Programme for Plant Genetic Resources (ECPGR) *Vigna* Database website maintained by the Austrian Agency for Health and Food Safety (AGES), the World Vegetable Center in Taiwan (AVRDC), the International Institute of Tropical Agriculture (IITA), FAO WIEWS Directory of Germplasm Holdings, SINGER and the Network for the Genetic Improvement of Cowpea for Africa (NGICA), as well as the *Vigna* Crop Germplasm committee from the USDA ARS-GRIN. The relevant participants in the Conference on Biotechnology, Breeding and Seed Systems for African Crops, organized by the Rockefeller Foundation and the Instituto de Investigação Agrária de Moçambique (IIAM), held in March 2007, were also added to the list that was then refined during the crop-specific meeting held at NBPGR in June 2009.

Overall, 63 experts, from 28 countries and 37 different organizations, were listed (see Annex II). Out of these, Dr Dominique Dumet (IITA) and Dr S.K. Mishra (NBPGR) were identified as Crop Leaders and were asked to review the list and add/delete names as they saw fit or pertinent. They were also asked to select experts to join the Core Advisory Group, for the definition of an initial key set of descriptors for cowpea. During the last phase of development of the key list, Dr Dumet communicated that she felt it more appropriate to be replaced by Christian Fatokun from IITA as Crop Leader for this crop.

Survey preparation and distribution

Due to the tight timeframe of the project and Dr Dumet only being available for the last phase of the definition of the key set, the initial list was further refined during the crop-specific consultation meeting held at NBPGR, India in June 2009, involving several scientists from NBPGR and the Indian Agricultural Research Institute (IARI). Dr Mishra accepted to be the Crop Leader and other experts at the NBPGR crop-specific consultation participated in the discussions. They were asked to refine the list of experts already identified and to go through the initial list drawn from the comparison table.

A worldwide distribution of experts was involved in an online survey to define a first priority set of descriptors to describe, to access and to utilize cowpea genetic resources. This key set was afterwards validated by a Core Advisory Group (see 'Contributors') led by Dr S.K. Mishra of NBPGR and Dr Christian Fatokun of IITA.

The survey on *Vigna* spp., proposing the Minimum List of Descriptors (see Annex III) as approved at NBPGR, was uploaded into the SurveyMonkey application on the Internet (see Annex IV) and an email invitation was sent out to the list of selected experts on 2 July 2009 providing them with the link to access the Survey. They were invited to rate the importance of the proposed characterization and evaluation descriptors for this crop and were also encouraged to mention any additional trait that was found to be relevant yet missing from the proposed Minimum List, along with a substantiated justification for its inclusion. The survey deadline was set at 30 July 2009. A first reminder was sent out on 17 July 2009 and a second on 29 July 2009 to ensure that the greatest possible feedback was obtained.

Survey analysis and refinement of the Minimum List

Of the 63 experts who were identified and involved in the exercise, 23 from 13 countries and 17 organizations recorded their comments using the online survey (see Annex V). Results from the survey were analyzed and descriptors were ranked by rating average and percentage of importance (see Annex VI). An email consultation was carried out among members of the CAG asking them to validate the descriptors resulting from the survey as 'most important' (see Annex VII). Descriptors having a wide consensus amongst the experts were highlighted in blue bold face. These summary results of the survey, together with a report containing comments received by the participants (see Annex VIII), were sent to the Core Advisory Group inviting experts to select descriptors that should be included in the minimum list by indicating them with an 'X' in the relevant column. A first draft of the key set for cowpea, including relevant descriptor states and methods, was produced and submitted to the Crop Leaders and to the CAG for final validation (see Annex IX). Their advice was also requested for the inclusion of 'Days to pod maturity' and the definition of the descriptor states of the 'Seed coat colour' descriptor.

Comments received were included and harmonized, wherever possible, with the final version and were shared for final validation, through email, with the experts who contributed to the selection of the final key set of characterization and evaluation descriptors for cowpea. The deadline for validation was set for 12 February 2010. An important issue was raised by one of the members of the CAG who strongly suggested the addition of the descriptor 'Testa texture' to the final list because the rating obtained from the survey was the same as 'Eye colour'. He also requested to rename the descriptor 'Plant growth habit' with 'Plant architecture'. After a consultation with CAG members regarding this issue, all the inputs received were collected and shared with the Crop Leaders (Dr Fatoukun and Dr Mishra) for their final decision.

Definition of a final key set of descriptors for cowpea

The final document approved by the Crop Leaders and CAG, including all the descriptor states and contributors (see Annex X), was tagged for layout, edited by a freelance editor and sent to the Bioversity Publications Unit for layout and on-line publication processes. Furthermore, the publication was shared with the ECPGR Secretariat; the Generation Challenge Programme (GCP) Ontology and the SGRP Crop Genebank Knowledge Base partners. Additionally, data were converted into Excel files for uploading into the GRIN-Global genebank data-management system being developed by USDA and into the global accession level information portal (GENESYS), linking national, regional and international genebank databases in support of the conservation and use of plant genetic resources for food and agriculture (PGRFA). The Excel files were also provided to the System-wide Information Network for Genetic Resources (SINGER) and to EURISCO.

Acknowledgement

Bioversity is grateful to all the scientists and researchers who have contributed to the development of the strategic set of 'Key access and utilization descriptors for cowpea genetic resources', and to the Global Crop Diversity Trust for their financial support. Particular recognition goes to the Crop Leaders, Dr Christian Fatokun from IITA, Nigeria and Dr S.K. Mishra from NBPGR, India, for providing valuable scientific direction. Ms Adriana Alercia provided technical expertise and guided the entire production process.

Annex I – Summary comparison table weighing up important descriptors for cowpea drawn from different sources[1]

Descr. No.	Descriptors for *Vigna* spp. (cowpea)	IBPGR 1983 (1)	USDA (2)	IITA, 2006 (3)	NIAS (4)	NBPGR Long (5)	NBPGR Min_09 (5)
4.1.1	Growth habit	*	*	*	*	*	*
4.1.2	Growth pattern	*				*	
4.1.3	Twining tendency	*		*		*	
4.1.4	Plant pigmentation	*		*		*	*
4.1.5	Terminal leaflet shape	*	*			* (difficult)	
4.1.6	Plant hairiness	*				*	*
4.2.1	Days to 50% flowering	*		*	*	*	*
4.2.2	Raceme position	*		*		*	
4.2.3	Days to first mature pods	*	*	*		Delete	
4.2.4	Pod attachment to peduncle	*		*		*	
4.2.5	Immature pod pigmentation	*		*	*	*	*
4.2.6	Pod curvature of mature pods	*				*	
4.2.7	Pod length [cm]	*	*	* but [mm]	*	*	* (cm is ok)
4.2.8	Number of locules per pod	*		*	*	*	
4.3.1	Seed shape	*	*			*	
4.3.2	Testa texture	*	*	*		*	*
4.3.3	Eye pattern	*	*	*		*	
4.3.4	Eye colour	*	*	*	*	*	*
4.3.5	100 Seed weight [g]	*	* 25%		* 100 but in [g]	*	*
6.1.1	Hypocotyl length [mm]	*				*	
6.1.2	Leaf colour	*				*	
6.1.3	Leaf marking	*				*	
6.1.4	Terminal leaflet length [mm]	*		*		*	
6.1.5	Terminal leaflet width [mm]	*		*		*	
6.1.6	Leaf texture	*				*	
6.1.7	Stipule length [mm]	*				*	
6.1.8	Stipule width [mm]	*				*	
6.1.9	Number of main branches	*		*	*	*	*
6.1.10	Number of nodes on main stem	*		*	*	*	
6.1.11	Plant early vigour	*		*		*	
6.1.12	Leaf-stem ratio	*				*	
6.1.13	Percentage dry weight	*				Not required	
6.1.14	Green matter yield per plant [g]	*				*	
6.1.15	Capacity for re-growth	*				*	
6.1.16	*In vitro* dry matter digestibility	*				*	
6.2.1	Flowering pigment pattern	*		*		Delete (see flower colour)	
6.2.2	Flower colour	*	*		*	*	*
6.2.3	Flower standard length [mm]	*				*	
6.2.4	Calyx lobe length [mm]	*				*	
6.2.5	Duration of flowering	*				Delete	
6.2.6	Number of racemes per plant	*				*	
6.2.7	Peduncle length [mm]	*				*(important for harvesting)	*
6.2.8	Number of pods per peduncle	*	*	*		*	*
6.2.9	Number of pods per plant	*				*	
6.2.10	Pod width [cm]	*		* but [mm]	*	Delete	
6.2.11	Pod wall thickness	*				Difficult to measure	

6.2.12	Pod colour	*	* (dry)			*	*
6.3.1	Seed length [mm]	*	* (but size)	*		*	
6.3.2	Seed width [mm]	*	* (but size)	* (but size)		*	
6.3.3	Seed thickness [mm]	*		*		*	
6.3.4	Seed crowding	*		*		*	
6.3.5	Splitting of testa	*				*	
6.3.6	Attachment of testa	*				*	
6.3.7	Percentage seed protein	*				*	*
7.1	Low temperature	*				Not required	
7.2	High temperature	*				*	
7.3	Drought	*				*	*
7.4	High soil moisture	*				*	
8.1.1	Coried bugs	*				*	
8.1.2	Striped bean weevil (*Alcidodes leucogrammus*)	*				*	*
8.1.3	Cowpea aphid (*Aphis craccivora*)	*	*	*		*	
8.1.4	Pea aphid (*Aphis fabae*)	*				*	
8.1.5	Cowpea storage weevil (*Callosobruchus chinensis*)	*				*	
8.1.6	Cowpea curculio (*Chalcodermus aeneus*)	*				*	
8.1.7	Beetle (*Chrysolagria* spp.)	*				*	
8.1.8	Pod borer (*Cydia ptychora*)	*				*	
8.1.9	Leaf hoppers (*Empoasca* Kerri)	*				*	
8.1.10	Epilachna beetles (*Epilachna* spp.)	*				*	
8.1.11	Lima bean pod borer (*Etiella zinckenella*)	*				*	
8.1.12	African bollworm (*Heliothis armigera*)	*				*	
8.1.13	Beetle (*Lagria villosa*)	*				*	
8.1.14	Legume pod borer (*Maruca testulalis*)	*				*	
8.1.15	Adzuki pod borer (*Matsumuraeses phaseoli*)	*				*	
8.1.16	Striped foliage beetle (*Medythia quaterna*)	*				*	
8.1.17	Flower thrips (*Megalurothrips sjostedti*)	*				*	
8.1.18	Blister beetle (*Mylabris* spp.)	*				*	*
8.1.19	Green stink bug (*Nezara viridula*)	*				*	
8.1.20	Foliage beetles (*Ootheca bennigseni Ootheca mutabilis*)	*				*	
8.1.21	Pod weevil (*Piezotrachelus varius*)	*				*	
8.1.22	Foliage thrips (*Sericothrips occipitalis*)	*				*	
8.1.23	Egyptian leaf worm (*Spodoptera littoalis*)	*				*	
8.2.1	Ascochyta blight (*Ascochyta phaseolorum* Sacc.)	*				*	
8.2.2	Cercospora leaf spot (*Cercospora cruenta* Sacc.)	*		*		*	*
8.2.3	Lamb's tail pod tot (*Choanephora* spp.)	*				*	
8.2.4	Brown blotch (*Colletotrichum truncatum* (Schw.) Andrus & Moore)	*				*	
8.2.5	Anthracnose (*Collectrichum, Lindemuthianum*)	*				*	
8.2.6	Target leaf spot (*Corynespora cassiicola*)	*				*	
8.2.7	Scab (*Elsinoë phaseoli* Jenkins)	*				*	

8.2.8	Powdery mildew (*Erysiphe polygoni* DC)	*				*	*
8.2.9	Fusarium wilt (*Fusarium oxysporum Shlect*)	*	*			*	
8.2.10	Fusarium collar and stem rot (*Fusarium solani* (Mart) Appel & Wollenw)	*				*	
8.2.11	Pink rust (*Phakosora pachyrizi* Syd.)	*				*	
8.2.12	Phytophtora stem rot (*Phytophthora cactorum* (Leb. & Cohn) Schroet)	*				*	
8.2.13	Leaf smut (*Protomycopsis phaseoli*)	*				*	
8.2.14	Pythium stem rot (*Pythium aphanidermatum* (Edson) Fritz.)	*				*	
8.2.15	Seedling mortality (*Pythium aphanidermatum* (Edson) Fritz.)	*				*	
8.2.16	Seedling mortality (*Rhizoctonia solani* Kuehn)	*				*	
8.2.17	Web blight (*Rhizoctonia solani* Kuehn)	*				*	
8.2.18	Sclerotium stem rot (*Sclerotium rolfsii* Sacc.)	*				*	
8.2.19	Septoria leaf spot (*Septonia vignae*, *Septoraia vignicola*)	*				*	
8.2.20	False rust (*Synchytrium dolichi*)	*				*	
8.2.21	Brown rust (*Uromyces appendiculatus*)	*				*	
8.2.22	Veticillium wilt *(Verticillium albo-atrum* Reinke & Berth)	*				*	
8.3.1	Bacterial light and canker (*Xanthomonas vignicola* Burkh.)	*				*	
8.4.1	Cowpea aphid-borne mosaic	*	*			*	
8.4.2	Cowpea banding mosaic	*				*	
8.4.3	Cowpea chloritic mottle cowpea golden mosaic	*	*			*	
8.4.4	Cowpea golden mosaic	*				*	
8.4.5	Cowpea mild mottle	*				*	
8.4.6	Cowpea mottle	*				*	
8.4.7	Cowpea ringspot	*				*	
8.4.8	Cowpea (severe) mosaic	*	*			*	
8.4.9	Cowpea (yellow) mosaic	*	*			*	*
8.4.10	Cucumber mosaic	*	*			*	
8.4.11	Southern bean mosaic	*				*	
8.4.12	Sunn-hemp mosaic	*				*	
New	Plant height at maturity (Average of 5 plants) [cm]		*		*	*	
New	Pod position		*	*		*	
New	Seed coat colour		*	*		*	*
New	Cotyledon colour				*	*	*
	Hillum ring colour				*	Not required	
New	Colour of mottles on seed coat				*	*	

[1] (1) 'Descriptors for Cowpea' (IBPGR, now Bioversity International, in 1983);
(2) Descriptors for VIGNA (USDA, ARS, GRIN);
(3) 'Cowpea [*Vigna unguiculata* (L.) Walp.] core collection defined by geographical, agronomical and botanical descriptors' (V. Mahalakshmi, Q. Ng, M. Lawson and R. Ortiz Plant Genetic Resources: Characterization and Utilization, Vol. 5, Issue 3, pp. 113-119, NIAB, 2007);
(4) Descriptors for Characterization and Evaluation of Cowpea (National Institute of Agrobiological Sciences, NIAS, Genebank of Japan);
(5) Long and Minimum list of descriptors identified by participants in the crop-specific meeting held at the NBPGR in June 2009.

Annex II – List of experts identified to participate in the survey

SOURCE	*ROLE*	*NAME*	*ORGANIZATION*	*COUNTRY*
SINGER survey	**Crop Leader**	**Dumet, Dominique**	IITA	Nigeria
NBPGR 09	**Crop Leader**	**Mishra, S.K.**	NBPGR	India
NGICA website	**CAG**	Boukar, Ousmane	IITA	Nigeria
Replied instead of Lopes (Germplasm collection)	**CAG**	Damasceno e Silva, Kaesel Jackson	EMBRAPA	Brazil
NGICA website	**CAG**	Fatokun, Christian	IITA	Nigeria
Chair *Vigna* Crop Germplasm committee	**CAG**	Fery, Richard	USDA/ARS	USA
Replied instead of Kotter (WIEWS)	**CAG**	Lohwasser, Ulrike	Leibniz Institute of Plant Genetics and Crop Plant Research (IPK)	Germany
Germplasm collection	**CAG**	Morris, Brad	USDA/ARS	USA
UPOV P. Button	**CAG**	Niwa, Yuji	UPOV	Japan
UPOV P. Button	**CAG**	Yuasa, Mitsuo	UPOV	Japan
Participant conference 2007	Reviewer	Arinaitwe, Abel	Makerere University	Uganda
WIEWS	Director General	Arnaldo, Adolfo	Instituto de Investigaciones Fundamentales en Agricultura Tropical (INIFAT)	Cuba
NGICA website	Cowpea entomologist	Baoua, Ibrahim	INRAN	Niger
NBPGR 2009	Reviewer	Bharadwaj, C	IARI, Genetics	India
IITA website		Boahen, Stephen	IITA	Mozambique
NGICA website	Reviewer	Bressan, Ray A.	Purdue University	USA
ECPGR	Reviewer	Burlayaeva, Marina	VIR Vavilov Institute	Russian Federation
NGICA website	Reviewer	Campos, Francisco A.P.	Federal University of Cerará	Brazil
ECPGR	Reviewer	De la Cuadra, Celia	INIA Madrid	Spain
Also in bean survey	Reviewer	De Ron, Antonio M.	Misión Biológica de Galicia - CSIC - Phaselieu	Spain
Germplasm collection	Reviewer	Debouck, Daniel G.	CIAT	Colombia
WIEWS	Reviewer	Dillon, Sally	Australian Tropical Crops & Forages Genetic Resources Centre	Australia
NBPGR 2009	Reviewer	Dua, Ram Prakash	NBPGR	India
NGICA website	Reviewer	Ehlers, Jeff	University of California Riverside	USA

IITA website	Coordinator, Legumes for Livelihoods Project	Graner, Andreas	IPK	Germany
USDA website	Reviewer	Harrison, Howard	USDA/ARS	USA
WIEWS	Reviewer	Jenks, Matthew	Purdue University	USA
USDA website	Research Agronomist	Kainz, Wolfgang	AGES	Austria
NBPGR 2009	Reviewer	Kharkwal, M.C.	IARI, Genetics	India
NBPGR 2009	Reviewer	Kumar, J.	IARI, Genetics	India
NGICA website	Reviewer	Kyeong-ho, Chung	AVRDC	Taiwan
ECPGR	Reviewer	Lawrence, Peter	Australian Tropical Crops &Forage Genetic Res. Centre	Australia
AVRDC contacts	Legume researcher	Mabutha, Obert	Ministry of Agriculture	Botswana
Germplasm collection	Reviewer	Mahajan, R.K.	NBPGR	India
Germplasm collection	Reviewer	Mamadou Touré,	IER, Cinzana Station, Segou	Mali
ECPGR	Reviewer	Manoah, Myra	Israel Gene Bank for Agricultural Crops, Agricultural Research Organisation, Volacni Center	Israel
NGICA website	Reviewer	Moar, William	Auburn University	USA
NGICA website	Plant breeder	Mohammad F. Ishiyaku	Ahmadu Bello University	Nigeria
ICRISAT website	Reviewer	Monyo, Emmanuel	ICRISAT	Malawi
ICRISAT website	Breeder	Moutari, Adamou	INRAN	Niamey
NGICA website	Reviewer	Murdock, Larry	Purdue University	USA
Jefferson website	Director of programs	Myers Rob	Jefferson Agriculture Institute	USA
NGICA website	Reviewer	Ndiaga Cisse	ISRA/CNRA	Senegal
Suggested by ECPGR Coordinator	Director General	Negri, Valeria	University of Perugia	Italy
NGICA website	Reviewer	Nwalozie, Marcel	CORAF	Senegal
Suggested by ECPGR Coordinator	Reviewer	Obreza, Matija	IITA	Nigeria
NGICA website	Reviewer	Pandravada, S.R.	NBPGR	India
SINGER survey	Genebank data manager	Rai, Mathura	IIVR, Varanasi	India
NBPGR 2009	Reviewer	Raje, R.S.	IARI, Genetics	India
NBPGR 2009	Reviewer	Rana, J.C.	NBPGR	India
NBPGR website	Reviewer	Roberts, Philip A.	University of California Riverside	USA

NGICA website	Reviewer	Singh, Bir. B.	Retired	Nigeria
NGICA website	Reviewer	Sithole-Niang, Idah	University of Zimbabwe	Zimbabwe
AVRDC contacts	Cowpea Breeder	Srinivasan Ramasamy	AVRDC	Taiwan
NGICA Network	Reviewer	Stavropoulos, Nikolaos	NAGREF	Greece
AVRDC contacts	Entomologist	Tamo, Manuele	IITA	Benin
ECPGR	Reviewer	Terry, Eugene	AATF c/o ILRI	Kenya
IITA website	Legume entomologist	Thies, Judy	USDA/ARS	USA
ICRISAT	Cowpea breeder	Upadhyaya, Hari D	ICRISAT	India
NGICA website	Plant pathologist	Van Vugt, Daniel	IITA	Malawi
USDA website	Research Plant Pathologist	Vanderborght, Thierry	National Botanic Garden	Belgium
ICRISAT	Reviewer	Widders, Irvin E.	Bean/cowpea CRSP	USA
IITA website	Legume Agronomist	Zong Xuxiao	ICGR-CAAS	China

Annex III – Set of descriptors for cowpea as included in the survey (June 2009) obtained during the crop consultation meeting held at NBPGR

1.	Growth habit	(4.1.1)
2.	Plant pigmentation	(4.1.4)
3.	Plant hairiness	(4.1.6)
4.	Days to 50% flowering	(4.2.1)
5.	Immature pod pigmentation	(4.2.5)
6.	Pod length [cm]	(4.2.7)
7.	Testa texture	(4.3.2)
8.	Eye colour	(4.3.4)
9.	100 Seed weight [g]	(4.3.5)
10.	Number of main branches	(6.1.9)
11.	Flower colour	(6.2.2)
12.	Peduncle length [mm]	(6.2.7)
13.	Number of pods per peduncle	(6.2.8)
14.	Pod colour	(6.2.12)
15.	Seed coat colour	
16.	Cotyledon colour	
17.	Percentage seed protein	(6.3.7)
18.	Drought	(7.3)
19.	Striped bean weevil (*Alcidodes leucogrammus*)	(8.1.2)
20.	Blister beetle (*Mylabris* spp.)	(8.1.18)
21.	Cercospora leaf spot (*Cercospora cruenta*)	(8.2.2)
22.	Powdery mildew (*Erysiphe polygoni*)	(8.2.8)
23.	Cowpea (yellow) mosaic	(8.4.9)

Annex IV – Survey to choose a key set of descriptors for cowpea utilization

WELCOME

Welcome to the survey for the selection of a key set of characterization and evaluation descriptors for cowpea to support an international information system to enhance the utilization of germplasm held in genebanks.

Your knowledge and experience are being sought to define an initial **key set** of descriptors that identify traits important to crop production and facilitate the use of accessions by researchers.

Your participation in it is highly appreciated. The deadline for this survey is **30 July 2009**

This key set of descriptors will be made available through a global portal for identifying sets of accessions for evaluation and use. For characterization, the aim is a key set of maximally differentiating traits that provide the most impact in discriminating between accessions. For evaluation, the aim is to focus on a few important traits for production, such as those related to abiotic or biotic stresses of cosmopolitan nature.

This survey consists of two parts:
- PART I: Characterization descriptors.

- PART II: Evaluation descriptors.

We thank you in advance for investing your time and expertise in selecting the set of descriptors.

*** Please allow us to acknowledge your contribution by completing your full contact details below:**

Name:

Position:

Organization:

Country:

Email Address:

PART I: Characterization descriptors

These traits enable easy and quick discrimination between phenotypes. They are generally highly heritable, can be easily seen by the eye and are equally expressed in all environments.

Based on your experience, please select descriptors that provide the most impact in discriminating between accessions. It also allows you to indicate if any essential descriptor that can contribute to its use is missing from the minimum list presented.

*Numbers in parentheses on the right -hand side are the corresponding descriptors numbers as published in the IBPGR publication 'Descriptors for Cowpea' (1983).

	Not important	Important	Very important
Growth habit (4.1.1)	◯	◯	◯
Plant pigmentation (4.1.4)	◯	◯	◯
Plant hairiness (4.1.6)	◯	◯	◯
Days to 50% flowering (4.2.1)	◯	◯	◯
Immature pod pigmentation (4.2.5)	◯	◯	◯
Pod length [cm] (4.2.7)	◯	◯	◯
Testa texture (4.3.2)	◯	◯	◯
Eye colour (4.3.4)	◯	◯	◯
100 Seed weight [g] (4.3.5)	◯	◯	◯

If you consider that an essential trait is missing from this list, please indicate it here along with a substantiated justification.

PART II: Evaluation descriptors

These descriptors include characters such as biotic stresses. They are the most interesting traits in crop improvement. Please consider the following factors relating to the trait when making your final decision: (i) Global impact, (ii) Initial strategic set, (iii) Importance for germplasm utilization, (iv) Data availability, (v) True economic damage and (vi) Wide geographical occurrence.

Please, rate these traits in order of importance at the global level. It also allows you to indicate if any essential trait for production is missing from the minimum list presented or indicate any that may not be very significant to global production.

	Not important	Important	Very important
Number of main branches (6.1.9)	◯	◯	◯
Flower colour (6.2.2)	◯	◯	◯
Peduncle length [mm] (6.2.7)	◯	◯	◯
Number of pods per peduncle (6.2.8)	◯	◯	◯
Pod colour (6.2.12)	◯	◯	◯
Seed coat colour	◯	◯	◯
Cotyledon colour	◯	◯	◯
Percentage seed protein (6.3.7)	◯	◯	◯
Drought (7.3)	◯	◯	◯
Striped bean weevil (*Alcidodes leucogrammus*) (8.1.2)	◯	◯	◯
Blister beetle (*Mylabris* spp.) (8.1.18)	◯	◯	◯
Cercospora leaf spot (*Cercospora cruenta*) (8.2.2)	◯	◯	◯
Powdery mildew (*Erysiphe polygoni*) (8.2.8)	◯	◯	◯
Cowpea (yellow) mosaic (8.4.9)	◯	◯	◯

If you consider that an essential trait important for crop improvement and production is missing from this list, or, if any of the descriptors listed is not clearly useful to promote utilization, please indicate it here along with a substantiated justification.

NOTE: Please remember, this list is the starting point and will grow over time, as required.

THANK YOU VERY MUCH FOR YOUR PARTICIPATION.

Annex V – List of respondents to the survey and contributing through email

ROLE	*NAME*	*POSITION*	*ORGANIZATION*	*Country*
Crop Leader [New (ex-CAG)]	**Fatokun, C.A.**	Plant Breeder	International Institute of Tropical Agriculture (IITA)	Nigeria
Crop Leader	**Mishra, S.K.**		National Bureau of Plant Genetic Resources (NBPGR)	India
CAG (New)	Boukar, Ousmane	Cowpea breeder	International Institute of Tropical Agriculture (IITA)	Nigeria
CAG	Damasceno e Silva, Kaesel Jackson	Researcher	Center of Agriculture Research of MidNorth - Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA)	Brazil
CAG	Fery, Richard L.	Supervisory Research Geneticist/Research Leader	United States Department of Agriculture, Agricultural Research Service (USDA-ARS), US Vegetable Laboratory	USA
CAG	Lohwasser, Ulrike	Genebank Taxonomist	Leibniz Institute of Plant Genetics and Crop Plant Research	Germany
CAG	Niwa, Yuji	Examiner	Ministry of Agriculture, Forestry and Fisheries	Japan
Reviewer	Adeleke, Remi		International Institute of Tropical Agriculture (IITA)	Nigeria
Reviewer	Bharadwaj, C.	Senior Scientist (Breeding)	Division of Genetics, Indian Agricultural Research Institute, Indian Council of Agricultural Research (IARI-ICAR)	India
Reviewer	Burlyaeva, Marina	*Vigna* Collections Curator	N.I. Vavilov Research Institute of Plant Industry (VIR)	Russian Federation
Reviewer	Cisse, Ndiaga	Plant Breeder	Institut Sénégalais de Recherches Agricoles (ISRA)	Senegal
Reviewer	De Ron, Antonio M.	Research Professor Plant Genetic Resources	Misión Biológica de Galicia, Consejo Superior de Investigaciones Científicas (MBG-CSIC)	Spain
Reviewer	Dillon, Sally	Research Scientist	Queensland Primary Industries and Fisheries	Australia
Reviewer	Dumet, Dominique	Head of the Genetic Resources Center	International Institute of Tropical Agriculture (IITA)	Nigeria
Reviewer	Ehlers, Jeffrey	Research Specialist	University of California, Riverside	USA
Reviewer	Ishiyaku, Mohammad Faguji	Head Cowpea Breeding Unit	Institute for Agricultural Research, Ahmadu Bello University, Zaria	Nigeria
Reviewer	Kainz, Wolfgang	Curator	Austrian Agency for Health and Food Safety (AGES)	Austria
Reviewer	Myers, Robert	Director of Programs	Jefferson Institute	USA
Reviewer	Negri, Valeria	Professor	Applied Biology Department, University of Perugia	Italy
Reviewer	Pandravada, S.R.	Senior Scientist	National Bureau of Plant Genetic Resources (NBPGR), Regional Station, Hyderabd	India
Reviewer	Pederson, Gary	Research Leader	United States Department of Agriculture, Agricultural Research Service (USDA-ARS), Plant Genetic Resources Conservation Unit	USA
Reviewer	Rana, J.C.	Principal Scientist	National Bureau of Plant Genetic Resources (NBPGR), Regional Station, Phagli, Shimla	India
Reviewer	Srinivasan, R.	Entomologist	Asian Vegetable Research and Development Center (AVRDC-The World Vegetable Center)	Taiwan

Annex VI – Survey summary results ranked by rating and percentage of importance

Descriptor	Rating Average
Characterization	
Pod length [cm] (4.2.7)	4.43
Days to 50% flowering (4.2.1)	4.33
100 Seed weight [g] (4.3.5)	4.29
Growth habit (4.1.1)	4.10
Testa texture (4.3.2)	3.14
Eye colour (4.3.4)	3.14
Immature pod pigmentation (4.2.5)	2.90
Plant pigmentation (4.1.4)	2.20
Plant hairiness (4.1.6)	2.14
Evaluation	
Seed coat colour	4.35
Number of pods per peduncle (6.2.8)	4.00
Percentage seed protein (6.3.7)	3.75
Drought (7.3)	3.67
Pod colour (6.2.12)	3.52
Cowpea (yellow) mosaic (8.4.9)	3.35
Flower colour (6.2.2)	3.30
Cercospora leaf spot (*Cercospora cruenta*) (8.2.2)	2.95
Powdery mildew (*Erysiphe polygoni*) (8.2.8)	2.84
Number of main branches (6.1.9)	2.76
Peduncle length [mm] (6.2.7)	2.24
Blister beetle (*Mylabris* spp.) (8.1.18)	2.21
Striped bean weevil (*Alcidodes leucogrammus*) (8.1.2)	2.00
Cotyledon colour	1.80

Descriptor	% Importance (important)	% Importance (Very important)
Characterization		
Pod length [cm] (4.2.7)	28.6% (6)	71.4% (15)
100 Seed weight [g] (4.3.5)	23.8% (5)	71.4% (15)
Days to 50% flowering (4.2.1)	33.3% (7)	66.7% (14)
Growth habit (4.1.1)	33.3% (7)	61.9% (13)
Eye colour (4.3.4)	33.3% (7)	42.9% (9)
Testa texture (4.3.2)	57.1% (12)	28.6% (6)
Plant hairiness (4.1.6)	23.8% (5)	28.6% (6)
Immature pod pigmentation (4.2.5)	57.1% (12)	23.8% (5)
Plant pigmentation (4.1.4)	40.0% (8)	20.0% (4)
Evaluation		
Seed coat colour	20.0% (4)	75.0% (15)
Number of pods per peduncle (6.2.8)	38.1% (8)	57.1% (12)
Drought (7.3)	42.9% (9)	47.6% (10)
Pod colour (6.2.12)	38.1% (8)	47.6% (10)
Percentage seed protein (6.3.7)	50.0% (10)	45.0% (9)
Flower colour (6.2.2)	35.0% (7)	45.0% (9)
Cowpea (yellow) mosaic (8.4.9)	45.0% (9)	40.0% (8)
Cercospora leaf spot (*Cercospora cruenta*) (8.2.2)	63.2% (12)	21.1% (4)
Striped bean weevil (*Alcidodes leucogrammus*) (8.1.2)	31.6% (6)	21.1% (4)
Peduncle length [mm] (6.2.7)	42.9% (9)	19.0% (4)
Powdery mildew (*Erysiphe polygoni*) (8.2.8)	68.4% (13)	15.8% (3)
Blister beetle (*Mylabris* spp.) (8.1.18)	47.4% (9)	15.8% (3)
Cotyledon colour	35.0% (7)	15.0% (3)
Number of main branches (6.1.9)	76.2% (16)	9.5% (2)

Annex VII – List of descriptors proposed in the survey ranked by rating average sent to the Crop Leaders for validation

Descriptor	Your selection	Rating Average
Characterization		
Pod length [cm] (4.2.7)		4.43
Days to 50% flowering (4.2.1)		4.33
100 Seed weight [g] (4.3.5)		4.29
Growth habit (4.1.1)		4.10
Testa texture (4.3.2)		3.14
Eye colour (4.3.4)		3.14
Immature pod pigmentation (4.2.5)		2.90
Plant pigmentation (4.1.4)		2.20
Plant hairiness (4.1.6)		2.14
Evaluation		
Seed coat colour		4.35
Number of pods per peduncle (6.2.8)		4.00
Percentage seed protein (6.3.7)		3.75
Drought (7.3)		3.67
Pod colour (6.2.12)		3.52
Cowpea (yellow) mosaic (8.4.9)		3.35
Flower colour (6.2.2)		3.30
Cercospora leaf spot (*Cercospora cruenta*) (8.2.2)		2.95
Powdery mildew (*Erysiphe polygoni*) (8.2.8)		2.84
Number of main branches (6.1.9)		2.76
Peduncle length [mm] (6.2.7)		2.24
Blister beetle (*Mylabris* spp.) (8.1.18)		2.21
Striped bean weevil (*Alcidodes leucogrammus*) (8.1.2)		2.00
Cotyledon colour		1.80

Annex VIII – Additional descriptors included in the open-ended section of the survey

Cowpea descriptor		Name of expert										
Additional traits	**N. times selected**	**Burlyaeva (Vavilov Inst. Russian Federation)**	**Srinivasan (AVRDC -The World Vegetable Center, Taiwan)**	**Kaesel Jackson D. (EMBRAPA, Brazil)**	**Rana (NBPGR, India)**	**Ehlers (Univ. of California, Riverside, USA)**	**Kainz (AGES, Austria)**	**Faguji Ishiyaku (Inst. Agric. Res., Ahmadu Bello Univ., Nigeria)**	**Dumet (IITA, Nigeria)**	**Boukar (IITA, Nigeria)**	**Cisse (ISRA, Senegal)**	**Myers (Jefferson Institute, USA)**
Immature pod -presence of membrane (absent, medium, profuse)	**1**	X										
Immature pod - presence of fibre (absent, medium, abundant)	**1**	X										
Sugar content of immature pods	**1**	X										
Stem - length	**1**	X										
Seed shape (4.3.1)	**1**			X								
Average Seeds per pod	**2**				X (For grain seeds/pod is important and for vegetable pod length and fibre content matters)		X					
Peduncle position-above canopy or within. (This clearly and rapidly distinguish accessions)	**1**							X				
Eye shape	**1**								X			
Early, medium or late maturing	**2**								X	X Days to 95% maturity to help identify the accessions as early, medium or late		
Leaf Shape	**1**										X	

Pod dehiscence (after maturity) (weak, medium, strong)	**2**	X										X Harvestability - how easy is it to harvest the variety? Related to that is lodging resistance.
Pod curvature (4.2.6)	**1**	X										
Internodes length	**1**			X								
Hypocotyl length (6.1.1)	**1**			X								
Epicotyl length	**1**			X								
Cooking ability (very poor, medium, very good)	**1**	X										
The seed quality has also been considered, mainly for the minerals contents like zinc and iron.	**1**			X								
For fodder types foliage quantity is important	**1**				X							
Cowpea storage weevil (*Callosobruchus* spp.) (8.1.5)	**2**		X								X	
Pod borer (*Maruca vitrata*) (8.1.8)	**1**		X									
Bean aphid (*Aphis craccivora*) (8.1.3)	**4**		X			X		X			X	
Cowpea aphid-borne mosaic (8.4.1)	**3**			X		X				X		
Flower thrips (*Megalurothrips usitatus*) (8.1.17)	**3**		X			X					X	
Cucumber mosaic (8.4.10)	**3**			X						X	X	
Brown blotch (*Colletotricum truncatum*) (8.2.4)	**1**			X								
Thanatephorus cucumeris	**1**			X								
Resistance to root-knot nematodes	**1**					X						
Bacterial blight	**3**							X		X	X	
Striga	**1**									X		
Alectra	**2**							X		X		
Scab (*Sphaceloma* sp)	**1**							X				
COMMENTS												
We consider flower colour, pod colour, seed coat colour as characterization desciptors that also are very important as evaluation descriptors				X								

Annex IX – Key access and utilization descriptors for cowpea sent to CAG for validation

PLANT DATA

Growth habit (4.1.1)

Evaluated in the 6th week after sowing

1 Acute erect (branches form acute angles with main stem)
2 Erect (branching angle less acute than above)
3 Semi-erect (branches perpendicular to main stem, but do not touch the ground)
4 Intermediate (lower branches touch the ground)
5 Semi-prostrate (main stem reaches 20 or more centimetres)
6 Prostrate (plants flat on ground; branches spread several metres)
7 Climbing

Days to 50% flowering (4.2.1)

Number of days from sowing until 50% of the plants have begun to flower. Recorded for plants with the same sowing date at the same location each year

Pod length [cm] (4.2.7)

Average length of the 10 longest mature pods from 10 randomly selected plants

Days to pod maturity (4.2.X)

Number of days from sowing to when 95% of the plants have mature pods

Eye colour (4.3.4)

0 Eye absent (white, cream)
1 Brown splash or gray
2 Tan brown
3 Red
4 Green
5 Blue to black
6 Blue to black spots or mottle
7 Speckled (even distribution of fine speckling)
8 Mottled (dark brown pigment typically absent around hilum)
9 Mottled and speckled (Victor)
99 Other (specify in the descriptor **Notes**)

100-Seed weight [g] (4.3.5)

Weight of 100 seeds with 12% moisture content

Seed coat colour (4.3.X)

Flower colour (6.2.2)

1 White
2 Violet
3 Mauve-pink
99 Other (specify in the descriptor **Notes**)

Number of pods per peduncle (6.2.8)

Recorded under total insect control. Average number of 10 randomly selected peduncles

Pod colour (6.2.12)

Of mature pod

1 Pale tan or straw
2 Dark tan
3 Dark brown
4 Black or dark purple
99 Other (specify in the descriptor **Notes**)

Seed protein [%] (6.3.7)

ABIOTIC STRESSES

Drought (7.3)

BIOTIC STRESSES

Cowpea (yellow) mosaic virus (CPMV) (8.4.9)

NOTES

Any additional information may be specified here, particularly that referring to the category '99=Other' present in some of the descriptors above.

Annex X – Final key set of descriptors for cowpea genetic resources obtained after validation

Key access and utilization descriptors for cowpea genetic resources

This list consists of an initial set of characterization and evaluation descriptors for cowpea (*Vigna unguiculata*) genetic resources utilization. This strategic set of descriptors, together with passport data, will become the basis for the global accession level information portal being developed by Bioversity International with the financial support of the Global Crop Diversity Trust (the Trust). It will facilitate access to and utilization of cowpea accessions held in genebanks and does not preclude the addition of further descriptors, should data subsequently become available.

Based on the comprehensive list 'Descriptors for Cowpea' published by IBPGR (now Bioversity International) in 1983, the list was subsequently compared with a number of sources such as 'Descriptors for VIGNA' (USDA, ARS, GRIN), 'Cowpea [*Vigna unguiculata* (L.) Walp.] core collection defined by geographical, agronomical and botanical descriptors'[1] (IITA, 2006), and 'Descriptors for Characterization and Evaluation of Cowpea' (National Institute of Agrobiological Sciences, Genebank of Japan). The initial list was further refined during a crop-specific consultation meeting held at the National Bureau of Plant Genetic Resources (NBPGR, India). It involved several scientists from NBPGR and the Indian Agricultural Research Institute (IARI).

A worldwide distribution of experts was involved in an online survey to define a first priority set of descriptors to describe, to access and to utilize cowpea genetic resources. This key set was afterwards validated by a Core Advisory Group (see 'Contributors') led by Dr S.K. Mishra of NBPGR and Dr Christian Fatokun of IITA.

Biotic and abiotic stresses included in the list were chosen because of their wide geographic occurrence and significant economic impact at a global level.

Numbers in parentheses on the right-hand side are the corresponding descriptor numbers listed in the 1983 publication. Descriptors with numbers ending in 'letters' are either modified or are new descriptors that were added during the development of the list below.

PLANT DATA

Growth habit (4.1.1)

Evaluated in the 6th week after sowing

1 Acute erect (branches form acute angles with main stem)
2 Erect (branching angle less acute than above)
3 Semi-erect (branches perpendicular to main stem, but do not touch the ground)
4 Intermediate (lower branches touch the ground)
5 Semi-prostrate (main stem reaches 20 or more centimetres)
6 Prostrate (plants flat on ground; branches spread several metres)
7 Climbing

[1] V. Mahalakshmi, Q. Ng, M. Lawson and R. Ortiz, Plant Genetic Resources: Characterization and Utilization, Vol. 5, Issue 3, pp.113-119, NIAB, 2007

Days to 50% flowering (4.2.1)
Number of days from sowing until 50% of the plants have begun to flower. Recorded for plants with the same sowing date at the same location each year

Pod length [cm] (4.2.7)
Average length of the 10 longest mature pods from 10 randomly selected plants

Days to pod maturity (4.2.X)
Number of days from sowing to when 95% of the plants have mature pods

Testa texture (4.3.2)
1 Smooth
3 Smooth to rough
5 Rough (fine reticulation)
7 Rough to wrinkled
9 Wrinkled (coarse folds on the testa)

Eye colour (4.3.4)
0 Eye absent (white, cream)
1 Brown splash or gray
2 Tan brown
3 Red
4 Green
5 Blue to black
6 Blue to black spots or mottle
7 Speckled (even distribution of fine speckling)
8 Mottled (dark brown pigment typically absent around hilum)
9 Mottled and speckled
99 Other (specify in the descriptor Notes)

100-Seed weight [g] (4.3.5)
Weight of 100 seeds with 12% moisture content

Seed coat colour (4.3.X)
Recorded at maturity
1 White
2 Cream
3 Brown
4 Red
5 Purple
6 Black
99 Other (i.e. ‘yellow’ or ‘blue’, specify in the descriptor **Notes**)

Flower colour (6.2.2)
1 White
2 Violet
3 Mauve-pink
99 Other (specify in the descriptor **Notes**)

Number of pods per peduncle (6.2.8)
Recorded under total insect control. Average number of 10 randomly selected peduncles

Pod colour (6.2.12)

Of mature pod

1 Pale tan or straw
2 Dark tan
3 Dark brown
4 Black or dark purple
99 Other (specify in the descriptor **Notes**)

Seed protein content [%] (6.3.7)

ABIOTIC STRESSES

Drought (7.3)

BIOTIC STRESSES

Cowpea (yellow) mosaic virus (CPMV) (8.4.9)

NOTES

Any additional information may be specified here, particularly that referring to the category '99=Other' present in some of the descriptors above.

CONTRIBUTORS

Bioversity is grateful to all the scientists and researchers who have contributed to the development of this strategic set of 'Key access and utilization descriptors for cowpea genetic resources', and in particular to Dr Christian Fatokun and Dr S.K. Mishra for providing valuable scientific direction. Adriana Alercia provided technical expertise and guided the entire production process.

CORE ADVISORY GROUP

S.K. Mishra, National Bureau of Plant Genetic Resources (NBPGR), India
Christian Fatokun, International Institute of Tropical Agriculture (IITA), Nigeria
Ousmane Boukar, International Institute of Tropical Agriculture (IITA), Nigeria
Kaesel Jackson Damasceno e Silva, Center of Agriculture Research of MidNorth, Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), Brazil
Richard L. Fery, United States Department of Agriculture, Agricultural Research Service (USDA-ARS), US Vegetable Laboratory, USA
Ulrike Lohwasser, Leibniz Institute of Plant Genetics and Crop Plant Research, Germany
Yuji Niwa, Ministry of Agriculture, Forestry and Fisheries, Japan

REVIEWERS

Australia
Sally Dillon, Queensland Primary Industries and Fisheries

Austria
Wolfgang Kainz, Austrian Agency for Health and Food Safety (AGES)

India

C. Bharadwaj, Division of Genetics, Indian Agricultural Research Institute, Indian Council of Agricultural Research (IARI-ICAR)

S.R. Pandravada, National Bureau of Plant Genetic Resources (NBPGR), Regional Station, Hyderabd

J.C. Rana, National Bureau of Plant Genetic Resources (NBPGR), Regional Station, Phagli, Shimla

Italy

Valeria Negri, Applied Biology Department, University of Perugia

Nigeria

Remi Adeleke, International Institute of Tropical Agriculture (IITA)

Dominique Dumet, International Institute of Tropical Agriculture (IITA)

Mohammad Faguji Ishiyaku, Institute for Agricultural Research, Ahmadu Bello University, Zaria

Russian Federation

Marina Burlyaeva, N.I. Vavilov Research Institute of Plant Industry (VIR)

Senegal

Ndiaga Cisse, Institut Sénégalais de Recherches Agricoles (ISRA)

Spain

Antonio M. De Ron, Misión Biológica de Galicia, Consejo Superior de Investigaciones Científicas (MBG-CSIC)

Taiwan

R. Srinivasan, Asian Vegetable Research and Development Center (AVRDC-The World Vegetable Center)

USA

Jeffrey Ehlers, University of California, Riverside

Robert Myers, Jefferson Institute

Gary Pederson, United States Department of Agriculture, Agricultural Research Service (USDA-ARS), Plant Genetic Resources Conservation Unit

Methodology for the definition of a key set of characterization and evaluation descriptors for faba bean (*Vicia faba*)

Information collection and preparation of the Minimum Descriptor List (MDL)

Information for the definition of a MDL for faba bean was drawn from 'Faba Bean Descriptors' (IBPGR/ICARDA, 1985). Descriptors were discussed with Dr. Ken Street from ICARDA, who agreed to be Crop Leader for this exercise. The comprehensive descriptors list included in this publication was compared with essential descriptors listed in the 'Descriptors for Faba bean' (USDA, ARS, GRIN); UPOV technical guidelines for Broad Bean; Minimal descriptors of Faba Bean from NBPGR, and the traits in need of further research identified in the Draft 'Global Strategy for the *Ex Situ* Conservation of Faba Bean' (the Trust, March, 2009), since the final version of this document was not available at that time but its draft was at an advanced stage (see Annex I).

Preparation of the List of Experts

Being the original publication too old to be used for this purpose, collaboration was sought from scientists included in the European Database for *Vicia faba* (ECPGR), particularly from the ECPGR Grain Legumes Working Group, and from participants to the Global Collaborative *Ex-situ* Conservation Strategies for Food Legumes held in Aleppo, Syria, from 19th to 22nd February 2007. The expert list was further compiled by querying the FAO WIEWS Directory of germplasm collections for *Vicia*. Overall, 80 experts were identified, coming from 50 countries and 67 different organizations. Among them, a Crop Leader (Ken Street) was selected who, consequently, chose a Core Advisory Group consisting of eight experts to assist in the definition of a Minimum set of descriptors for this crop (see Annex II).

Survey preparation and distribution

A draft survey on Faba Bean was prepared listing the descriptors as approved by consultations with the Crop Leader (see Annex III). Once approved, the final version of the survey was uploaded into the SurveyMonkey application on the internet. On 24th March 2009 an email invitation to the survey was sent out to the list of identified experts, who were invited to rate the importance of the proposed characterization and evaluation descriptors (41 descriptors) for this crop (see Annex IV).

Experts were also encouraged to mention any additional trait that was found to be relevant yet missing from the proposed minimum list, along with a substantiated justification for its inclusion. The survey deadline was set at 20th April 2009. A first reminder was sent out on 7th April and a second one on 16th April to ensure that the greatest possible feedback was obtained.

Survey analysis and refinement of Minimum List

Of the 80 experts who were identified and involved in the exercise 21, coming from 16 countries and 17 organizations, recorded their comments using the SurveyMonkey consultation (see Annex V). Results from the survey were analysed and descriptors ranked by rating average and percentage of importance (see Annex VI). The summary results of the survey conducted with the SurveyMonkey tool, together with a report containing comments received by the participants (see Annex VII) was sent to the Crop Leader for his validation. His revised list was subsequently shared with the Core Advisory Group on 25th May 2009 to settle the definition of the key set of descriptors for this crop (see Annex VIII). The Core Advisory Group agreed on the final minimum set (see Annex IX).These identified set of characterization and evaluation traits were grouped together to create a new document compliant with the project terms of reference.

Once the core subset of characterization and evaluation standards for Faba Bean was finalised, descriptor states were integrated into the list (see Annex X). The final document, including all contributors (see Annex XI), was proofread and sent to the Publication Unit for layout and on-line publication processes. The final publication was also shared with ECPGR partners and was uploaded in the SGRP Crop Genebank Knowledge Base. Furthermore, data were converted into Excel files for uploading into the GRIN-Global genebank data-management system being developed by USDA and into GENESYS, linking national, regional and international genebank databases in support of the conservation and use of plant genetic resources for food and agriculture (PGRFA). The Excel files were also provided to the System-wide Information Network for Genetic Resources (SINGER) and to EURISCO.

Acknowledgement

Bioversity is grateful to all the scientists and researchers who have contributed to the development of the strategic set of ‘Key access and utilization descriptors for faba bean genetic resources’, and to the Global Crop Diversity Trust for their financial support. Particular recognition goes to the Crop Leader, Dr ken Street (ICARDA) for providing valuable scientific direction.

Annex I: - Summary comparison table for important descriptors for Faba Bean drawn from a number of sources[1]

Descr. no.	Descriptors for *Vicia faba* (Broad bean or Faba bean)	IBPGR 1985	USDA	KEN STREET (selection)	UPOV	STRATEGY (the Trust)	NBPGR
4.1.1	Growth habit	*	*	*	*		*
4.1.6	Plant height [cm]	*	*	*	*		*
4.3.3	100-seed weight [g]	*	*	*	*		*
4.1.4	Basal node branching	*	*	*			*
4.2.3	Flower ground colour	*	*	*			*
4.1.5	Higher node branching	*	*	*			
4.3.5	Hilum colour	*	*	*			*
4.2.4	Intensity of streaks	*	*				
6.1.3	Leaflet number	*	*				*
6.1.2	Leaflet shape	*	*				*
4.1.3	Leaflet size	*	*				*
4.3.1	Ovules per pod	*	*		*		
	Plant width		*				
4.2.9	Pod colour	*	*	*			*
4.2.6	Pod angle	*	*		*		
6.2.4	Pod distribution	*	*				
4.2.10	Pod length [cm]	*	* [mm]	*	*		*
4.2.7	Pod shape	*	*	*			*
6.2.5	Pod shatter	*	*	*			
4.2.8	Pod surface	*	*				
	Pod width [mm]		*		*		*

Descr. no.	Descriptors for *Vicia faba* (Broad bean or Faba bean)	IBPGR 1985	USDA	KEN STREET (selection)	UPOV	STRATEGY (the Trust)	NBPGR
6.2.3	Pods per node	*	*	*			
4.3.4	Seed ground colour (Testa colour)	*	*	*	*		*
4.3.6	Seed shape	*	*	*			*
	Seed size		*				
4.3.2	Seeds per pod	*	*	*			*
	Stem branching		*				
4.1.7	Stem colour	*	*				
4.1.2	Stem pigmentation	*	*				*
4.2.5	Wing petal colour	*	*	*	*		*
4.2.1	Days to flower	*	*	*	*	*	*
4.2.2	Pod maturity	*	*	*			*
6.3.6	Seed yield [g/m^2]	*	* **[kg/ha]**				
6.1.1	Stipule spot pigmentation	*					
6.1.4	Stem thickness (cm)	*		*			*
6.1.5	Resistance to lodging	*		*			
6.2.1	Number of flowers per inflorescence	*		*	*		*
6.2.2	Height of lowest pod-bearing node at harvest [cm]	*					
6.2.6	Male fertility	*					
6.2.7	Autofertility	*					
6.3.1	Testa pattern	*					
6.3.2	Protein content [%]	*					*
6.3.3	Sulphur amino acids (per 16 g N)	*		*			
6.3.4	Vicine and convicine content	*					*

Descr. no.	Descriptors for *Vicia faba* (Broad bean or Faba bean)	IBPGR 1985	USDA	KEN STREET (selection)	UPOV	STRATEGY (the Trust)	NBPGR
6.3.5	Cooking time	*		*			
7.1.1	Winter kill	*					
7.1.2	Low temperature damage	*					
7.2	High temperature	*		*		*	
7.3	Drought	*					
7.4	High soil moisture	*					
7.5	Salinity (Tolerance)	*		*			
8.1.1	Aphids (*Aphis* spp.)	*		*			
8.1.2	Leaf weevils (*Sitona* spp.)	*		*			
8.1.3	Leaf miners (*Liriomyza* spp)	*		*		*	
8.1.4	Stem borers (*Lixus* spp)	*		*			
8.1.5	Seed weevils (*Bruchus* spp.)	*		*			
8.1.6	Stem nematodes (*Ditylenchus diosaci*)	*		*			
8.1.7	Broomrape (*Orobanche crenata*) 8.1.7	*		*		*	
8.2.1	Chocolate spot (*Bortrytis fabae*) 8.2.1	*		*		*	
8.2.2.	Ascochyta blight (*Ascochyta fabae*) 8.2.2	*		*		*	
8.2.3	Leaf spot (*Alternaria* spp.) 8.2.3	*					
8.2.4	Rust (Uromyces fabae)	*					
8.2.5	Powder mildew (Erysiphe polygoni)	*					
8.2.6	Root rot complex (*Rhizoctonia* spp)	*		*			
8.2.7	Root rot complex (*Fusarium* spp)	*					
8.2.8	Stem rot (*Sclerotinia*)	*		*			
8.2.9	Other (specify in the NOTES descriptor, 11)	*					

Descr. no.	Descriptors for *Vicia faba* (Broad bean or Faba bean)	IBPGR 1985	USDA	KEN STREET (selection)	UPOV	STRATEGY (the Trust)	NBPGR
8.4.1	Alfalfa mosaic virus (AMV)	*					
8.4.2	Bean leaf roll virus (BLRV)	*					
8.4.3	Bean yellow mosaic virus (BYMV)	*		*			
8.4.4	Pea enation mosaic virus (PEMV)	*					
8.4.5	Broad bean true mosaic virus (BBTMV=EAMV)	*				*	
8.4.6	Broad bean stain virus (BBSV)	*					
	Independent vascular system			*			
	Tolerance to chilly conditions			*			
	Tolerance to frost (ex low temp)	*		*			
	Plant: number of stems (including tillers more than half the length of the main stem				*		
	Leaflet: length (basal pair of leaflet at secondary node)				*		
	Leaflet width (basal pair of leaflet at secondary node)				*		
	Leaflet: position of maximum width (basal pair of leaflet at secondary node				*		
	Wing: melanin spot				*		
	Wing: colour of melanin spot				*		
	Standard: anthocyanin colouration				*		

[1] 'Faba Bean Descriptors' (IBPGR/ICARDA, 1985); 'Descriptors for Faba bean' (USDA, ARS, GRIN); UPOV thecnical guidelines for Broad Bean; 'Minimal descriptors of Faba Bean' from NBPGR; traits in need of further research identified in the Draft 'Global Strategy for the *Ex Situ* Conservation of Faba Bean' [Global Crop Diversity Trust (the Trust), March, 2009] and descriptors suggested by Ken Street

Annex II – List of experts identified for participation to the survey for the definition of a minimum set of descriptors for Faba Bean

Role	Name	Organization	Country
Crop Leader (SRG)	**Street, Ken**	ICARDA	Syria
ECPGR/Crop Strategy	Ambrose, Mike	John Innes Centre	UK
Core Group	Duc, Gerard	INRA (ECPGR)	France
Core Group	Maalouf, Fouad	ICARDA	Syria
Core Group	Malhotra, Rajendra	ICARDA	Syria
Core Group	Mathur, Prem	Bioversity	India
Core Group	Robertson, Larry	USDA	USA
Core Group	Sarker, Ashutosh	ICARDA	Syria
Crop Strategy/WIEWS	Redden, Bob	Australian Temperate Field Crops Collection	Australia
ECPGR	Angelova, Siyka	Institute for Plant Genetic Resources "K. Malkov" (IPGR)	Bulgaria
ECPGR	Atikyilmaz, Nüket responded to survey (Lerzan Aykas)	Aegean Agricultural Research Institute (AARI)	Turkey
ECPGR	Babayeva, Sevda compiled survey (Almas Asadova)	Genetic Resources Institute of Azerbaijan National Academy of Sciences	Azerbaijan
ECPGR	Baudoin, Jean Pierre	Faculté universitaire des Sciences agronomiques de Gembloux	Belgium
ECPGR	Bogusas, Romas	Lithuanian Institute of Agriculture	Lithuania
ECPGR	Canko, Agim	Centre of Agricultural Technology Transfer Fushe-Kruje	Albania
ECPGR	Carboni, Andrea	CRA - CIN	Italy
ECPGR	Cenusa, Maria	Institutul de Cercetare Dezvoltare Pentru Legumicultura si Floricultura Vidra	Romania
ECPGR	Dimov, Zoran	University Ss. Cyril and Methodius	Macedonia (FYR)
ECPGR	Doherty, Gerry	Potato Centre - Department of Agriculture and Food	Ireland
ECPGR	Duarte, Isabel Maria	Estação Nacional de Melhoramento de Plantas	Portugal

Role	Name	Organization	Country
ECPGR/Crop Strategy	Holly, László	Research Centre for Agrobotany	Hungary
ECPGR	Hovinen, Simo	Boreal Plant Breeding Ltd.	Finland
ECPGR/WIEWS	Hýbl, Miroslav	AGRITEC Ltd. Sumperk	Czech Republic
ECPGR	Iliadis, Costantinos	NAGREF - Fodder Crops and Pasture Institute	Greece
ECPGR/WIEWS	Kik, Chris	Centre for Genetic Resources, the Netherlands (CGN)	The Netherlands
ECPGR	Korakhashvili, Avtandil	Agrarian State University of Georgia	Georgia
ECPGR	Kristian Thorup-Kristensen	Faculty of Agricultural Sciences, University of Aarhus	Denmark
ECPGR	Mechtler, Klemens	AGES - Austrian Agency for Health and Food Safety	Austria
ECPGR	Meglic, Vladimir	Crop and Seed Science Department - Agricultural Institute of Slovenia	Slovenia
ECPGR	Mendel, Lubomir	Research Institute of Plant Production - Slovak Agricultural Research Centre	Slovakia
ECPGR	Pallides, Andreas	Agricultural Research Institute	Cyprus
ECPGR	Ruge-Wehling, Brigitte	Julius Kühn-Institute (JKI)	Germany
ECPGR	Semergyan, Suren	Scientific Centre of Agriculture and Plant Protection	Armenia
ECPGR	Sudaric, Aleksandra	Agricultural Institute Osijek	Croatia
ECPGR	Swiecicki, Wojciech	Institute of Plant Genetics	Poland
ECPGR	Vasic, Mirjana	Institute of Field and Vegetable Crops Novi Sad	Serbia
ECPGR/Crop Strategy	Vishnyakova, Margarita A.	N.I. Vavilov Institute of Plant Industry (VIR)	Russia
ECPGR	Yadav, Shyam Singh	Indian Agricultural Research Institute (IARI)	India
Crop Strategy	Abdelguerfi, A.	Institut National Agronomique (INA)	Algeria
Crop Strategy/WIEWS	Abdi, Adugna	Institute of Biodiversity Conservation and Research (IBCR)	Ethiopia
Crop Strategy	Acuña, Hernan	INIA CARI	Chile
Crop Strategy	Buchwaldt, Lone	Agriculture and Agri-Food Canada	Canada
Crop Strategy	de los Mozos Pascual, Marcelino	Banco de Germoplasma, Centro de Investigacion Agraria de Albaladejito	Spain
Crop Strategy	Della, Athena	Agricultural Research Insitute	Cyprus
Crop Strategy	Diederichsen, Axel	Agriculture and Agri-Food Canada	Canada

Role	Name	Organization	Country
Crop Strategy	El-Hawary, Mohamed Ibrahim	National Gene Bank of Egypt	Egypt
Crop Strategy	Furman, Bonnie J.	ARS/USDA	USA
Crop Strategy/WIEWS	Galasso, Incoronata	CNR	Italy
Crop Strategy	Gowda, C.L.L.	ICRISAT	India
Crop Strategy	Horváth, Lajos	Institute for Agrobotany	Hungary
Crop Strategy	Jamal, Majd	GCSAR - Ministry of Agric & Agrarian Reform	Syria
Crop Strategy	Moal, Sharif	Plant Genetic Resources Unit Crop Improv - Ministry of Agriculture	Afghanistan
Crop Strategy	Monreal, Álvaro Ramos	Consejeria de Agricultura Ganadería	Spain
Crop Strategy	Pandey, R.L.	Dept Plant Breeding and Genetics I. Gandhi Agric. Univ	India
Crop Strategy	Ryabchoun, Victor K.	National Centre for PGR of Ukraine	Ukraine
Crop Strategy	Sharma, S.K.	ICAR, NBPGR	India
Crop Strategy	Srivastava, Surendra	Nepal Agricultural Research	Nepal
Crop Strategy	Suso, María José	Instituto de Agricultura Sostenible (CSIC)	Spain
Crop Strategy/WIEWS	Tan, Ayfer	Aegean Agricultural Research Institute (AARI)	Turkey
Crop Strategy	Valkoun, Jan	ICARDA	Syria
Crop Strategy	Van Ginkel, Maarten	Department of Primary Industries Horsham	Australia
Crop Strategy	Veloso, Maria Manuela	Departamento de Recursos Genéticos e Melhoramento, Estação Agronómica Nacional	Portugal
Crop Strategy	Welsh, Molly	Phaseolus Germplasm Collection - USDA/ARS	USA
Crop Strategy	Xuxiao, Zong	Institute of Crop Germplasm Resources, CAAS	China
WIEWS	(Graner, A. he is the Director) forwared message to Helmut Knuepffer and Matthias Kotter	Genebank, Leibniz Institute of Plant Genetics and Crop Plant Research	Germany
WIEWS	Jean Hanson	ILRI	Ethiopia
WIEWS	Podyma, W.	Plant Breeding and Acclimatization Institute	Poland
WIEWS	Shepherd, D.	School of Biological Sciences, University of Southampton	UK
WIEWS	Stoyanova, S.	Institute for Plant Genetic Resources "K.Malkov"	Bulgaria
WIEWS		Australian Medicago Genetic Resources Centre	Australia

Role	Name	Organization	Country
WIEWS		Centro de Investigaciones Fitoecogenéticas de Pairumani	Bolivia
WIEWS		Embrapa Recursos Genéticos e Biotecnologia	Brazil
WIEWS		Departamento Nacional de Recursos Fitogenéticos y Biotecnología	Ecuador
WIEWS		National Genebank of Kenya, Crop Plant Genetic Resources Centre (KARI)	Kenya
WIEWS		Estación Experimental Agraria Illpa	Peru
WIEWS		Suceava Genebank	Romania
WIEWS		Plant Breeding Station	Slovakia
WIEWS		Nordic Genetic Resource Center	Sweden
New Reviewer	Wolfgang Link	Department of Crop sciences, University of Göttingen	Germany
New Reviewer Curator collection Faba bean	Sergey Bulyntsev	Vavilov Institute of Plant Industry	Russia

Annex III – Faba bean characterization and evaluation descriptors revised by Ken Street and proposed in the survey sent out on 24th March 2009

CHARACTERIZATION

- Growth habit (4.1.1)
- Leaflet size (4.1.3)
- Branching from basal nodes (4.1.4)
- Branching from higher nodes (4.1.5)
- Plant height [cm] (4.1.6)
- Days to flowering (4.2.1)
- Days to maturity (4.2.2)
- Flower ground colour (4.2.3)
- Wing petal colour (4.2.5)
- Pod shape (4.2.7)
- Pod colour at maturity (4.2.9)
- Pod length [cm] (4.2.10)
- Number of seeds per pod (4.3.2)
- 100 seed weight [g] (4.3.3)
- Ground colour of testa (seed coat) (4.3.4)
- Hilum colour (4.3.5)
- Seed shape (4.3.6)

EVALUATION

- Stem thickness [cm] (6.1.4)
- Resistance to lodging (6.1.5)
- Number of flowers per inflorescence (6.2.1)
- Number of pods per node (6.2.3)
- Pod shattering (6.2.5)
- Sulphur amino acids (per 16 g N) (6.3.3)
- Cooking time (6.3.5)
- Independent vascular system
- Tolerance to high temperature (7.2)
  (Indicate if observed at the juvenile, vegetative, flowering, pod set or grain filling phase)
- Tolerance to chilly conditions
  (Observed at the flowering stage)
- Tolerance to frost
  (Observed at the flowering stage)
- Salinity (7.5)
- Aphids (*Aphis* spp.) (8.1.1)

- Leaf weevils (*Sitona* spp.) (8.1.2)
- Leaf miners (*Liriomyza* spp.) (8.1.3)
- Stem borers (*Lixus* spp.) (8.1.4)
- Seed weevils (*Bruchus* spp.) (8.1.5)
- Stem nematodes (*Ditylenchus dipsaci*) (8.1.6)
- Broomrape (*Orobanche crenata*) (8.1.7)
- Chocolate spot (*Bortrytis fabae*) (8.2.1)
- Ascochyta blight (*Ascochyta fabae*) (8.2.2)
- Root rot complex (*Rhizoctonia* spp) (8.2.6)
- Stem rot (*Sclerotinia* spp.) (8.2.8)
- Bean yellow mosaic (BYMV) (8.4.3)

Annex IV – Survey to choose a key set of Descriptors for Faba bean (*Vicia faba*)

WELCOME

Welcome to the survey for the selection of a key set of characterization and evaluation descriptors to support an international information system to enhance the utilization of germplasm held in genebanks.

Your knowledge and experience are being sought to select this initial '**key set of descriptors**' of *Vicia faba* accessions to identify traits important to crop production and to facilitate their use by researchers.

Your participation in it is highly appreciated. The deadline for this survey is **20th April 2009**.

This key set of characterization and evaluation descriptors will be made available through a global facility for identifying sets of accessions for evaluation and use. For characterization, the aim is a key set of maximally differentiating traits that provide the most impact in discriminating between accessions. For evaluation, the aim is to focus on a few important traits for production, such as tolerance to an important disease or salinity.

The list presented here has been drawn from the IBPGR publication 'Faba Bean Descriptors' (1985) and, further revised in consultation with Dr. Kenneth Street from ICARDA.

This survey consists of two parts:
- PART I: Lists the most important characterization descriptors for Faba bean. Based on your experience, please rate the descriptors according to their importance in identifying accessions. It also allows you to indicate if any essential descriptor that can contribute to its use is missing from the minimum list presented.

- PART II: Lists important evaluation descriptors for Faba bean. Please, rate these traits in order of importance at the global level. It also allows you to indicate if any essential trait for production is missing from the minimum list presented or indicate any that may not be very significant to global production.

We thank you in advance for investing your time and expertise in selecting this initial, key set of descriptors.

* **Please allow us to acknowledge your contribution by completing your full contact details below:**

Name:
Position:
Organization:
Address:
City/Town:
Country:
Email:

PART I: Characterization descriptors

These traits enable easy and quick discrimination between phenotypes. They are generally highly heritable, can be easily seen by the eye and are equally expressed in all environments.

*Numbers in parentheses on the right-hand side are the corresponding descriptors numbers as published in the IBPGR publication 'Faba Bean Descriptors' (1985).

	Not important	Important	Very important
Growth habit (4.1.1)	j	j	j
Leaflet size (4.1.3)	j	j	j
Branching from basal nodes (4.1.4)	j	j	j
Branching from higher nodes (4.1.5)	j	j	j
Plant height [cm] (4.1.6)	j	j	j
Days to flowering (4.2.1)	j	j	j
Days to pod maturity (4.2.2)	j	j	j
Flower ground colour (4.2.3)	j	j	j
Wing petal colour (4.2.5)	j	j	j
Pod shape (4.2.7)	j	j	j
Pod colour at maturity (4.2.9)	j	j	j
Pod length [cm] (4.2.10)	j	j	j
100 seed weight [g] (4.3.3)	j	j	j
Ground colour of testa (seed coat) (4.3.4)	j	j	j
Hilum colour (4.3.5)	j	j	j
Seed shape (4.3.6)	j	j	j

If you consider that an essential trait is missing from this list, please indicate it here along with a substantiated justification.

PART II: Evaluation descriptors

These descriptors include characters such as pod shattering, biotic and abiotic stresses. They are the most interesting traits in crop improvement. Please consider the following factors relating to the trait when making your final decision: (i) Global impact, (ii) Initial strategic set, (iii) Importance for germplasm utilization, (iv) Data availability, (v) True economic damage and (vi) Wide geographical occurrence.

	Not Important	Important	Very important
Stem thickness [cm] (6.1.4)	j	j	j
Resistance to lodging (6.1.5)	j	j	j
Number of flowers per inflorescence (6.2.1)	j	j	j
Number of pods per node (6.2.3)	j	j	j
Pod shattering (6.2.5)	j	j	j
Sulphur amino acids (per 16 g N) (6.3.3)	j	j	j
Cooking time (6.3.5)	j	j	j
Independent vascular system	j	j	j
Tolerance to high temperature (7.2)	j	j	j
Tolerance to chilly conditions	j	j	j
Tolerance to frost	j	j	j
Tolerance to salinity (7.5)	j	j	j
Aphids (*Aphis* spp.) (8.1.1)	j	j	j
Leaf weevils (*Sitona* spp.) (8.1.2)	j	j	j
Leaf miners (*Liriomyza* spp.) (8.1.3)	j	j	j
Stem borers (*Lixus* spp.) (8.1.4)	j	j	j
Seed weevils (*Bruchus* spp.) (8.1.5)	j	j	j
Stem nematodes (*Ditylenchus dipsaci*) (8.1.6)	j	j	j
Broomrape (*Orobanche* crenata) (8.1.7)	j	j	j
Chocolate spot (*Botrytis fabae*) (8.2.1)	j	j	j
Ascochyta blight (*Ascochyta fabae*) (8.2.2)	j	j	j
Root rot complex (*Rhizoctonia* spp.) (8.2.6)	j	j	j
Stem rot (*Sclerotinia* spp.) (8.2.8)	j	j	j
Bean yellow mosaic (BYMV) (8.4.3)	j	j	j

If you consider that an essential trait important for crop improvement and production is missing from this list, or, if any of the descriptors listed is not clearly useful to promote utilization, please indicate it here along with a substantiated justification.

NOTE: Please remember, this list is the starting point and will grow over time, as required.

THANK YOU VERY MUCH FOR YOUR PARTICIPATION.

Annex V – Respondents to the survey consultation for the definition of a Key set of descriptors for faba bean

Role	Name	Organization	Country
Crop leader	**Street, Kenneth**	ICARDA	Syria
CAG	Maalouf, Fouad	ICARDA	Syria
CAG	Duc, Gérard	INRA	France
CAG	Robertson, Larry	USDA-ARS	USA
CAG	MATHUR, P. N.	Bioversity International	India
CAG	Redden, Robert (Bob)	Department of Primary Industries Victoria	Australia
Reviewer	Asadova, Almas	Genetic Resources Institute of Azerbaijan National Academy of Sciences	Azerbaijan
Reviewer	Aykas, Lerzan	Aegean Agricultural Research Institute	Turkey
Reviewer	Bulyntsev, Sergey	Vavilov Institute of Plant Industry	Russia
Reviewer	Carboni, Andrea	CRA-CIN	Italy
Reviewer	Claure, E. Tito	Pairumani's Phytoecogenetical Research center	Bolivia
Reviewer	Diederichsen, Axel	Plant Gene Resources of Canada, Agriculture and Agri-Food Canada	Canada
Reviewer	Duarte, Isabel	INRB/INIA	Portugal
Reviewer	Furman, Bonnie J.	USDA/ARS	USA
Reviewer	Link, Wolfgang	University of Göttingen	Germany
Reviewer	Lohwasser, Ulrike	Leibniz Institute of Plant Genetics and Crop Plant Research	Germany
Reviewer	Srinivasan, Kalyani	NBPGR	India
Reviewer	Suso, María José	Instituto de Agricultura Sostenible (CSIC)	Spain
Reviewer	Veloso, Maria Manuela	INRB/INIA	Portugal
Reviewer	Xuxiao, Zong	Institute of Crop Science, Chinese Academy of Agricultural Sciences	China
Reviewer	Srinivasan, Kalyani	NBPGR	India

Annex VI – Descriptors listed in the Faba Bean survey ranked by rating average and by percentage of importance

Descriptor	Street's selection	Rating Average
100 seed weight [g] (4.3.3)		4.70
Days to flowering (4.2.1)		4.40
Plant height [cm] (4.1.6)		4.20
Days to pod maturity (4.2.2)		4.16
Pod shattering (6.2.5)		3.95
Ground colour of testa (seed coat) (4.3.4)		3.94
Resistance to lodging (6.1.5)		3.90
Pod length [cm] (4.2.10)		3.89
Seed weevils *(Bruchus* spp.) (8.1.5)		3.78
Flower ground colour (4.2.3)		3.68
Number of seeds per pod (4.3.2)		3.68
Chocolate spot (*Botrytis fabae*) (8.2.1)		3.68
Seed shape (4.3.6)		3.65
Aphids (*Aphis* spp.) (8.1.1)		3.65
Tolerance to frost		3.58
Ascochyta blight (*Ascochyta fabae*) (8.2.2)		3.58
Growth habit (4.1.1)		3.55
Number of pods per node (6.2.3)		3.47
Tolerance to salinity (7.5)		3.33
Bean yellow mosaic (BYMV) (8.4.3)		3.32
Wing petal colour (4.2.5)		3.30

Descriptor	% Importance (important)	% Importance (Very important)
100 seed weight [g] (4.3.3)	15.0 (3)	85.0 (17)
Days to flowering (4.2.1)	30.0 (6)	70.0 (14)
Pod shattering (6.2.5)	26.3 (5)	63.2 (12)
Plant height [cm] (4.1.6)	40.0 (8)	60.0 (12)
Resistance to lodging (6.1.5)	30.0 (6)	60.0 (12)
Days to pod maturity (4.2.2)	42.1 (8)	57.9 (11)
Flower ground colour (4.2.3)	26.3 (5)	57.9 (11)
Chocolate spot (*Botrytis fabae*) (8.2.1)	26.3 (5)	57.9 (11)
Ground colour of testa (seed coat) (4.3.4)	38.9 (7)	55.6 (10)
Seed weevils *(Bruchus* spp.) (8.1.5)	33.3 (6)	55.6 (10)
Aphids (*Aphis* spp.) (8.1.1)	30.0 (6)	55.0 (11)
Pod length [cm] (4.2.10)	42.1 (8)	52.6 (10)
Tolerance to frost	31.6 (6)	52.6 (10)
Ascochyta blight (*Ascochyta fabae*) (8.2.2)	31.6 (6)	52.6 (10)
Tolerance to salinity (7.5)	27.8 (5)	50.0 (9)
Growth habit (4.1.1)	35.0 (7)	50.0 (10)
Number of pods per node (6.2.3)	36.8 (7)	47.4 (9)
Wing petal colour (4.2.5)	35.0 (7)	45.0 (9)
Number of seeds per pod (4.3.2)	52.6 (10)	42.1 (8)
Tolerance to high temperature (7.2)	36.8 (7)	42.1 (8)
Tolerance to chilly conditions	31.6 (6)	42.1 (8)

Descriptor	Street's selection	Rating Average
Leaf miners *(Liriomyza* spp.) (8.1.3)		3.26
Number of flowers per inflorescence (6.2.1)		3.25
Tolerance to high temperature (7.2)		3.21
Stem rot (*Sclerotinia* spp.) (8.2.8)		3.21
Hilum colour (4.3.5)		3.20
Leaf weevils (*Sitona* spp.) (8.1.2)		3.20
Branching from basal nodes (4.1.4)		3.11
Root rot complex *(Rhizoctonia* spp.) (8.2.6)		3.11
Pod shape (4.2.7)		3.10
Tolerance to chilly conditions		3.05
Stem borers *(Lixus* spp.) (8.1.4)		2.89
Stem nematodes *(Ditylenchus dipsaci)* (8.1.6)		2.74
Leaflet size (4.1.3)		2.71
Pod colour at maturity (4.2.9)		2.47
Broomrape (*Orobanche crenata*) (8.1.7)		2.45
Stem thickness [cm] (6.1.4)		2.30
Branching from higher nodes (4.1.5)		2.17
Cooking time (6.3.5)		2.00
Sulphur amino acids (per 16 g N) (6.3.3)		1.89
Independent vascular system		1.84

Descriptor	% Importance (important)	% Importance (Very important)
Stem rot (*Sclerotinia* spp.) (8.2.8)	36.8 (7)	42.1 (8)
Hilum colour (4.3.5)	40.0 (8)	40.0 (8)
Seed shape (4.3.6)	55.0 (11)	40.0 (8)
Leaf weevils (*Sitona* spp.) (8.1.2)	40.0 (8)	40.0 (8)
Broomrape (*Orobanche crenata*) (8.1.7)	15.0 (3)	40.0 (8)
Root rot complex *(Rhizoctonia* spp.) (8.2.6)	38.9 (7)	38.9 (7)
Branching from basal nodes (4.1.4)	42.1 (8)	36.8 (7)
Leaf miners *(Liriomyza* spp.) (8.1.3)	47.4 (9)	36.8 (7)
Pod shape (4.2.7)	45.0 (9)	35.0 (7)
Number of flowers per inflorescence (6.2.1)	50.0 (10)	35.0 (7)
Bean yellow mosaic (BYMV) (8.4.3)	57.9 (11)	31.6 (6)
Stem borers *(Lixus* spp.) (8.1.4)	50.0 (9)	27.8 (5)
Stem nematodes *(Ditylenchus dipsaci)* (8.1.6)	47.4 (9)	26.3 (5)
Pod colour at maturity (4.2.9)	47.4 (9)	21.1 (4)
Branching from higher nodes (4.1.5)	44.4 (8)	16.7 (3)
Sulphur amino acids (per 16 g N) (6.3.3)	36.8 (7)	15.8 (3)
Leaflet size (4.1.3)	66.7 (14)	14.3 (3)
Stem thickness [cm] (6.1.4)	60.0 (12)	10.0 (2)
Cooking time (6.3.5)	57.9 (11)	5.3 (1)
Independent vascular system	52.6 (10)	5.3 (1)

Annex VII – Additional characterization and evaluation descriptors proposed in the Faba Bean survey results

Faba Bean descriptor		Name of expert							
		Redden, Bob	Asadova, Almas.	Duc, Gérard.	Diederichsen, Axel.	Link, Wolfgang	Maalouf, Fouad.	Srinivasan, Kalyani.	Claure, Tito E.
Additional characterization descriptor	**N. of times selected**	**Very imp.**	**Very imp.**	**Very imp.**	**Very imp.**	**Very imp.**	**Very imp.**	**Very imp.**	**Very imp.**
Mean canopy height quicker to measure once for whole plot, than separate plant heights, and of equal utility	1	X							
Number of pods per plant	1		X						
Number of pods per nodes	1						X		
Number of flowers per raceme: Important for yield potential	1				X				
Number of flower per nodes: is associated with yield and with the level of outcrossing rate	1						X		
Number of leaflets per leaf	2				X			X	
Early plant vigour	1							X	
Leaflet shape	1							X	
Stem pigmentation	1							X	
Seed coat colour (**Seed colour**, because dark colours are not liked by the farmers and also by consumers.)	2							X	X
Pod width	1							X	
COMMENTS									
remark about leaflet size, shape, number /leaf and colour: certainly with genotypic differences but there is a need for calibration of records				X					

Faba Bean descriptor		Name of expert							
		Redden, Bob	Asadova, Almas.	Duc, Gérard.	Diederichsen, Axel.	Link, Wolfgang	Maalouf, Fouad.	Srinivasan, Kalyani.	Claure, Tito E.
Additional evaluation descriptor	**N. of times selected**	**Very imp.**	**Very imp.**	**Very imp.**	**Very imp.**	**Very imp.**	**Very imp.**	**Very imp.**	**Very imp.**
Importance of **bruchids** inversely related to seed storage hygeine and quality of storage. Susceptibility to any pest / disease should be noted whever infection occassionally significant	**1**	**X**							
Remark: The root rot complex may also involve ***Fusarium* spp** in some case.	**1**			**X**					
Self Fertility: Important for breeding and germplasm conservation.	**1**				**X**				
It is rather **methionine** and **cysteine** content than all amino acids.	**1**					**X**			
Vicine and Convicine content %	**2**					**X**		**X**	
Protein content %	**1**							**X**	
FBYNV: very important because they damage the crop in all Mediterranean area. There is a need to find sources for resistance	**1**						**X**		

Annex VIII - First priority descriptors for Faba Bean (*Vicia faba*) sent to CAG on 26th May 2009 drawn from survey results and validated by Ken Street

1. Growth habit (4.1.1)
2. Plant height [cm] (4.1.6)
3. Days to flowering (4.2.1)
4. Days to pod maturity (4.2.2)
5. Flower ground colour (4.2.3)
6. Wing petal colour (4.2.5)
7. Pod length [cm] (4.2.10)
8. Number of seeds per pod (4.3.2)
9. 100 seed weight [g] (4.3.3)
10. Ground colour of testa (seed coat) (4.3.4)
11. Seed shape (4.3.6)
12. Resistance to lodging (6.1.5)
13. Number of pods per node (6.2.3)
14. Pod shattering (6.2.5)
15. Tolerance to high temperature (7.2)
16. Tolerance to salinity (7.5)
17. Tolerance to chilly conditions
18. Tolerance to frost
19. Aphids (*Aphis* spp.) (8.1.1)
20. Seed weevils *(Bruchus* spp.) (8.1.5)
21. Chocolate spot (*Botrytis fabae*) (8.2.1)
22. Ascochyta blight (*Ascochyta fabae*) (8.2.2)
23. Stem rot (*Sclerotinia* spp.) (8.2.8)

Annex IX – Final list of descriptors compiled after consultation with the Core Advisory Group showing descriptors added (in green) and removed (in red)

1. Growth habit (4.1.1)
2. **Branching from basal nodes (4.1.4)**
3. Plant height [cm] (4.1.6)
4. Days to flowering (4.2.1)
5. Days to pod maturity (4.2.2)
6. Flower ground colour (4.2.3)
7. Wing petal colour (4.2.5)
8. **Pod angle / attitude at maturity (4.2.6)**
9. Pod length [cm] (4.2.10)
10. Number of seeds per pod (4.3.2)
11. 100 seed weight [g] (4.3.3)
12. Ground colour of testa (seed coat) (4.3.4)
13. Seed shape (4.3.6)
14. Resistance to lodging (6.1.5)
15. Number of pods per node (6.2.3)
16. Pod shattering (6.2.5)
17. Tolerance to high temperature (7.2)
18. Tolerance to salinity (7.5)
19. Tolerance to frost
20. Aphids (*Aphis* spp.) (8.1.1)
21. Seed weevils *(Bruchus* spp.) (8.1.5)
22. Chocolate spot (*Botrytis fabae*) (8.2.1)
23. Ascochyta blight (*Ascochyta fabae*) (8.2.2)
24. **Rust (*Uromyces fabae*) (8.2.4)**
25. Stem rot (*Sclerotinia* spp.) (8.2.8)
26. **Number of flower per nodes**
27. **Faba Bean Yellow Mosaic Virus (FBYM)**

Tolerance for chilly conditions

Annex X – Final list with descriptor states

Growth habit (4.1.1)

1 Determinate, i.e. stems with terminal inflorescence
2 Semi-determinate, i.e. without terminal inflorescence
3 Indeterminate

Branching from basal nodes (4.1.4)

Mean number of branches (to the nearest whole number) per plant taken from five representative plants in late flowering stage

Plant height [cm] (4.1.6)

Measured at near maturity from ground to the tip of the plant. Average of 10 plants

Days to flowering (4.2.1)

Number of days from sowing until 50% of plants have flowered. However, in dry land areas where planting occurs in dry soils, it is counted from the first day of rainfall or irrigation which is sufficient for germination

Days to pod maturity (4.2.2)

Number of days from sowing until 90% of the pods have dried. See 4.2.1 for planting in dry soils

Flower ground colour (4.2.3)

Ground colour of standard petal (flag)

1 White
2 Violet
3 Dark brown
4 Light brown
5 Pink
6 Red
7 Yellow
99 Other (i.e. 'mixed', specify in the **Notes** descriptor)

Wing petal colour (4.2.5)

1 Uniformly white
2 Uniformly coloured
3 Spotted
99 Other (i.e. 'mixed', specify in the **Notes** descriptor)

Pod angle/attitude at maturity (4.2.6)

1 Erect
2 Horizontal
3 Pendent
99 Other (i.e. 'mixed', specify in the **Notes** descriptor)

Pod length [cm] (4.2.10)
Mean of five dry pods

Number of seeds per pod (4.3.2)
Mean of five dry pods

100-seed weight [g] (4.3.3)

Ground colour of testa (seed coat) (4.3.4)
Observed immediately after harvest (within one month after harvest)

1 Black
2 Dark brown
3 Light brown
4 Light green
5 Dark green
6 Red
7 Violet
8 Yellow
9 White
10 Grey
99 Other (i.e. 'mixed', specify in the **Notes** descriptor)

Seed shape (4.3.6)

1 Flattened
2 Angular
3 Round
99 Other (i.e. 'mixed', specify the **Notes** descriptor)

Resistance to lodging (6.1.5)

3 Low
5 Medium
7 High

Number of pods per node (6.2.3)
Mean number of pods on the second pod-bearing node of five plants

Pod shattering (6.2.5)

0 Non-shattering (wrinkled-pod type)
1 Shattering

Number of flowers per node (6.2.X)

ABIOTIC STRESSES

High temperature (7.2)

Salinity (7.5)

Frost (7.X)

BIOTIC STRESSES

Aphids (*Aphis* spp.) (8.1.1)

Seed weevils (*Bruchus* spp.) (8.1.5)

Chocolate spot (*Botrytis fabae*) (8.2.1)

Ascochyta blight (*Ascochyta fabae*) (8.2.2)

Rust (*Uromyces fabae*) (8.2.4)

Stem rot (*Sclerotinia* spp.) (8.2.8)

Faba Bean Yellow Mosaic Virus (FBYM) (8.4.X)

ANNE XI - List of contributors

Core Advisory Group

Kenneth Street, ICARDA, Syria
Gérard Duc, INRA, France
Fouad Maalouf, ICARDA, Syria
P. N. Mathur, Bioversity International, India
Robert Redden, Department of Primary Industries Victoria, Australia
Larry Robertson, USDA-ARS, USA

Reviewers

Algeria
A. Abdelguerfi, ENSA

Azerbaijan
Almas Asadova, Genetic Resources Institute of Azerbaijan National Academy of Sciences

Bolivia
Tito E. Claure, Pairumani's Phytoecogenetical Research Center

Canada
Axel Diederichsen, Plant Gene Resources of Canada, Agriculture and Agri-Food Canada

China
Zong Xuxiao, Institute of Crop Science, Chinese Academy of Agricultural Sciences

Germany
Wolfgang Link, University of Göttingen
Ulrike Lohwasser, Leibniz Institute of Plant Genetics and Crop Plant Research

India
Kalyani Srinivasan, NBPGR

Italy
Andrea Carboni, CRA-CIN

Portugal
Isabel Duarte, INRB/INIA
Maria Manuela Veloso, INRB/INIA

Russia
Sergey Bulyntsev, Vavilov Institute of Plant Industry

Spain
María José Suso, Instituto de Agricultura Sostenible (CSIC)

Turkey
Lerzan Aykas, Aegean Agricultural Research Institute

USA
Bonnie J. Furman, USDA-ARS

Methodology for the definition of a key set of characterization and evaluation descriptors for finger millet [*Eleusine coracana* (L.) Gaertn]

Information collection and preparation of the Minimum Descriptor List (MDL)

Information for the definition of a Minimum Descriptor List for finger millet [*Eleusine coracana* (L.) Gaertn] was based on the publication 'Descriptors for Finger Millet' published by IBPGR (now Bioversity International) in 1985. Since the relevant Crop strategy for finger millet was not available at the time of development of this key set, the 'Regional strategy for the *ex situ* conservation of plant genetic resources in Eastern Africa' (Global Crop Diversity Trust, 2006), was analyzed particularly with regard to evaluation traits such as susceptibility to important biotic and abiotic stresses.

This comprehensive descriptors list was then compared with essential traits listed in 'Descriptors for GRASS-WARMSEASON' (USDA, ARS, GRIN); 'Morphological diversity in finger millet germplasm introduced from Southern and Eastern Africa' [(H.D. Upadhyaya, C.L.L. Gowda and V. Gopal Reddy) SAT eJournal, ICRISAT, Vol. 3, Issue 1, December 2007]; 'Descriptors for Characterization and Evaluation of Finger millet' [National Institute of Agrobiological Sciences (NIAS); Genebank of Japan], and with 'Phenotypic Diversity of Ethiopian Finger Millet [*Eleusine coracana* (L.) Gaertn] in Relation to Geographical Regions as an Aid to Germplasm Collection and Conservation Strategy' [(Kebere Bezaweletaw, Prapa Sripichitt, Wasana Wongyai and Vipa Hongtrakul) Kasetsart Journal (Natural Science), 41:7-16, 2007].

An excel table was prepared comparing traits listed in the above mentioned sources. The table was shared with the Crop Leader and then discussed with participants in the crop-specific meeting held in June 2009 at the National Bureau of Plant Genetic Resources (NBPGR), and involving experts from the Indian Agricultural Research Institute (IARI), All India Coordinated Millet Project (AICMP), NBPGR Headquarters and Shimla Research Station (see Annex I). During the meeting, characterization and evaluation traits important for finger millet were identified and a key set agreed upon. A comparison table containing only the Minimum List of characterization and evaluation descriptors was compiled to assist the Crop Leader in the selection of the list of traits to be proposed in the on-line survey (see Annex II).

Preparation of the List of Experts

The List of Experts was prepared taking into account the participants involved in crop-specific consultations for the definition of the 'Regional strategy for the *ex situ* conservation of plant genetic resources in Eastern Africa' (the Trust, 2006). Scientists present in the Sorghum & Millet directory of the Interactive Resource Center (IRC) website and some experts involved in the McKnight Foundation Collaborative Crop Research Program project were also included in the list.

Additional reviewers were selected from among authors of relevant articles for this crop, such as the one on *Ethiopian finger millet* used for preparing the minimum list.

Overall 66 experts from 24 countries and 42 different organizations were identified (see Annex III). Out of these, a Crop Leader, Dr A. Seetharam from All India Coordinated Research Projects (AICRP) on Small millets, and a Core Advisory Group (CAG), consisting of six experts, were selected to assist in the definition of a minimum set of descriptors for this crop. Members of the CAG were chosen from world renowned organizations such as International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), United States Department of Agriculture (USDA), NBPGR, and from experts involved in the AICRPs on Small millets Project.

Survey preparation and distribution

A draft survey on *Eleusine Coracana* was prepared following consultations with the Crop Leader and finger millet experts during the crop-specific meeting held at NBPGR. At the meeting a proposal was made to include both Long and Minimum Lists of Descriptors in the survey considering that, according to the Memorandum of Understanding between Bioversity International and ICAR, lists of traditional descriptors should be revised for five crops, including finger millet. However, because of the complexity and length of the survey text, the coordinator of this activity decided to include only the minimum set of traits defined during the meeting. This was done after the participants had already agreed on the Long List, thus solely the Minimum List needed a wider validation (see Annex IV). Once approved, the final draft of the survey was uploaded into the SurveyMonkey application on internet. An email with the link to the survey was sent to scientists identified in the List of Experts on 23 June 2009 inviting them to validate the initial Minimum set of descriptors of *Eleusine coracana* accessions to promote the utilization of finger millet germplasm (see Annex V). Experts were also encouraged to mention any additional trait that was found to be relevant yet missing from the proposed list, along with a substantiated justification for its inclusion. The survey deadline was set at 23 July 2009, therefore, a first reminder was sent out on 7 July 2009 and a second one on 17 July 2009. By popular demand the deadline was extended to 6 August 2009 to ensure that the greatest possible feedback was obtained.

Survey analysis and refinement of the Minimum List

Of the 66 experts identified and involved in the exercise, 22 from 13 countries and 18 different organizations recorded their comments using the online survey (see Annex VI). Among them, there were the Crop Leader and seven members of the Core Advisory Group (CAG). Results from the survey were analyzed and descriptors ranked by rating average and percentage of importance (see Annex VII). The summary results of the survey together with a report containing comments received by the participants (see

Annex VIII) were sent to the Crop Leader and to the Core Advisory Group for further consultation and to help select a reduced set of key traits. In order to reach a wider consensus on the final key set of traits, additional members were added to the CAG at this stage. All feedback received from advisory members and reviewers was compared and harmonized, where possible (see Annex IX). This exercise led to a first draft of the key set for finger millet that was submitted to the Crop Leader and the Core Advisory Group again for final validation. Of particular note, no descriptors concerning abiotic stresses were included in the key set since none of the CAG selected "Soil salinity" (7.5) (the only abiotic stress proposed), as "Very Important" and because of its low rating.

Definition of a final key set of descriptors for finger millet

The final document approved by the Crop Leader and CAG, including all the contributors (see Annex X), was proofread by an external editor and sent to the Bioversity Publications Unit for layout and on-line publication processes. Furthermore, the publication was shared with the ECPGR Secretariat; the Generation Challenge Programme (GCP) Ontology and the SGRP Crop Genebank Knowledge Base partners. Additionally, data were converted into Excel files for uploading into the GRIN-Global genebank data-management system being developed by USDA first, and subsequently into the Global Accession Level Information Portal (GENESYS), linking national, regional and international genebank databases in support of the conservation and use of plant genetic resources for food and agriculture (PGRFA). The Excel files were also provided to the System-wide Information Network for Genetic Resources (SINGER) and to EURISCO.

Acknowledgement

Bioversity is grateful to all the scientists and researchers who have contributed to the development of this strategic set of key access and utilization descriptors for finger millet genetic resources, and to the Global Crop Diversity Trust for their financial support. Particular recognition goes to the Crop Leader, Dr A. Seetharam from AICRP Small millets (India), for providing valuable scientific direction. Ms Adriana Alercia provided technical expertise and guided the entire production process.

Annex I – Comparison table weighing up important descriptors for finger millet drawn from different sources[i] [ii]

Bioversity Descriptors	IBPGR 1985 (1)	USDA (2)	ICRISAT (3)	NIAS (4)	Ethiopian finger m. article (5)	Long List (6)	Min + Data Avail (6)
Growth [plant] habit 4.1.1 (Seedling stage)	*			*	*	*	
Plant height [cm] 4.1.2	*	*	*	*		*	*
Culm branching 4.1.3	*					*	
Plant pigmentation 4.1.4	*		*			*	*
Productive tillers (NUMBER) 4.2.1	*			*		*	*
Days to flowering 4.2.2	*		*	*		*	*
Ear exsertion [mm] 4.2.3 (n/n)							
Ear shape 4.2.4	*			*	*	*	*
Ear size 4.2.5 (see finger l W)	*						
Finger branching 4.2.6	*					*	*
Discontinuity of spikelets on finger 4.2.7	*					*	
Finger length [mm] 4.2.8	*			*		*	*
Finger width [mm] 4.2.9	*					*	
Glume length [mm] 4.2.10	*					*	
Spikelet shattering 4.2.11 N/N							
Number of grains per spikelet 4.2.12	*					*	*
Grain covering 4.2.13	*					*	
Grain colour 4.3.1	*		*	*	*	*	*
Culm thickness [mm] 6.1.1	*			*		*	
Leaf number 6.1.2	*					*	*
Leaf sheat length [mm] 6.1.3							
Leaf sheat width [mm] 6.1.4							
Leaf blade length [cm] 6.1.5							
Leaf blade width [cm] 6.1.6							
Stomatal frequency 6.1.7							
Blade length of flag leaf [cm] 6.1.8	*			*		*	
Blade width of flag leaf [cm] 6.1.9	*					*	
Lodging susceptibility 6.1.10	*					*	
Green fodder yield 6.1.11	*			*		*	*
Peduncle length [cm] 6.2.1	*					*	
Finger number 6.2.2	*					*	*
Spikelet density 6.2.3	*					*	
Days to maturity 6.2.4	*			*		*	*
Synchrony of ear maturity 6.2.5	*					*	

Grain shape 6.3.1	*				*	*	
Grain surface 6.3.2	*				*	*	
Grain uniformity 6.3.3	*					*	
Pericarp persistence after threshing 6.3.4	*			*	*	*	
1000 grain weight [g] 6.3.5	*			*		*	*
Grain yield per plant [g] 6.3.6	*			*		*	*
Grain yield potential 6.3.7							
Malting quality 6.3.8	*					*	*
Protein content [%] 6.3.9	*					*	*
Lysine content [%] 6.3.10	*					*	
Methionine content [%] 6.3.11	*					*	
Mineral content [%] 6.3.12	*					*	
Calcium content [%] 6.3.12	*					*	*
Low temperature 7.1							
High temperature 7.2							
Drought 7.3	*					*	
High soil moisture 7.4							
Soil salinity 7.5	*					*	*
Shoot flies (*Atherigona* spp.) 8.1.1	*					*	
White grubs (*Holotrichia* spp.) 8.1.2	*					*	
Armyworms (*Mythimna* spp.) 8.1.3	*					*	
Hairy caterpillars (*Amsacta albistriga* (Walk), *Estigmene lactinea G.*) 8.1.4	*					*	
Bollworms (*Heliothis armigera* (Hub.)) 8.1.5	*					*	
Stem borers (*Busseola* spp. - *Chilo* spp. - *Sesamia* spp.) 8.1.6	*					*	*
Aphids (*Hysteroneura setariae* (Thomas) - *Rhopalosiphum maidis* (Fitch) - *Tetraneura* spp.) 8.1.7	*					*	
Earhead caterpillars (*Cacoecia* spp. - *Cryptoblades* spp. - *Eublemma* spp. - *Stenachroia elongella* Hamps) 8.1.8	*					*	
Beetles (*Epicauta* spp. - *Epilachna similis* (Thunb.) - *Monolepta signata* O.) 8.1.9	*					*	
Earhead bugs (*Calocoris angustatus* (Leth.) - *Dolycoris indicus* (Slal.) - *Menida Histrio* (Fabr.) - *Nezara viridula* L.) 8.1.10	*					*	
Midges (*Contarinia* spp.) 8.1.11	*					*	
Weevils (*Myllocerus* spp. - *Nematocerus* spp.) 8.1.12	*					*	
Grain moth (*Sitotroga cerealella* (Oliv.)) 8.1.13	*					*	

Grasshoppers 8.1.14	*					*	
Locusts 8.1.15							
Birds 8.1.16						*	
Blast on foliage 8.2.1	*			*		*	*
Blast on neck 8.2.2	*			*		*	*
Blast on finger 8.2.3	*			*		*	*
Foot rots 8.2.4	*					*	
Wilts 8.2.5	*					*	
Leaf spots (*Cercospora* spp. - *Collectotrichum graminicola* (Ces.) Wilson - *Drechslera rostratum* (Drechs.) - Richard & Fraser) = (*Exserohilum rostratum* Drechs. - *Phyllachora eleusines Speg.*) 8.2.6	*					*	*
Downy mildews (*Sclerophthora macrospora* (Sacc.) Thirum., Shaw & Naras.) 8.2.7	*					*	
Smuts (*Melanosichium eleusinis* (Kulk.) Mundk. & Thirum.) 8.2.8	*					*	
Grain molds (*Curvularia lunata* (Walk.) Bold.) 8.2.9	*					*	

---

[i] (1) 'Descriptors for Finger Millet' (IBPGR, 1985); (2) 'Descriptors for GRASS-WARMSEASON' (USDA, ARS, GRIN); (3) 'Morphological diversity in finger millet germplasm introduced from Southern and Eastern Africa' [(HD Upadhyaya, CLL Gowda and V Gopal Reddy) SAT eJournal, ICRISAT, Vol. 3, Issue 1, December 2007]; (4) 'Descriptors for Characterization and Evaluation of Finger millet' [National Institute of Agrobiological Sciences (NIAS), Genebank of Japan]; (5) 'Phenotypic Diversity of Ethiopian Finger Millet [*Eleusine coracana* (L.) Gaertn] in Relation to Geographical Regions as an Aid to Germplasm Collection and Conservation Strategy' [(Kebere Bezaweletaw, Prapa Sripichitt, Wasana Wongyai and Vipa Hongtrakul) Kasetsart Journal (Natural Science) 41:7 – 16, 2007]; (6) Long and Minimum list of descriptors identified by participants in the crop-specific meeting held at the NBPGR in June 2009.

[ii] Descriptors highlighted in yellow are the Minimum key set of characterization and evaluation descriptors for genetic resources utilization; descriptors highlighted in red are descriptors for deletion.

Annex II – Comparison table for a Minimum List of characterization and evaluation descriptors sent to the Crop Leader on 10 June 2009

Descriptors for finger millet (*Eleusine coracana)*	IBPGR 1985	USDA	ICRISAT	NIAS	Ethiopian finger millet article	in C&E (Data Available)
Plant height [cm] 4.1.2	*	*	*	*		*
Plant pigmentation 4.1.4	*		*			*
Productive tillers (NUMBER) 4.2.1	*			*		*
Days to flowering 4.2.2	*		*	*		*
Ear shape 4.2.4	*			*	*	*
Finger branching 4.2.6	*					*
Finger length [mm] 4.2.8	*			*		*
Number of grains per spikelet 4.2.12	*					*
Grain colour 4.3.1	*		*	*	*	*
Leaf number 6.1.2	*					*
Green fodder yield 6.1.11	*			*		*
Finger number 6.2.2	*					*
Days to maturity 6.2.4	*			*		*
1000 grain weight [g] 6.3.5	*			*		*
Grain yield per plant [g] 6.3.6	*			*		*
Malting quality 6.3.8	*					*
Protein content [%] 6.3.9	*					*
Calcium content [%] 6.3.12	*					*
Soil salinity 7.5	*					*
Stem borers (*Busseola* spp. - *Chilo* spp. - *Sesamia* spp.) 8.1.6	*					*
Blast on foliage 8.2.1	*			*		*
Blast on neck 8.2.2	*			*		*
Blast on finger 8.2.3	*			*		*
Leaf spots (*Cercospora* spp. - *Collectotrichum graminicola* (Ces.) Wilson) - *Drechslera rostratum* (Drechs. - Richard & Fraser) = *Exserohilum rostratum* Drechs.) - *Phyllachora eleusines Speg.*) 8.2.6	*					*

Annex III – Experts identified to participate to the online survey

ROLE	*NAME*	*ORGANIZATION*	*COUNTRY*
Crop Leader	**Seetharam, A.**	Ex-Project Coordinator, AICRP on Small millets	India
CAG	Baniya, B.K.	NARC (Retired)	Nepal
New CAG	Bramel, Paula	IITA	Nigeria
CAG suggested ontology workshop	Hash, C. Tom	ICRISAT	India
New CAG	Lohwasser, Ulrike	Leibniz Institute of Plant Genetics and Crop Plant Research (IPK)	Germany
CAG	Rana, J.C.	NBPGR, Regional Station, Phagli, Shimla	India
New CAG	Updhyaya, Hari D.	ICRISAT	India
Syngenta internet	Abraha, Negusse	NARI	Eritrea
Syngenta internet	Ageru, Asfaw Adugna	Melkassa Agricultural Research Center	Ethiopia
Syngenta internet	Ahmadou, Issaka	INRAN	Niger
Reviewer	Bandyopadhyay, Ranajit	IITA	Nigeria
Comparative Genomics Bennetzen's Lab	Bennetzen, Jeffrey Lynn	Department of Genetics, University of Georgia	USA
Article internet 1[1]	Bezaweletaw, Kebere	Awassa Agric. Research Center	Ethiopia
Syngenta internet	Bidinger, F.R.	ICRISAT	India
Syngenta internet	Bonamigo, Luiz	Sementes	Brazil
Syngenta internet	Buntin, G. David	UGA	USA
Reviewer	Chee, Peng	UGA	USA
Reviewer	Chen, Chengci	Montana State University	USA
Syngenta internet	Clerget, Benoit	ICRISAT	Mali
Reviewer	Cohn, Donna	Hampshire College	USA
Syngenta internet	Degu, Erenso	Melkassa Agricultural Research Center	Ethiopia
Collaborative Crop Research Program	Devos, Katrien Martha	University of Georgia (UGA)	USA
Article internet 2[2]	Dida, M. Mathews	Maseno University	Kenya
Reviewer	Elfadil, Adam	Ag Research Corporation	Sudan

[1] Article internet 1: Kasetsart J. (Nat. Sci.) 41:7-16 (2007), Phenotypic Diversity of Ethiopian Finger Millet [Eleusine coracana (L.) Gaertn] in Relation to Geographical Regions as an Aid to Germplasm Collection and Conservation Strategy Kebere Bezaweletaw1, Prapa Sripichitt2.

[2] Article internet 2: Population Structure and Diversity in Finger Millet Germplasm.

WIEWS	Ellis, David	National Center for Genetic Resources Preservation (NCGRP)	USA
Reviewer	Endale, Dinku	USDA, GA	USA
Reviewer	Erbaugh, Mark	Ohio State University	USA
Syngenta internet	Ferreira, Alves	Sementes	Brazil
Syngenta internet	Fite, Geleta	Dept of Agricultural Research	Botswana
Reviewer	Fofana, Amadou	ISRA-CRZ	Senegal
Syngenta internet	Franca Neto, Jose	EMBRAPA	Brazil
Syngenta internet	Habindavyi, Esperance	ISABU	Burundi
Syngenta internet	Harinarayana, Gollapudi	Ganga Kaveri Seeds	India
Reviewer (no longer CAG)	Harrison Dunn , Melanie L.	ARS-USDA, GA	USA
Reviewer	Haussmann, Bettina	ICRISAT	Niger
Syngenta internet	Hernandez Alatorre, Jose Antonio	INIFAP	Mexico
Collaborative Crop Research Program	Hittalmani, Shailaja	University of Agriculture sciences Bangalore (UASB)	India
Reviewer (no longer CAG)	Jayarame, Gowda	AICRP on Small millets	India
Reviewer	Kamuntu, Seperatus	Ukiriguru Mwanza Agricultural Research Institute	Tanzania
Reviewer (no longer CAG)	Khairwal, I.S.	AICPMIP	India
Reviewer	Kumar, Anand	AERC	Canada
Germplasm Collection (2003)	Lawrence, Peter	Australian Tropical Crops & Forages Genetic Resources Centre	Australia
Collaborative Crop Research Program	Leong, Sally	University of Wisconsin	USA
NBPGR meeting June 2009	Mahajan, R.K.	NBPGR	India
Reviewer	Mativavarira, Munyaradzi	Crop Breeding Institute	Zimbabwe
Reviewer	Maloo, S.R.	MPUAT, Udaipur, Rajasthan	India
NBPGR Expert meeting 2009	Mishra, S.K.	NBPGR	India
Reviewer	Ni, Xinzhi	USDA, GA	USA
Syngenta internet	Nutsugah, Stephen	SARI	Ghana
Syngenta internet	Oduori, Chrispus O.A.	KARI	Kenya

Syngenta internet	Rai, K.N.	ICRISAT	India
Syngenta internet	Rattunde, Fred	ICRISAT	Mali
SINGER Survey (Genebank data manager)	Reddy, Thimma	ICRISAT	India
Syngenta internet	Reddy, V. Gopal	ICRISAT	India
Reviewer	Rooney, Lloyd	TAMU	USA
Syngenta internet	Sanogo, Moussa	IER	Mali
Suggested by H. Knüpffer	Schmidt, Barbel	IPK Genebank Dept	Germany
Syngenta internet	Sharma, Y.K.	Agric Research Station	India
Article internet 1[1]	Sripichitt, Prapa	Kasetsart University	Thailand
Pearl millet breeder	Sy, Ousmane	Institut Sénégalais de Recherches Agricoles (ISRA)	Senegal
Syngenta internet	Tesso, Tesfaye	Melkassa Agricultural Research Center	Ethiopia
Syngenta internet	Traore, Hamidou	INERA-CREAF	Burkina Faso
NBPGR June visit 2009	Verma, V.D.	NBPGR Regional Station, Phagli, Shimla	India
Syngenta internet	Weltzien Rattunde, Eva	ICRISAT	Mali
Reviewer	Xuxiao, Zong	Institute of Crop Germplasm Resources, CAAS	China
Syngenta internet	Yadav, Om Parkash	CAZRI	India
WIEWS		Institute of Biodiversity Conservation	Ethiopia
KARI Website		National Genebank of Kenya, Crop Plant Genetic Resources Centre - Muguga KARI-NGBK	Kenya
KARI Website		Agricultural Research Centre - Katumani KARI-Katumani	Kenya

[1] Article internet 1: Kasetsart J. (Nat. Sci.) 41:7-16 (2007), Phenotypic Diversity of Ethiopian Finger Millet [*Eleusine coracana* (L.) Gaertn] in Relation to Geographical Regions as an Aid to Germplasm Collection and Conservation Strategy Kebere Bezaweletaw1, Prapa Sripichitt2.

Annex IV – Key set of characterization and evaluation descriptors for finger millet (*Eleusine coracana*) validated at the crop-specific meeting held at NBPGR in June 2009 and used for the online survey

Plant height [cm] 4.1.2	*
Plant pigmentation 4.1.4	*
Productive tillers (NUMBER) 4.2.1	*
Days to flowering 4.2.2	*
Ear shape 4.2.4	*
Finger branching 4.2.6	*
Finger length [mm] 4.2.8	*
Number of grains per spikelet 4.2.12	*
Grain colour 4.3.1	*
Leaf number 6.1.2	*
Green fodder yield 6.1.11	*
Finger number 6.2.2	*
Days to maturity 6.2.4	*
1000 grain weight [g] 6.3.5	*
Grain yield per plant [g] 6.3.6	*
Malting quality 6.3.8	*
Protein content [%] 6.3.9	*
Calcium content [%] 6.3.12	*
Soil salinity 7.5	*
Stem borers (*Busseola* spp. - *Chilo* spp. - *Sesamia* spp.) 8.1.6	*
Blast on foliage 8.2.1	*
Blast on neck 8.2.2	*
Blast on finger 8.2.3	*
Leaf spots (*Cercospora* spp., *Collectotrichum graminicola*, *Drechslera rostratum*, *Exserohilum rostratum*, *Phyllachora eleusines*) 8.2.6	*

Annex V – Online survey to choose a key set of descriptors for finger millet utilization

WELCOME

Welcome to the survey for the selection of a key set of characterization and evaluation descriptors for finger millet to support an international information system to enhance the utilization of germplasm held in genebanks.

Your knowledge and experience are being sought to define an initial '**key set**' of descriptors that identify traits important to crop production and facilitate the use of accessions by researchers.

Your participation in it is highly appreciated. The deadline for this survey is **23 July 2009**.

This key set of descriptors will be made available through a global portal for identifying sets of accessions for evaluation and use. For characterization, the aim is a key set of maximally differentiating traits that provide the most impact in discriminating between accessions. For evaluation, the aim is to focus on a few important traits for production, such as those related to abiotic or biotic stresses of cosmopolitan nature.

By selecting descriptors as **'very important'**, you are helping us define the key set that will be instrumental for assisting researchers to more easily utilize finger millet accessions.

This survey consists of two parts:
- PART I: Characterization descriptors.

- PART II: Evaluation descriptors.

We thank you in advance for investing your time and expertise in selecting the set of descriptors.

*** Please allow us to acknowledge your contribution by completing your full contact details below:**

Name:

Position:

Organization:

Country:

Email:

PART I: Characterization descriptors

These traits enable easy and quick discrimination between phenotypes. They are generally highly heritable, can be easily seen by the eye and are equally expressed in all environments.

Based on your experience, please rate the descriptors according to their importance. It also allows you to indicate if any essential descriptor that can contribute to its use is missing from the minimum list presented.

*Numbers in parentheses on the right-hand side are the corresponding descriptors numbers as published in the IBPGR publication 'Descriptors for Finger millet' (1985).

	Not important	Important	Very important
Plant height [cm] (4.1.2)			
Plant pigmentation (4.1.4)			
Productive tillers (4.2.1)			
Days to flowering (4.2.2)			
Ear shape (4.2.4)			
Finger branching (4.2.6)			
Finger length [mm] (4.2.8)			
Number of grains per spikelet (4.2.12)			
Grain colour (4.3.1)			

If you consider that an essential trait is missing from this list, please indicate it here along with a substantiated justification.

PART II: Evaluation descriptors

These descriptors include characters such as grain yield and biotic and abiotic stresses. They are the most interesting traits in crop improvement. Please consider the following factors relating to the trait when making your final decision: (i) Global impact, (ii) Initial strategic set, (iii) Importance for germplasm utilization, (iv) Data availability, (v) True economic damage and (vi) Wide geographical occurrence.

Please, rate these traits in order of importance at the global level. It also allows you to indicate if any essential trait for production is missing from the minimum list presented or indicate any that may not be very significant to global production.

	Not Important	Important	Very important
Leaf number (6.1.2)	☐	☐	☐
Green fodder yield (6.1.11)	☐	☐	☐
Finger number (6.2.2)	☐	☐	☐
Days to maturity (6.2.4)	☐	☐	☐
1000-grain weight [g] (6.3.5)	☐	☐	☐
Grain yield per plant [g] (6.3.6)	☐	☐	☐
Malting quality (6.3.8)	☐	☐	☐
Grain protein content [%] (6.3.9)	☐	☐	☐
Calcium content [%] (6.3.13)	☐	☐	☐
Soil salinity (7.5)	☐	☐	☐
Stem borers (*Busseola* spp. - *Chilo* spp. - *Sesamia* spp.) (8.1.6)	☐	☐	☐
Blast on foliage (8.2.1)	☐	☐	☐
Blast on neck (8.2.2)	☐	☐	☐
Blast on finger (8.2.3)	☐	☐	☐
Leaf spots (*Cercospora* spp. - *Collectotrichum graminicola* - *Drechslera rostratum = Exserohilum rostratum* - *Phyllachora eleusines*) (8.2.6)	☐	☐	☐

If you consider that an essential trait important for crop improvement and production is missing from the list above, please indicate it here along with a substantiated justification.

NOTE: Please remember, this list is the starting point and will grow over time, as required.

THANK YOU VERY MUCH FOR YOUR PARTICIPATION.

Annex VI – Respondents to the online survey

ROLE	*NAME*	*POSITION*	*ORGANIZATION*	*COUNTRY*
Crop Leader	**Seetharam, A.**	Ex-Project Coordinator	All India Coordinated Research Project (AICRP) - Small millets	India
CAG	Baniya, Bimal Kumar	Principal Scientist Retired	NARC	Nepal
CAG	Bramel, Paula	DDG-R4D	IITA	Nigeria
CAG	Hash, C. Tom		ICRISAT	India
CAG	Lohwasser, Ulrike	Genebank Taxonomist	Leibniz Institute of Plant Genetics and Crop Plant Research	Germany
CAG	Mathur, Prem		Bioversity International	India
CAG	Rana, J.C.	Principal Scientist	National Bureau of Plant Genetic Resources (NBPGR) Regional Station	India
CAG	Upadhyaya, Hari D.	Principal Scientist and Head, Gene Bank	ICRISAT	India
Reviewer	Asfaw Adugna	Plant Breeder	Ethiopian Institute of Agricultural Research (EIAR)	Ethiopia
Reviewer	Ashok, Kumar	Principal Scientist	NBPGR	India
Reviewer	Dida, Mathews M.	Senior Lecturer	Maseno University	Kenya
Reviewer	Dillon, Sally	Research Scientist	Queensland Primary Industries and Fisheries	Australia
Reviewer	Elfadil Mukhtar Adam	Scientist	Agricultural Research Corporation	Sudan
Reviewer	Habindavyi, Espérance	Researcher	Institut des Sciences Agronomiques du Burundi	Burundi
Reviewer	Hittalmani, Shailaja	Professor and Head	University of Agricultural Sciences, Bangalore	India
Reviewer	Kamuntu, Seperatus P.	Agricultural Research Officer	Lake Zone Agricultural Research Institute and Development (LZARDI) Ukiriguru Mwanza	Tanzania
Reviewer	Kumar, K. Anand	Research Lead	AERC Inc.	Canada
Reviewer	Mare, Marco	Millets Breeder	Crop Breeding Institute (C.B.I)	Zimbabwe
Reviewer	Oduori, C.	Senior Research Officer	Kenya Agricultural Research Institute	Kenya
Reviewer	Reddy, M. Thimma	Scientific Associate	ICRISAT	India
Reviewer	Sy, Ousmane	Pearl millet breeder	Institut Sénégalais de Recherches Agricoles (ISRA)	Senegal
Reviewer	Taye, Tadesse	Sorghum and Millet research coordinator	Ethiopian Institute of Agricultural Research (EIAR)	Ethiopia

Annex VII – Survey results ranked by rating average and percentage of importance

Descriptor	Rating Average
Characterization	
Days to flowering (4.2.2)	4.58
Grain colour (4.3.1)	4.40
Ear shape (4.2.4)	4.30
Plant height [cm] (4.1.2)	4.25
Finger length [mm] (4.2.8)	4.25
Productive tillers (4.2.1)	4.05
Finger branching (4.2.6)	4.00
Plant pigmentation (4.1.4)	3.40
Number of grains per spikelet (4.2.12)	3.35
Evaluation	
1000-grain weight [g] (6.3.5)	4.40
Finger number (6.2.2)	4.35
Grain protein content [%] (6.3.9)	4.20
Grain yield per plant [g] (6.3.6)	4.00
Days to maturity (6.2.4)	3.95
Blast on finger (8.2.3)	3.95
Green fodder yield (6.1.11)	3.84
Calcium content [%] (6.3.13)	3.65
Blast on foliage (8.2.1)	3.60
Malting quality (6.3.8)	3.50
Blast on neck (8.2.2)	3.50
Stem borers (*Busseola* spp. - *Chilo* spp. - *Sesamia* spp.) (8.1.6)	3.15
Leaf number (6.1.2)	2.89
Soil salinity (7.5)	2.85
Leaf spots (*Cercospora* spp. - *Collectotrichum graminicola* - *Drechslera rostratum* = *Exserohilum rostratum* - *Phyllachora eleusines*) (8.2.6)	2.80

Descriptor	Important (%)	Very important (%)
Characterization		
Days to flowering (4.2.2)	21.10%	78.90%
Grain colour (4.3.1)	30.00%	70.00%
Plant height [cm] (4.1.2)	25.00%	70.00%
Finger length [mm] (4.2.8)	25.00%	70.00%
Ear shape (4.2.4)	35.00%	65.00%
Finger branching (4.2.6)	25.00%	65.00%
Productive tillers (4.2.1)	35.00%	60.00%
Number of grains per spikelet (4.2.12)	45.00%	40.00%
Plant pigmentation (4.1.4)	55.00%	35.00%
Evaluation		
Finger number (6.2.2)	20.00%	75.00%
1000-grain weight [g] (6.3.5)	30.00%	70.00%
Grain protein content [%] (6.3.9)	40.00%	60.00%
Grain yield per plant [g] (6.3.6)	36.80%	57.90%
Days to maturity (6.2.4)	40.00%	55.00%
Blast on finger (8.2.3)	40.00%	55.00%
Calcium content [%] (6.3.13)	30.00%	55.00%
Blast on foliage (8.2.1)	45.00%	45.00%
Green fodder yield (6.1.11)	57.90%	42.10%
Malting quality (6.3.8)	50.00%	40.00%
Blast on neck (8.2.2)	50.00%	40.00%
Stem borers (*Busseola* spp. - *Chilo* spp. - *Sesamia* spp.) (8.1.6)	55.00%	30.00%
Leaf spots (*Cercospora* spp. - *Collectotrichum graminicola* - *Drechslera rostratum* = *Exserohilum rostratum* - *Phyllachora eleusines*) (8.2.6)	60.00%	20.00%
Soil salinity (7.5)	70.00%	15.00%
Leaf number (6.1.2)	78.90%	10.50%

Annex VIII – Additional traits proposed in the survey

Finger millet descriptor		Name of expert								
Additional characterization traits	**N. times proposed**	**Ousmane Sy**	**Marco Mare**	**Asfaw Adugna**	**Elfadil Mukhtar Adam**	**J.C. Rana**	**Hari D. Upadhyaya**	**C. Oduori**	**Bimal Kumar Baniya**	**Shailaja Hittalmani**
Size of the grain is very important, bigger the grain size, more likely is the variety for most farmers	**2**	**X**	**X**							
Panicle exsertion	**1**				**X**					
Threshability of grains is also an important trait which farmers consider while making selection	**1**					**X**				
Plant aspect score	**1**						**X**			
Overall agronomic desirability of the accessions as observed visually	**1**						**X**			
Additional evaluation traits										
Dry matter weight, this is very important for farmers who needs fodder for animals	**1**	**X**								
Head compacity is important, if the head is compact, there is possibility of hiding insects	**1**	**X**								
Number of fingers	**1**			**X**						
Finger width	**1**				**X**					
Finger characteristic: this will help the extent of diseases susceptibility and insect infestation	**1**								**X**	
Striga support Shootfly at seedling stage	**1**							**X**		
Cooking and keeping quality	**1**									**X**

Annex IX – Summary results table sent to the Crop Leader and the CAG for validation

Descriptor	Your selection	Rating Average
Characterization		
Days to flowering (4.2.2)		**4.58**
Grain colour (4.3.1)		**4.40**
Ear shape (4.2.4)		**4.30**
Plant height [cm] (4.1.2)		**4.25**
Finger length [mm] (4.2.8)		**4.25**
Productive tillers (4.2.1)		**4.05**
Finger branching (4.2.6)		**4.00**
Plant pigmentation (4.1.4)		3.40
Number of grains per spikelet (4.2.12)		3.35
Evaluation		
1000-grain weight [g] (6.3.5)		**4.40**
Finger number (6.2.2)		**4.35**
Grain protein content [%] (6.3.9)		**4.20**
Grain yield per plant [g] (6.3.6)		**4.00**
Days to maturity (6.2.4)		**3.95**
Blast on finger (8.2.3)		**3.95**
Green fodder yield (6.1.11)		3.84
Calcium content [%] (6.3.13)		3.65
Blast on foliage (8.2.1)		3.60
Malting quality (6.3.8)		3.50
Blast on neck (8.2.2)		3.50
Stem borers (*Busseola* spp. - *Chilo* spp. - *Sesamia* spp.) (8.1.6)		3.15
Leaf number (6.1.2)		2.89
Soil salinity (7.5)		2.85
Leaf spots (*Cercospora* spp. - *Collectotrichum graminicola* - *Drechslera rostratum* = *Exserohilum rostratum* - *Phyllachora eleusines*) (8.2.6)		2.80

Annex X – Final key set of descriptors for finger millet genetic resources

Key access and utilization descriptors for finger millet genetic resources

This list consists of an initial set of characterization and evaluation descriptors for finger millet genetic resources utilization. This strategic set of descriptors, together with passport data, will become the basis for the global accession level information portal being developed by Bioversity International with the financial support of the Global Crop Diversity Trust (the Trust). It will facilitate access to and utilization of finger millet accessions held in genebanks and does not preclude the addition of further descriptors, should data subsequently become available.

Based on the comprehensive list 'Descriptors for Finger millet' published by IBPGR (now Bioversity International) in 1985, the list was subsequently compared with a number of sources such as 'Descriptors for GRASS-WARMSEASON' (USDA, ARS, GRIN), 'Morphological diversity in finger millet germplasm introduced from Southern and Eastern Africa' (SAT eJournal, ICRISAT, Vol. 3, Issue 1, December 2007), 'Descriptors for Characterization and Evaluation of Finger millet (National Institute of Agrobiological Sciences, Genebank of Japan), 'Phenotypic Diversity of Ethiopian Finger Millet [*Eleusine coracana* (L.) Gaertn] in Relation to Geographical Regions as an Aid to Germplasm Collection and Conservation Strategy' (Kasetsart Journal, Natural Science, 41:7-16, 2007).

The initial list was further refined during a crop-specific consultation meeting held at the National Bureau of Plant Genetic Resources (NBPGR, India) in June 2009. It involved several scientists from NBPGR, the Indian Agricultural Research Institute (IARI) and the All India Coordinated Research Project on Small Millets (AICRP-Small Millets).

A worldwide distribution of experts was involved in an online survey to define a first priority set of descriptors to describe, to access and to utilize finger millet genetic resources. This key set was afterwards validated by a Core Advisory Group (see 'Contributors') led by Dr A. Seetharam, Ex-Project Coordinator, All India Coordinated Research Project on Small Millets.

Biotic stresses included in the list were chosen because of their wide geographic occurrence and significant economic impact at a global level.

Numbers in parentheses on the right-hand side are the corresponding descriptor numbers listed in the 1985 publication.

PLANT DATA

Plant height [cm] (4.1.2)

From ground level to the tip of inflorescence (ear). At dough stage

Plant pigmentation (4.1.4)

At flowering

0 Not pigmented
1 Pigmented

Productive tillers (4.2.1)

Number of basal tillers which bear mature ears

Days to flowering (4.2.2)

From sowing to stage when ears have emerged from 50% of main tillers

Ear shape (4.2.4)

At dough stage

1 Droopy (fingers lax and drooping)
2 Open (fingers straight)
3 Semi-compact (tops of fingers curved)
4 Compact (fingers incurved)
5 Fist-like (fingers very incurved)

Finger branching (4.2.6)

At dough stage

0 Absent
1 Present

Finger length [mm] (4.2.8)

From base to the tip of longest spike (finger) on main tiller. At dough stage

Number of grains per spikelet (4.2.12)

At maturity

3 Low (4 grains)
5 Intermediate (6 grains)
7 High (8 grains)

Grain colour (4.3.1)

Post-harvest

1 White
2 Light brown
3 Copper-brown
4 Purple-brown
99 Other (specify in descriptor **Notes**)

Green fodder yield (6.1.11)

Consider tillering, height, leafiness, bulk and senescence. At maturity

Finger number (6.2.2)

On main ear. At dough stage

Days to maturity (6.2.4)

From sowing to stage when 50% of main tillers have mature ears

1000-grain weight [g] (6.3.5)

Grain yield per plant [g] (6.3.6)

Mean of five plants, post-harvest

Grain protein content [DW %] (6.3.9)

Percentage of dry grain weight

Calcium content [DW %] (6.3.13)

Percentage of dry grain weight

BIOTIC STRESSES

Stem borers (*Busseola* spp.; *Chilo* spp.; *Sesamia* spp.) (8.1.6)

Blast on foliage (*Pyricularia* sp.) (8.2.1)
At 30 days

Blast on neck (*Pyricularia* sp.) (8.2.2)
At maturity

Blast on finger (*Pyricularia* sp.) (8.2.3)
At maturity

NOTES

Any additional information may be specified here, particularly that referring to the category '99=Other' present in some of the descriptors above.

CONTRIBUTORS

Bioversity is grateful to all the scientists and researchers who have contributed to the development of this strategic set of 'Key access and utilization descriptors for finger millet genetic resources', and in particular to Dr A. Seetharam for providing valuable scientific direction. Ms Adriana Alercia provided technical expertise and guided the entire production process.

CORE ADVISORY GROUP

A. Seetharam, Ex-Project Coordinator, All India Coordinated Research Project on Small Millets, India
Bimal Kumar Baniya, Nepal Agricultural Research Council (NARC), Nepal
Paula Bramel, International Institute of Tropical Agriculture (IITA), Nigeria
Tom C. Hash, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India
Ulrike Lohwasser, Leibniz Institute of Plant Genetics and Crop Plant Research, Germany
Prem Mathur, Bioversity International, India
J.C. Rana, National Bureau of Plant Genetic Resources (NBPGR), Regional Station, Phagli, Shimla, India
Hari D. Upadhyaya, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India

REVIEWERS

Australia

Sally Dillon, Queensland Primary Industries and Fisheries

Burundi

Espérance Habindavyi, Institut des Sciences Agronomiques du Burundi

Canada

K. Anand Kumar, Agriculture Environmental Renewal Canada (AERC) Inc.

Ethiopia

Asfaw Adugna, Ethiopian Institute of Agricultural Research (EIAR)
Taye Tadesse, Ethiopian Institute of Agricultural Research (EIAR)

India

Ashok Kumar, National Bureau of Plant Genetic Resources (NBPGR)
Hittalmani Shailaja, University of Agricultural Sciences, Bangalore
M. Thimma Reddy, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)

Kenya
Mathews M. Dida, Maseno University
C. Oduori, Kenya Agricultural Research Institute

Senegal
Ousmane Sy, Institut Sénégalais de Recherches Agricoles (ISRA)

Sudan
Adam Mukhtar Elfadil, Agricultural Research Corporation

Tanzania
Seperatus P. Kamuntu, Lake Zone Agricultural Research and Development Institute (LZARDI)

Zimbabwe
Marco Mare, Crop Breeding Institute (CBI)

Methodology for the definition of a key set of characterization and evaluation descriptors for grass pea (*Lathyrus* spp.)

Information collection and preparation of a Minimum Descriptor List (MDL)

Information for the definition of a MDL for *Lathyrus* was drawn from the publication Descriptors for *Lathyrus* spp. (IPGRI, 2000). The list derived from this publication was subsequently integrated and harmonized with descriptors suggested in the 'Crop Strategy for the ex-situ conservation of *Lathyrus*' (the Trust, 2007), particularly with regards to the inclusion of evaluation traits such as susceptibility to important biotic and abiotic stresses for grass pea.

Preparing List of Experts

A list of experts was prepared taking into account the list of original reviewers involved in the publication 'Descriptors for *Lathyrus* spp.' (IPGRI, 2000), as well as experts taking part in crop-specific consultations for the definition of the 'Crop Strategy for the ex-situ conservation of *Lathyrus* (the Trust, 2007). Experts belonging to the *Lathyrus* Germplasm Collections Directory were also included. Overall, the list was composed of 60 experts, coming from 31 countries and 51 different organizations (see Annex II). Out of these, a Group Leader (Dr Prem N. Mathur) and a Core Advisory group consisting of five experts was selected to assist in the definition of a minimum set of descriptors for this crop, which was subsequently circulated for validation among a wider group of experts. Experts forming the CAG were selected from world renowned organizations such as ICARDA, the Leibniz Institute of Plant Genetics and Crop Plant Research, the Bangladesh Agricultural Research Institute, the Indira Ghandi Agricultural University, the Department of Agriculture and Food of Western Australia and crop-specific networks such as the ECPGR.

Survey preparation and distribution

A draft survey on *Lathyrus* was prepared following consultations with the Crop Leader and the CAG at the beginning of July 2008. Once approved, the final draft of the survey was uploaded into the Survey Monkey application on the internet and an email invitation sent out to experts. A link to the Survey was provided to experts, who were invited to validate the initial 'Minimum set of descriptors' of *Lathyrus* accessions to promote its utilization (see Annex I). Experts were also encouraged to mention any additional trait(s) that was (were) found to be relevant yet missing from the proposed List, along with a substantiated justification for its (their) inclusion. The survey deadline was set at 28 July 2008. A reminder was sent out on the 22 July to ensure that the greatest possible feedback was obtained.

Survey analysis

Of the 60 experts who were identified and involved in the exercise (see Annex II), **14**, coming from **11** countries, recorded their comments using the online survey (see Annex III). Comments received were harmonised and sent to the Crop Leader for further refinement. Dr. Ken Street from ICARDA, also provided essential input for the refinement of the minimum list. The revised minimum list, together with descriptor states for each descriptor was sent to the CAG for final approval on 28 October 2008, requesting that final comments be submitted to the Coordinator by 7 November. The final minimum list, approved by the Crop Leader and the CAG, is presented in Annex IV. Afterwards a final key set was prepared adding descriptor states and contributors (see Annex V).

Once the core subset of characterization and evaluation standards for grass pea was finalised, data were transformed into Excel files for uploading into the GRIN-Global genebank data-management system being developed by USDA, and into GENESYS, linking national, regional and international genebank databases in support of the conservation and use of plant genetic resources for food and agriculture (PGRFA). The Excel files were also shared with the System-wide Information Network for Genetic Resources (SINGER), the germplasm information exchange network of the Consultative Group on International Agricultural Research (CGIAR) and EURISCO.

Acknowledgement

Bioversity is grateful to all the scientists and researchers who have contributed to the development of the strategic set of 'Key access and utilization descriptors for *Lathyrus* genetic resources', and to the Global Crop Diversity Trust for their financial support.

Annex I – Survey to choose a Minimum set of Descriptors for Grass Pea (*Lathyrus* spp.)

1. WELCOME

Welcome to the survey for the selection of a key set of characterization and evaluation descriptors to support an international system of information to enhance the utilization of germplasm held in genebanks.

Your knowledge and experience is requested to validate this initial 'Minimum set of descriptors' of Lathyrus accessions to facilitate their use by researchers.

This key set of characterization and evaluation descriptors will be made available through a global facility for identifying sets of accessions for evaluation and use. For characterization, the aim is a small set of maximally differentiating traits that provide the most impact in discriminating between accessions and, sometimes, may be also relevant to choosing accessions for evaluation. For example, plant height may be indicative in identifying tolerance to lodging. For evaluation, the aim is to focus on a few important traits for production, such as resistance/tolerance to an important disease or some aspect of product quality. This initial set of characterization and evaluation data will constitute the basis of an international facility for researchers to identify the sets of accessions more likely to contain the genetic variation they require for their specific crop improvement programmes.

The list presented here has been drawn from the IPGRI publication "Descriptors for Lathyrus spp."(2000), and adopted by the Trust Crop Strategy Meeting for the ex-situ conservation of Lathyrus (2007).

This survey should take no longer than 15 minutes. Your participation in it is highly appreciated. The deadline for this survey is JULY 28TH 2008.

We thank you in advance for investing your time and expertise in validating this initial, key set of descriptors.

This survey consists of two parts:

- PART I: Lists important characterization descriptors for Lathyrus. It also allows you to indicate if any essential descriptor that can contribute to its use is missing from the minimum list presented.

- PART II: Lists important evaluation descriptors for Lathyrus. It also allows you to indicate if any essential trait for production is missing from the minimum list presented or indicate any that may not be very significant to global production.

Please allow us to acknowledge your contribution by completing your full contact details below:

Name

Position

Institute

Address

City/Town

Country

Email

Phone

Fax

2. Part I: Characterization descriptors

Characterization descriptors* are those that permit accessions to be easily described and categorized into groups. They are generally highly heritable, can be easily seen by the eye and are expressed equally in all environments.

*Numbers in parentheses on the right-hand side are the corresponding descriptors numbers as published in the Bioversity publication 'Descriptors for Lathyrus spp., 2000'.

PLANT GROWTH HABIT (7.1.6)
Recorded at the beginning of the flowering period
1 Prostrate
2 Spreading
3 Semi-erect
4 Erect

SEEDLING VIGOUR (7.1.3)
Recorded 20 days after emergence
3 Poor
5 Intermediate
7 Vigorous

PLANT HEIGHT [cm] (7.2.1)
Height of plant at physiological maturity measured from ground to the tip of the longest branch

NUMBER OF PRIMARY BRANCHES (7.3.2)
Counted at first pod maturity (only pod-bearing branches)

ROOT NODULATION AT FULL BLOOMING STAGE (7.4.2)
0 No nodules
3 Low
5 Intermediate
7 High

DAYS TO 50% FLOWERING [d] (7.6.2)
Number of days from sowing to stage when 50% of plants have begun to flower in a row

DAYS TO MATURITY [d] (7.6.4)
From sowing to when 80% of plants have mature pods

FLOWER COLOUR (7.6.12)
Score on fresh, open flowers for score standard, wing and keel colours separately
1 White
2 White blue
3 Blue
4 Grey
5 Light yellow
6 Yellow
7 Pink
8 Orange
9 Red
10 Violet-blue
11 Violet

NUMBER OF PODS PER PLANT (7.7.2)
Mean number of pods. Recorded from randomly selected plants at physiological maturity

NUMBER OF SEEDS PER POD (7.7.16)
Mean number of seeds counted on randomly selected pods. Recorded at physiological maturity.

POD DEHISCENCE (7.7.17)
Scored one week after maturity
0 No shattering
3 Low shattering
5 Medium shattering
7 High shattering

SEED COAT COLOUR (7.8.3)
1 Greyed-white
2 Yellow-white
3 Grey
4 Brown
5 Yellow-green
6 Pink
7 Red-purple
8 Black
9 Grey mottled
99 Other (specify in descriptor)

100-SEED WEIGHT [g] (7.8.10)
Weight of 100 randomly selected mature seeds at 8-10% (air-dry) seed moisture content.

If you consider that an essential trait for the identification of the crop to promote its use is missing from this list, please add it here along with a substantiated justification.

4.PART II: Evaluation Descriptors

This type of descriptor includes those traits of significant importance to sustainable production, including abiotic and biotic stresses. In this case we want to target a few key evaluation traits for which we can initially collect data. This list is the starting point and would grow over time.

HARVEST INDEX [%] (8.1.6)
Ratio of total grain to total biological yield taken from randomly selected plants in a row

B-N-OXALYL-L-A, B-DIAMINOPROPIONIC ACID (ODAP) CONTENT [%] (8.2.4)
Estimate ODAP content in dry seed and any other plant part (specify such as dry cotyledons, dry embryo, etc.)

SEED CRUDE PROTEIN CONTENT [g/100g DW] (8.2.1)

SUSCEPTIBILITY TO BEAN APHIDS (Aphis craccivora) (10.1.1)

SUSCEPTIBILITY TO POD BORERS (Etiella zinckenella) (10.1.2)

SUSCEPTIBILITY TO JASSIDS

SUSCEPTIBILITY TO POWDERY MILDEW (Erysiphe polygoni f.sp. pisi) (10.3.1)

SUSCEPTIBILITY TO DOWNY MILDEW (Peronospora lathyri – palustris) 10.3.2)

SUSCEPTIBILITY TO BROOMRAPE (Orobanche spp.)

If you consider that an essential trait important for crop improvement and production is missing from this list, or, if any of the descriptors listed is not clearly useful to promote utilization, please indicate it here along with a substantiated justification.

*

Could you please indicate if you think the key descriptors chosen are suitable for the stated purpose?

Could you please indicate if you think the key descriptors chosen are suitable for the stated purpose?

- ☐ Yes
- ☐ No

NOTE: Please remember, this list is the starting point and will grow over time, as required.

THANK YOU VERY MUCH FOR YOUR PARTICIPATION.

Annex II - List of experts identified for participation to the Survey for the definition of a minimum set of descriptors for *Lathyrus*

Role	Name	Organization	Country
Crop leader	**Mathur, P.N.**	Bioversity International Office for South Asia	India
Core Group	Haque, Mamtazul	Bangladesh Agricultural Research Institute	Bangladesh
Core Group	Sarker, Ashutosh	ICARDA South East Asia Office	India
Core Group/Reviewer DL	Pandey R.L.	Indira Gandhi Agricultural University	India
Core group/Reviewers DL	Hanbury, C.D.	Department of Agriculture and Food, Western Australia	Australia
Core group/Reviewers DL	Lohwasser, Ulrike	Leibniz Institute of Plant Genetics and Crop Plant Research (ECPGR)	Germany
SRG	Muehlbauer, F.J.	USDA	USA
Reviewers Desc List	Benková, Michaela	Research Institute for Plant Production	Slovakia Republic
Reviewers Desc List	Combes, Daniel	IBEAS (ECPGR)	France
Reviewers Desc List	De la Cuadra, Celia	Centro de Recursos Fitogenéticos "La Canaleja"	Spain
Reviewers Desc List	De la Rosa, Lucia	Centro de Recursos Fitogenéticos "La Canaleja"	Spain
Reviewers Desc List	Frese, L.	Federal Centre for Breeding	Germany
Reviewers Desc List/SRG	Hanson, Jean	ILRI	Ethiopia
Reviewers Desc List	Islam, Obaidual	Bangladesh Agricultural Research Institute	Bangladesh
Reviewers Desc List	Lambein, Fernand	Faculty of Medicine, University of Ghent	Belgium
Reviewers Desc List	Linington, Simon	Seed Conservation Section, Royal Botanical Gardens	United Kingdom
Reviewers Desc List	Olegovna Burlyaeva, Marina	N.I. Vavilov Research Institute of Plant Industry (VIR)	Russia
Reviewers Desc List	Poulsen, Gert B.	Nordic Genebank	Sweden
Reviewers Desc List	Sharma, R.N.	Indira Gandhi Agricultural University	India
Reviewers Desc List	Smoliková, Marta	Research Institute for Fodder Plants Ltd.	Czech Republic

Role	Name	Organization	Country
Reviewers Desc List	Valkoun, Jan		Czech Republic
Strategy Expert	*	Australian Medicago Genetic Resources Centre	Australia
Strategy Expert	*	Genetic Resources Centre Bangladesh Agricultural Research Centre	Bangladesh
Strategy Expert	*	Institute for Plant Genetic Resources	Bulgaria
Strategy Expert	*	Biodiversity Conservation and Research Institute	Ethiopia
Strategy Expert	*	Department of Plant Breeding, Indian Institute of Pulses Research	India
Strategy Expert	*	Dept. of Botany, Institute of Life Science, Hebrew Univ. of Jerusalem	Israel
Strategy Expert	*	Agricultural Research Council	Nepal
Strategy Expert	*	Sector de Pastagens e Forragens Dept Past., Forrag., Proteaginosas	Portugal
Strategy Expert	*	Servicio de Investigacion Agraria Junta de Castilla y Leon	Spain
Strategy Expert	*	General Commission for Scientific Agricultural Research	Syria
Strategy Expert	*	Ustimovskaya Experimental Station for Plant Cultivation	Ukraine
Strategy Expert	Abdelguerfi, A.	Institut National Agronomique (INA)	Algeria
Strategy Expert	Abdi, Adugna	Institute of Biodiversity Conservation and Research (IBCR)	Ethiopia
Strategy Expert	Acuña, Hernan	Centro Regional de Investigación Quilamapu, Inia	Chile
Strategy Expert	Ambrose, Mike	John Innes Centre	United Kingdom
Strategy Expert	Diederichsen, Axel	Agriculture and Agri-Food Canada	Canada
Strategy Expert	De los Mozos Pascual, Marcelino	Banco de Germoplasma, Centro de Investigacion Agraria de Albaladejito	Spain
Strategy Expert	Della, Athena	Agricultural Research Insitute	Cyprus
Strategy Expert	El-Hawary, Mohamed Ibrahim	National Gene Bank of Egypt	Egypt
Strategy Expert	Furman, Bonnie J.	ARS/USDA	USA

Role	Name	Organization	Country
Strategy Expert	Galasso, Incoronata	CNR	Italy
Strategy Expert	Gowda, C.L.L.	ICRISAT	
Strategy Expert	Holly, László	National Institute for Agricultural Quality Control Research Centre for Agrobotany	Hungary
Strategy Expert	Horváth, Lajos	Institute for Agrobotany	Hungary
Strategy Expert	Jamal, Majd	GCSAR - Ministry of Agric & Agrarian Reform	Syria
Strategy Expert	Moal, Sharif	Plant Genetic Resources Unit Crop Improv - Ministry of Agriculture	Afghanistan
Strategy Expert	Monreal, Álvaro Ramos	Consejeria de Agricultura Ganadería	Spain
Strategy Expert	Redden, Bob	Australian Temperate Field Crops Collection	Australia
Strategy Expert	Ryabchoun, Victor K.	National Centre for PGR of Ukraine	Ukraine
Strategy Expert	Sharma, S.K.	ICAR	India
Strategy Expert	Srivastava, Surendra	Nepal Agricultural Research	Nepal
Strategy Expert	Suso, María José	Instituto de Agricultura Sostenible (CSIC)	Spain
Strategy Expert	Tan, Ayfer	Aegean Agricultural Research Institute (AARI)	Turkey
Strategy Expert	Van Ginkel, Maarten	Department of Primary Industries Horsham	Australia
Strategy Expert	Veloso, Maria Manuela	Departamento de Recursos Genéticos e Melhoramento, Estação Agronómica Nacional	Portugal
Strategy Expert	Vishnakovaya, Margarita	N.I. Vavilov Institute of Plant Industry (VIR)	Russia
Strategy Expert	Welsh, Molly	Phaseolus Germplasm Collection - USDA/ARS	USA
Strategy Expert	Xuxiao, Zong	Institute of Crop Germplasm Resources, CAAS	China
Strategy Expert	Zahoor, Ahmad	Institute of Agribiotechnology & Genetic Resources	Pakistan
Expert	Alexanian, Sergey	N.I. Vavilov Institute of Plant Industry (VIR)	

Annex III – Survey responses and suggested additions/deletions to the identified set of Minimum descriptors for *Lathyrus*

Name	Organization	Country	Characterization descriptors to be added	Characterization descriptors to be deleted	Evaluation descriptors to be added	Evaluation descriptors to be deleted	Do you think the key descriptors chosen are suitable for the stated purpose?
							Yes/No
Abdelguerfi, A.	INA	Algeria	*	*	*	*	Yes
De La Rosa, L.	INIA	Spain	Height to the first pod; Seed shape	*	Susceptibility to *Bruchus* sp. and *Fusarium* sp.	*	Yes
De los Mozos Pascual, M.	Centro de Investigación Agraria de Albaladejito	Spain	*	*	Straw crude protein content; Susceptibility to Bruchids	*	Yes
Diederichsen, A.	Agriculture and Agri-Food Canada	Canada	*	*	*	*	Yes
Hanbury, Colin	Department of Agriculture and Food, Western Australia	Australia	*	*	Susceptibility to *Helicoverpa* spp. larvae attack; Alfalfa mosaic virus (AMV), bean yellow mosaic virus (BYMV) and pea seed-borne mosaic virus (PSbMV).	*	Yes
Haque, Md. Mamtazul	Bangladesh Agricultural Research Institute	Bangladesh	Leaf tendril; hypocotyle and epicotyle color	*	Days to 1st flowering; pod length and seed yield	*	Yes
Lohwasser, Ulrike	Leibniz Institute of Plant Genetics and Crop Plant Research	Germany	*	*	*	*	Yes
Mathur, P.N.	BIOVERSITY INTERNATIONAL	India	*	*	*	*	Yes
Redden, Bob	Department of Primary Industries Victoria	Australia	*	*	Anthocynin on leaf; Immature pod colour	Root nodulation	Yes

Name	Organization	Country	Characterization descriptors to be added	Characterization descriptors to be deleted	Evaluation descriptors to be added	Evaluation descriptors to be deleted	Do you think the key descriptors chosen are suitable for the stated purpose?
Sharma, R.N.	Indira Gandhi Agricultural University	India	Seedling vigour (7.1.3) to be recoreded in accordance with seed index (100 seed wt.); Pod colour and pods/peduncle	*			Yes
Valkoun, Jan		Czech Republic	*	*	*	*	Yes
Vishnyakova, Margarita	Vavilov Institute of Plant Breeding	Russia	*	*	*Ascochyta orobi* Sacc. and *A. lathyri*	*	Yes
Welsh, Molly	USDA-ARS	WA	*	*	*	*	Yes
Xuxiao, Zong	CAAS	China	Date of first flowering; Ecological habitat; Fresh biomass; Dry biomass	*	Soluble solid matter content of sprouts (without cotyledon) for vegetable purposes; Vc content, protein content, sugar content and other soluble solid matter content in total (for vegetable purpose)	*	Yes

Annex IV – Agreed key set of descriptors approved by the Crop Leader and the Core Advisory Group on 25/10/2008

Numbers in parentheses on the right-hand side are the corresponding descriptors numbers as published in the Bioversity publication '*Descriptors for Lathyrus* spp., 2000'.

Seedling vigour	(7.1.3)
Plant growth habit	(7.1.6)
Plant height [cm]	(7.2.1)
Number of primary branches	(7.3.2)
Days to 50% flowering [d]	(7.6.2)
Days to maturity [d]	(7.6.4)
Flower colour	(7.6.12)
Pod bearing position [cm] (height to first pod)	(7.6.19)
Number of pods per plant	(7.7.2)
Number of seeds per pod	(7.7.16)
Pod dehiscence	(7.7.17)
Seed coat colour	(7.8.3)
100-seed weight [g]	(7.8.10)
Harvest index [%]	(8.1.6)
Seed crude protein content [g/100g DW]	(8.2.1)
β-N-Oxalyl-L-α, β-Diaminopropionic Acid (ODAP) content [%]	(8.2.4)
Susceptibility to bean aphids (*Aphis craccivora*)	(10.1.1)
Susceptibility to pod borers (*Etiella zinckenella*)	(10.1.2)
Susceptibility to Bruchids (*Bruchus* sp.)	(10.1.4)
Susceptibility to Jassids	(10.1.5)
Susceptibility to Powdery mildew (*Erysiphe polygoni* f.sp. *pisi*)	(10.3.1)
Susceptibility to Downy mildew (*Peronospora lathyri – palustris*)	(10.3.2)
Susceptibility to Broomrape (*Orobanche* spp.)	(10.X.1)

Annex V – Final key set of descriptors for *Lathyrus* genetic resources obtained after validation

Key access and utilization descriptors for *Lathyrus* spp. genetic resources

This list consists of an initial set of characterization and evaluation descriptors for *Lathyrus* utilization. This key set of strategic descriptors, together with passport data, will become the basis for the global accession level information portal (GENESYS) being developed by the Bioversity-led project, Global Information on Germplasm Accessions (GIGA). It will facilitate access to and utilization of *Lathyrus* accessions held in genebanks, and does not preclude the addition of further descriptors, should data subsequently become available.

Based on the comprehensive list of 'Descriptors for *Lathyrus* spp.' (IPGRI, 2000), the set was developed in consultation with *Lathyrus* experts worldwide, and further refined by a Core Advisory Group (see 'Contributors') led by Dr Prem Mathur of Bioversity International.

Biotic and abiotic stresses included in the list were chosen because of their cosmopolitan nature, wide geographical occurrence and significant economic impact.

The numbers in parentheses on the right-hand side are the corresponding descriptor numbers as published in 'Descriptors for *Lathyrus* spp.' (IPGRI, 2000). Descriptors with numbers ending in 'X' are new descriptors that were added during the revision of the original publication.

Seedling vigour (7.1.3)

Recorded 20 days after emergence

3 Poor
5 Intermediate
7 Vigorous

Plant growth habit (7.1.6)

Recorded at the beginning of flowering period

1 Prostrate
2 Spreading
3 Semi-erect
4 Erect

Plant height [cm] (7.2.1)

Height of plant at physiological maturity measured from ground to the tip of the longest branch

Number of primary branches (7.3.2)

Counted at first pod maturity (only pod-bearing branches)

Days to 50% flowering [d] (7.6.2)

Number of days from sowing to stage when 50% of plants have begun to flower in a row

Days to maturity [d] (7.6.4)
From sowing to when 80% of plants have mature pods

Flower colour (7.6.12)
Score on fresh, open flowers for score standard, wing and keel colours separately

1 White
2 White blue
3 Blue
4 Grey
5 Light yellow
6 Yellow
7 Pink
8 Orange
9 Red
10 Violet–blue
11 Violet
99 Other (specify in descriptor **Notes**)

Pod-bearing position [cm] (7.6.19)
Recorded as height to the lowest pod

Number of pods per plant (7.7.2)
Mean number of pods. Recorded from randomly selected plants at physiological maturity.

Number of seeds per pod (7.7.16)
Mean number of seeds counted on randomly selected pods. Recorded at physiological maturity.

Pod dehiscence (7.7.17)
Scored one week after maturity

0 No shattering
3 Low shattering
5 Medium shattering
7 High shattering

Seed coat colour (7.8.3)

1 Greyed–white
2 Yellow–white
3 Grey
4 Brown
5 Yellow–green
6 Pink
7 Red–purple
8 Black
9 Grey mottled
10 Green mottled
99 Other (specify in descriptor **Notes**)

100-seed weight [g] (7.8.10)
Weight of 100 randomly selected mature seeds at 8–10% (air-dry) seed moisture content

Harvest index [%] (8.1.6)
Ratio of total grain to total biological yield taken from randomly selected plants in a row

Seed crude protein content [g/100 g DW] (8.2.1)

β-N-Oxalyl-L-α, β-Diaminopropionic Acid (ODAP) content [%] (8.2.4)
Estimate ODAP content in dry seeds and any other plant part (specify, such as dry cotyledons, dry embryo, etc.)

Susceptibility to Bean aphids (*Aphis craccivora*) (10.1.1)

Susceptibility to Pod borers (*Etiella zinckenella*) (10.1.2)

Susceptibility to Bruchids (*Bruchus* spp.) (10.1.4)

Susceptibility to Jassids (10.1.X)

Susceptibility to Powdery mildew (*Erysiphe polygoni* f.sp. *pisi*) (10.3.1)

Susceptibility to Downy mildew (*Peronospora lathyri-palustris*) (10.3.2)

Susceptibility to Broomrape (*Orobanche* spp.) (10.X.X)

Notes
Any additional information may be specified here, particularly that referring to the category 'Other' present in some of the descriptors above.

CONTRIBUTORS

Bioversity is grateful to all the scientists and researchers who contributed to the development of this strategic set of key access and utilization descriptors for Lathyrus genetic resources. The following Bioversity staff contributed to this exercise: Michael Mackay, who provided scientific direction, and Adriana Alercia, who provided technical expertise and guided the whole production process. Special thanks go to Prem Mathur for his scientific advice and guidance on this crop.

Core Advisory Group

Prem Mathur, Bioversity International, Italy
Colin Hanbury, Department of Agriculture and Food, Western Australia
Mamtazul Haque, Bangladesh Agricultural Research Institute, Bangladesh
Ulrike Lohwasser, Leibniz Institute of Plant Genetics and Crop Plant Research, Germany (ECPGR)
R.L. Pandey, Indira Gandhi Agricultural University, India
Kenneth Street, ICARDA, Syria

Reviewers

Algeria

Aïssa Abdelguerfi, Institut National Agronomique (INA)

Australia
Bob Redden, Australian Temperate Field Crops Collection, Department of Primary Industries

Canada
Axel Diederichsen, Plant Gene Resources of Canada, Agriculture and Agri-Food Canada

China
Zong Xuxiao, Institute of Crop Sciences, Chinese Academy of Agricultural Sciences

Czech Republic
Jan Valkoun

India
R.N. Sharma, Indira Gandhi Agricultural University

Russia
Margarita Vishnyakova, Vavilov Institute of Plant Breeding

Spain
Lucia de la Rosa, Centro de Recursos Fitogenéticos – INIA
Marcelino de los Mozos Pascual, Centro de Investigación Agraria de Albaladejito

USA
Molly Welsh, USDA-ARS

Methodology for the definition of a key set of characterization and evaluation descriptors for lentil (*Lens* Miller)

Bioversity International

GLOBAL CROP DIVERSITY TRUST
A FOUNDATION FOR FOOD SECURITY

Information collection and preparation of the Minimum Descriptor List (MDL)

Information for the definition of a Minimum Descriptor List for lentil (*Lens* Miller) was drawn from the publication ‘Lentil Descriptors’ published by ICARDA and IBPGR (now Bioversity International) in 1985. The list derived from this publication was subsequently integrated and harmonized with descriptors suggested in the ‘Global Strategy for the *Ex-Situ* Conservation of Lentil (*Lens* Miller)’ (the Trust, 2008), particularly with regard to the inclusion of characters and traits relevant to abiotic and biotic stresses for lentil of particular importance in the context of climate change.

The comprehensive descriptors list included in this publication was compared with essential descriptors listed in Descriptors for LENTIL (USDA, ARS, GRIN, 1998); UPOV Technical Guidelines for Lentil (2003) and with descriptors listed in the article ‘Methodology to establish a composite collection: case study in lentil‘ (Plant Genetic Resources, Vol. 4, Issue 1, pp. 2-12, NIAB, 2006) by Bonnie J. Furman, ICARDA, 2005, as well as with those descriptors that were awarded funds for further research by the Trust in the Evaluation Awards Scheme (EAS) 2008. An Excel table was prepared comparing descriptors mentioned in each list, and then shared with experts participating in a crop-specific meeting held in India in June 2009 at the National Bureau of Plant Genetic Resources (NBPGR). The consultation, which involved several experts from NBPGR and the Indian Agricultural Research Institute (IARI), resulted in the definition of a preliminary key set of descriptors for lentil (see Annex I).

Preparation of the List of Experts

As the List of Experts involved in the publication ‘Lentil Descriptors’ (IBPGR and ICARDA, 1985) was too old, the experts taking part in the definition of the ‘Global Strategy for the *Ex-Situ* Conservation of Lentil (*Lens* Miller)’ (the Trust, 2008), who also participated to a survey sent out on 20 April 2006, were included. Participants of the Global Collaborative *Ex situ* Conservation Strategies for Food Legumes in Aleppo, Syria, in February 2007 and the experts belonging to the ‘Lentil Germplasm Collections Directory’ were also considered.

The databases of FAO WIEWS, ECPGR *Lens*, developed by the Aegean Agricultural Research Institute (AARI), Turkey, as well as that of the Centre for Legumes in Mediterranean Agriculture (CLIMA) offered a number of relevant names. A further source of experts was the list of participants in the ‘First South Asian Travelling Workshop on Food Legumes in India’ that took place in March 2008, attended by over 30 experts from India, Bangladesh, Nepal and Pakistan, obtained through the ICARDA website.

Additional names of experts were found in the websites of relevant organizations such as the Bangladesh Agricultural Research Institute (BARI), the South Australian Research and Development Institute (SARDI) and the Center for New Crops & Plant Products (Purdue University) and some relevant contacts obtained at the ENEA Chickpea congress held at the University of La Tuscia, Viterbo, Italy in 2009.

Crop Leaders and members of the Core Advisory Group were identified during a crop-specific meeting held at NBPGR in June 2009 chaired by Ms Adriana Alercia.

Overall, the list was composed of 64 experts, from 30 countries and 41 different organizations. Additionally, the invitation was sent to other nine relevant institutions, without addressing it to specific scientists (see Annex II). Out of these, two Crop Leaders, Ashutosh Sarker (ICARDA, Syria) and Shashi K. Mishra (NBPGR, India) and a Core Advisory Group (CAG) consisting of nine experts, selected from world renowned organizations, were identified to assist in the definition of a key set of descriptors for this crop, which was subsequently circulated for validation among a wider group of experts.

Survey preparation and distribution

A draft survey on lentil was prepared at the beginning of June 2009, including the first priority minimum set (see Annex III) obtained following consultations with the Crop Leaders and the CAG. Once approved, the final draft of the survey was uploaded into the SurveyMonkey application on the internet (see Annex IV). An email invitation, containing the link to access to the survey, was sent out to experts on 29 July 2009, inviting them to validate the initial ‘Minimum set of descriptors’ of lentil accessions to promote the utilization of germplasm. Experts were also encouraged to mention any additional relevant traits missing from the proposed list, along with a substantiated justification for their inclusion. The survey deadline was set at the 10 September 2009. A reminder was sent out on the 2 September 2009 to experts who had not yet responded. By popular demand the deadline was extended to 18 September 2009 to ensure that the greatest possible feedback was obtained.

Survey analysis and refinement of the Minimum List

Of the 64 experts who were identified and involved in the exercise, 21 from 13 countries recorded their comments using the online survey (see Annex V). Results from the survey were analyzed and descriptors were ranked by rating average and percentage of importance (see Annex VI). The summary results of the survey together with a report containing comments received by the participants (see Annex VII) were sent to the Core Advisory Group asking them to indicate descriptors that should be included in the final list.

Descriptors selected were compared in order to reach a 'First priority set of descriptors' (see Annex VIII) that was presented to the Core Advisory Group for their approval. The list was amended accordingly with comments received from experts, taking into account survey results and selections. Of particular note was that the descriptors 'Rust' and 'Number of pods per plant' were included by popular demand, and '*Stemphylium* spp.' was added as a causal organism for blight. The Coordinator sent an email to one of the Crop Leaders explaining that two out of the five descriptors suggested by him would not be added because of their rating resulted relatively low and none of the members of the Core Advisory Group had selected them. The revised minimum list (see Annex IX), including all contributors, descriptor states and methods for each descriptor, was sent to the whole group of participants in the exercise for their final validation on 16 February 2010.

Dr Ashutosh Sarker was asked to advice on the use of the proper unit of measurement for the descriptor 'Seed yield per plant'.

Definition of a final key set of descriptors for lentil

The final document approved (see Annex X), was proofread by an external editor and sent to the Bioversity Publication Unit for layout and on-line publication processes. Furthermore, the publication was shared with the ECPGR Secretariat; the Generation Challenge Programme (GCP) Ontology and the SGRP Crop Genebank Knowledge Base partners. Additionally, data were converted into Excel files for uploading into the GRIN-Global genebank data-management system being developed by USDA and subsequently into the global accession level information portal (GENESYS), linking national, regional and international genebank databases in support of the conservation and use of plant genetic resources for food and agriculture (PGRFA). The Excel files were also provided to the System-wide Information Network for Genetic Resources (SINGER) and to EURISCO.

Acknowledgement

Bioversity is grateful to all scientists and researchers who have contributed to the development of the strategic set of 'Key access and utilization descriptors for lentil genetic resources', and to the Global Crop Diversity Trust for their financial support. Particular recognition goes to the Crop Leaders, Dr Ashutosh Sarker (ICARDA, Syria) and Dr Shashi K. Mishra (NBPGR, India) for providing valuable scientific direction.

Annex I – Summary comparison table weighing up important descriptors for lentil drawn from different sources[i]

ICARDA /IBPGR Descr. number	Descriptor name	IBPGR/ ICARDA 1985 (1)	UPOV 2003 Most imp. (2)	ARS_ USDA (3)	EAS (4)	ICARDA article (5)	Strategy (6)	LONG NBPGR (7)	MIN-NBPGR (7)	ICARDA Sarker's selection
New	Plant growth habit	*		*				*	*	*
4.1.1	Anthocyanin colour in the hypocotyl	*	*(?)	*(?)				*	*	*
4.1.2	Plant pubescence	*		*		*		*	*	*
4.1.3	Leaflet size	*				*		*		*
4.1.4	Plant height [cm] (at maturity stage)	*	*at flowering	*		*	*	*	*	*
4.1.5	Tendrilness (present/absent)	*		*		*		*	*	*
4.2.1	Days to 50% flowering [d]	*	*	*		*	*	*	*	*
4.2.2	Days to maturity [d]	*		*		*	*	*	*	*
4.2.3	Flower ground colour	*	*	*		*		*	*	*
4.2.4	Pod pigmentation	*	*	*		*		*	*	*
4.3.1	Number of seeds per pod	*		*			*	*	*	*
4.3.2	100-seed weight [g]	*	* (DW)	*		*	*	*	*	*
4.3.3	Ground colour of seed testa	*	*	*				*	*	*
4.3.4	Pattern of seed testa	*		*				*	*	*
4.3.5	Colour of pattern on seed testa	*		*				*	*	*
4.3.6	Cotyledon colour	*	*	*			*	*	*	*
6.1.1	Lodging susceptibility	*					*	*		*
6.1.2	Biological yield per plant [g]	*				*		*		*
6.2.1	Number of pods per peduncle	*	* (pods)	*		*		*	*	*
New	Harvest index					*		*	*	*
6.2.2	Height of lowest pod [cm]	*		*		*		*		*
6.2.3	Pod shedding	*		*		*		*		*
6.2.4	Pod dehiscence	*		*		*		*		*

6.3.1	Seed yield per plant [g]	*		*		*	*	*	*	*
6.3.2	Seed Protein content [%]	*						*	*	*
6.3.3	Methionine and other sulphur containing amino acids [mg/g N]	*						*		
New	Seed iron content									*
New	Seed zinc content									*
6.3.4	Seed cooking time	*					*	*		*
7.1	Low temperature	*					*	Not required		*
7.1.1	Winter kill	*						Not required		
7.1.2	Frost tolerance	*						*		*
7.2	High temperature	*			*			*		*
7.3	Drought	*			*		*	*	*	*
7.4	High soil moisture	*						*		*
7.5	Salinity	*			*			*		*
8.1.1	Aphids (*Aphis craccivora* Koch)	*						*		*
8.1.2	Weevils (*Sitona* spp.)	*						*		*
8.1.3	Weevils (*Bruchus* spp.)	*						*		*
8.1.4	Pod borers (*Etiella zinckenella* Treit.)	*						*		
8.2.1	Rust (*Uromyces fabae* (Pers.) de Bary)	*			*		*	*	*	*
8.2.2	Blight (*Ascochyta* spp.)	*			*		*	*		*
8.2.3	Vascular wilts (*Fusarium oxysporum* f. sp. *lentis* Gordon)	*					*	*	*	*
8.2.4	Downy mildew (*Peronospora lentis* Gaum.)	*			*			*		*
8.5	Parasitic weeds (*Orobanche* spp.)	*						*	*	*
New	Dry seed width [mm]	*	*					*		*

New	**Dry seed profile in longitudinal cross-section**	*	*					*		*
New	**Resistance to Anthracnose**	*		*				*		
New	**Seed shape**	*		*				*	*	*
New	**Stem pigmentation**	*								*
New	**Leaflet shape**	*								
New	**Stemphylium blight (*Stemphylium botryosum)***									*
New	**Dry root rot *(Rhizoctonia solani* Kuhn)**									*
New	**Collar rot (*Sclerotium rolfsii* Sacc.)**									*
New	**Stem rot (*Sclerotinia sclerotium* (Lib.) de Bary)**									*
New	**Powdery mildew (*Erysiphe polygoni* D.C.)**									*
New	**Bean leaf roll virus**									*
New	**Bean yellow mosaic virus**									*
New	**Root-knot nematode *(Meloidogyne* spp.)**									*
New	**Dodder *(Cuscuta campestris)***									*
New	**Thrips *(Kakothrips robustus)***									*
	Pod length		*					**Seed weight already included**		

[i] (1) 'Lentil Descriptors' (IBPGR and ICARDA, 1985); (2) UPOV technical guidelines for LENTIL (2003); (3) Descriptors for Lentil (USDA, ARS, GRIN, 1998); (4) Evaluation Awards Scheme (EAS) by the Trust in 2008; (5) The article 'Methodology to establish a composite collection: case study in lentil' (Plant Genetic Resources 4(1); 2-12, NIAB, 2006) by Bonnie J. Furman, ICARDA, 2005; (6) 'Global Strategy for the *Ex-Situ* Conservation of Lentil (*Lens* Miller)' (the Trust, 2008); (7) Crop specific meeting held in India (June, 2009) involving experts from the National Bureau of Plant Genetic Resources (NBPGR) and the Indian Agricultural Research Institute (IARI).

Annex II – List of experts identified to participate in the survey

ROLE/SOURCE	*NAME*	*INSTITUTION*	*COUNTRY*
Crop Leader	**Sarker, Ashutosh**	ICARDA	Syria
Crop Leader	**Mishra, S.K.**	NBPGR	India
CAG/ECPGR (suggested by ECPGR Coordinator)	Alexanian, Sergei	N.I. Vavilov Research Institute of Plant Industry (VIR)	Russian Federation
CAG/UPOV	Boulineau, Francois	GEVES	France
CAG	Coyne, Clare	USDA/ARS	USA
CAG	Dua, Ram Prakash	NBPGR (Underutilized plants division)	India
CAG	Gowda, C.L.L.	ICRISAT	India
CAG (suggested by H. Knüpffer)	Kotter, Matthias	Genebank, Leibniz Institute of Plant Genetics and Crop Plant Research (IPK)	Germany
CAG/ECPGR (suggested by ECPGR Coordinator)	Latorre, Fernando	Centro Nacional de Recursos Fitogenéticos CRF - INIA	Spain
CAG	Muehlbauer, F.J.	USDA/ARS	USA
CAG/NBPGR	Rana, J.C.	NBPGR, Regional station, Shimla	India
Crop Strategy Expert	Abdelguerfi, A.	Institut National Agronomique (INA)	Algeria
Crop Strategy Expert	Abdi, Adugna	Institute of Biodiversity Conservation and Research (IBCR)	Ethiopia
Crop Strategy Expert	Acuña, Hernan	Centro Regional de Investigación Quilamapu, INIA	Chile
Crop Strategy Expert	Ahmed, Ibrahim	Biodiversity Conservation and Research Institute	Ethiopia
WIEWS	Al Faiz, Chaouki	Institut National de la Recherche Agronomique (INRA)	Morocco
SINGER survey	Amri, Ahmed	GRU (ICARDA)	Syria
ECPGR (suggested by ECPGR Coordinator)	Atikyilmaz, Nuket	Aegean Agricultural Research Institute (AARI)	Turkey
Crop Strategy Expert	Azizur, Rahman	Bangladesh Agricultural Research Institute (BARI)	Bangladesh
WIEWS	Benediková, Daniela	Research Institute of Plant Production Piešťany	Slovak Republic
Crop Strategy Expert	Buchwaldt, Lone	Plant Gene Res of Canada and Agri-Food	Canada
Purdue website	Carr, Patrick M.	North Dakota University	USA
Contact ENEA Chickpea congress	Crinò, Paola	ENEA	Italy
Contact ENEA Chickpea congress	De la Rosa, Lucía	INIA	Spain
Crop Strategy Expert	Della, Athena	Agricultural Research Institute	Cyprus
Crop Strategy Expert	Diederichsen, Axel	Agriculture and Agri-Food Canada	Canada
Crop Strategy Expert	Docho, Shamov	Institute for Plant Genetic Resources	Bulgaria
Purdue website	Edwarson, Steven	North Dakota Barley Council	USA
Crop Strategy Expert	El-Hawary, Mohamed Ibrahim	National Gene Bank of Egypt	Egypt

Crop Strategy Expert	Furman, Bonnie J.	ARS/USDA	USA
Crop Strategy Expert	Galasso, Incoronata	CNR (National Research Council)	Italy
Crop Strategy Expert	Holly, László	National Institute for Agricultural Quality Control -Research Centre for Agrobotany	Hungary
Crop Strategy Expert	Horváth, Lajos	Institute for Agrobotany	Hungary
Crop Strategy Expert	Jamal, Majd	GCSAR - Ministry of Agric & Agrarian Reform	Syria
CLIMA website	Khan, Tanveer	CLIMA	Australia
SARDI website	Maqbool, Ahmad	South Australian Research and Development Institute (SARDI)	Australia
SARDI website	Mc Murray, Larry	SARDI	Australia
WIEWS	Miren Edurne Aguiriano Labandibar	Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria. Centro de Recursos Fitogenéticos	Spain
Crop Strategy Expert	Moal, Sharif	Plant Genetic Resources Unit Crop Improvement, Ministry of Agriculture	Afghanistan
Purdue website	Mohamed, Ali I.	Virginia State University	USA
Crop Strategy Expert	Monreal, Álvaro Ramos	Consejeria de Agricultura Ganadería	Spain
CLIMA website	Oliver, Richard	CLIMA	Australia
Crop Strategy Expert	Pandey, R.L.	Indira Ghandi University	India
ECPGR (suggested by ECPGR Coordinator)	Pignone, Domenico	Istituto di Genetica Vegetale, Consiglio Nazionale delle Ricerche	Italy
WIEWS	Podyma, W.	Plant Breeding and Acclimatization Institute	Poland
Suggested by Tanveer	Pritchard, Ian	CLIMA	Australia
Crop Strategy Expert/WIEWS	Redden, Bob	Australian Temperate Field Crops Collection	Australia
Crop Strategy Expert/WIEWS	Ryabchoun, Victor K.	National Centre for PGR of Ukraine	Ukraine
ECPGR	Salazar, E.	Instituto de Investigaciones Agropecuarias, Centro Regional de Investigación La Platina	Chile
WIEWS	Sheperd, D.	School of Biological Sciences, University of Southampton	UK
Purdue website	Slinkard, Al	University of Saskatchewan	Canada
Crop Strategy Expert	Srivastava, Surendra	Nepal Agricultural Research	Nepal
WIEWS	Stoyanova, S.	Institute for Plant Genetic Resources "K. Malkov"	Bulgaria
Crop Strategy Expert	Suso, María José	Instituto de Agricultura Sostenible (CSIC)	Spain
CLIMA website	Sweetingham, Mark	CLIMA	Australia
Crop Strategy Expert	Tan, Ayfer	Aegean Agricultural Research Institute (AARI)	Turkey
ICGL	Upadhyaya, Hari D.	ICRISAT	India
Crop Strategy Expert	Van Ginkel, Maarten	ICARDA	Syria
ICGL	Vandenberg, Albert	University of Saskatchewan	Canada
Crop Strategy Expert/WIEWS	Veloso, Maria Manuela	Departamento de Recursos Genéticos e Melhoramento, Estação Agronómica Nacional	Portugal

Crop Strategy Expert	Xuxiao, Zong	Institute of Crop Germplasm Resources, CAAS	China
Internet	Yadav, Nawal Kishore	NGLRP, Rampur	Nepal
Lentil Collection Curator	Yankov, Ivan	N.I. Vavilov Research Institute of Plant Industry (VIR)	Russian Federation
Crop Strategy Expert/WIEWS	Zahoor, Ahmad	Institute of Agribiotechnology & Genetic Resources	Pakistan
Crop Strategy/WIEWS		Australian Medicago Genetic Resources Centre	Australia
Crop Strategy		Department of Plant Breeding, Indian Institute of Pulses Research	India
Crop Strategy		Dept. of Botany, Institute of Life Science, Hebrew Univ. of Jerusalem	Israel
WIEWS		Agricultural Research Centre	Libya
Crop Strategy		Agricultural Research Council	Nepal
Crop Strategy		Sector de Pastagens e Forragens Dept Past., Forrag., Proteaginosas	Portugal
Crop Strategy		Servicio de Investigación Agraria Junta de Castilla y Leon	Spain
Crop Strategy		General Commission for Scientific Agricultural Research	Syria
Crop Strategy		Ustimovskaya Experimental Station for Plant Cultivation	Ukraine

Annex III – First lentil key set of characterization and evaluation descriptors included in the survey (July 2009). Drawn from Sarker’s (ICARDA) selection in the comparison table and then revised

1. Plant growth habit
2. Anthocyanin colour in the hypocotyl (4.1.1)
3. Plant pubescence (4.1.2)
4. Leaflet size (4.1.3)
5. Plant height [cm] (at maturity stage) (4.1.4)
6. Tendrilness (present/absent) (4.1.5)
7. Days to 50% flowering [d] (4.2.1)
8. Days to 90% maturity [d] (4.2.2)
9. Flower ground colour (4.2.3)
10. Pod pigmentation (4.2.4)
11. Number of seeds per pod (4.3.1)
12. 100-seed weight [g] (4.3.2)
13. Seed shape
14. Dry seed width [mm]
15. Dry seed profile in longitudinal cross-section
16. Ground colour of seed testa (4.3.3)
17. Pattern of seed testa (4.3.4)
18. Colour of pattern on seed testa (4.3.5)
19. Cotyledon colour (4.3.6)
20. Lodging susceptibility (6.1.1)
21. Biological yield per plant [g] (6.1.2)
22. Number of pods per peduncle (6.2.1)
23. Harvest index
24. Height of lowest pod [cm] (6.2.2)
25. Pod shedding (6.2.3)
26. Pod dehiscence (6.2.4)
27. Seed yield per plant [g] (6.3.1)
28. Seed protein content [%] (6.3.2)
29. Seed iron content [%]
30. Seed zinc content [%]
31. Seed cooking time (6.3.4)
32. Low temperature (7.1)
33. Frost tolerance (7.1.2)
34. High temperature (7.2)
35. Drought (7.3)
36. High soil moisture (7.4)
37. Salinity (7.5)
38. Aphids (*Aphis craccivora*) (8.1.1)
39. Weevils (*Sitona* spp.) (8.1.2)
40. Weevils (*Bruchus* spp.) (8.1.3)
41. Rust (*Uromyces fabae*) (8.2.1)
42. Blight (*Ascochyta* spp.) (8.2.2)
43. Stemphylium blight (*Stemphylium botryosum*)
44. Vascular wilts (*Fusarium oxysporum* f. sp. *lentis*) (8.2.3)
45. Downy mildew (*Peronospora lentis*) (8.2.4)
46. Parasitic weeds (*Orobanche* spp.) (8.5)
47. Dry root rot (*Rhizoctonia solani*)
48. Collar rot (*Sclerotium rolfsii*)
49. Stem rot (*Sclerotinia sclerotium*)
50. Powdery mildew (*Erysiphe polygoni*)
51. Root-knot nematode (*Meloidogyne* spp.)
52. Dodder (*Cuscuta campestris*)
53. Thrips (*Kakothrips robustus*)
54. Bean leaf roll virus
55. Bean yellow mosaic virus

Annex IV – Survey to choose a key set of descriptors for lentil utilization

WELCOME

Welcome to the survey for the selection of a key set of characterization and evaluation descriptors for Lentil to support an international information system to enhance the utilization of germplasm held in genebanks.

Your knowledge and experience are being sought to define an initial **'key set'** of descriptors that identify traits important to crop production and facilitate the use of accessions by researchers.

Your participation in it is highly appreciated. The deadline for this survey is **10 September 2009**.

This key set of descriptors will be made available through a global portal for identifying sets of accessions for evaluation and use.

This survey consists of two parts:
- PART I: Characterization descriptors

- PART II: Evaluation descriptors

We thank you in advance for investing your time and expertise in selecting the set of descriptors.

*** Please allow us to acknowledge your contribution by completing your full contact details below:**

Name:

Position:

Organization:

Country:

Email:

PART I: Characterization descriptors

These traits enable easy and quick discrimination between phenotypes. They are generally highly heritable, can be easily seen by the eye and are equally expressed in all environments.

Based on your experience, please select descriptors that provide the most impact in discriminating between accessions. It also allows you to indicate if any essential descriptor that can contribute to its use is missing from the minimum list presented.

*Numbers in parentheses on the right-hand side are the corresponding descriptors numbers as published in the IBPGR/ICARDA publication 'Lentil Descriptors' (1985).

	Very important	Important	Not important
Plant growth habit	○	○	○
Anthocyanin colour in the hypocotyl (4.1.1)	○	○	○
Plant pubescence (4.1.2)	○	○	○
Leaflet size (4.1.3)	○	○	○
Plant height [cm] (at maturity stage) (4.1.4)	○	○	○
Tendrilness (present/absent) (4.1.5)	○	○	○
Days to 50% flowering [d] (4.2.1)	○	○	○
Days to 90% maturity [d] (4.2.2)	○	○	○
Flower ground colour (4.2.3)	○	○	○
Pod pigmentation (4.2.4)	○	○	○
Number of seeds per pod (4.3.1)	○	○	○
100-seed weight [g] (4.3.2)	○	○	○
Seed shape	○	○	○
Dry seed width [mm]	○	○	○
Dry seed profile in longitudinal cross-section	○	○	○
Ground colour of seed testa (4.3.3)	○	○	○
Pattern of seed testa (4.3.4)	○	○	○
Colour of pattern on seed testa (4.3.5)	○	○	○
Cotyledon colour (4.3.6)	○	○	○

If you consider that an essential trait is missing from this list, please indicate it here along with a substantiated justification.

PART II: Evaluation descriptors

These descriptors include characters such as abiotic and biotic stresses. They are the most interesting traits in crop improvement. Please consider the following factors relating to the trait when making your final decision: (i) Global impact, (ii) Initial strategic set, (iii) Importance for germplasm utilization, (iv) Data availability, (v) True economic damage and (vi) Wide geographical occurrence.

Please, rate these traits in order of importance at the global level. It also allows you to indicate if any essential trait for production is missing from the minimum list presented or indicate any that may not be very significant to global production.

	Very important	Important	Not Important
Lodging susceptibility (6.1.1)	○	○	○
Biological yield per plant [g] (6.1.2)	○	○	○
Number of pods per peduncle (6.2.1)	○	○	○
Harvest index	○	○	○
Height of lowest pod [cm] (6.2.2)	○	○	○
Pod shedding (6.2.3)	○	○	○
Pod dehiscence (6.2.4)	○	○	○
Seed yield per plant [g] (6.3.1)	○	○	○
Seed protein content [%] (6.3.2)	○	○	○
Seed iron content [%]	○	○	○
Seed zinc content [%]	○	○	○
Seed cooking time (6.3.4)	○	○	○
Low temperature (7.1)	○	○	○
Frost tolerance (7.1.2)	○	○	○
High temperature (7.2)	○	○	○
Drought (7.3)	○	○	○
High soil moisture (7.4)	○	○	○
Salinity (7.5)	○	○	○
Aphids (*Aphis craccivora*) (8.1.1)	○	○	○
Weevils (*Sitona* spp.) (8.1.2)	○	○	○
Weevils (*Bruchus* spp.) (8.1.3)	○	○	○
Rust (*Uromyces fabae*) (8.2.1)	○	○	○
Blight (*Ascochyta* spp.) (8.2.2)	○	○	○
Stemphylium blight (*Stemphylium botryosum*)	○	○	○
Vascular wilts (*Fusarium oxysporum* f. sp. *lentis*) (8.2.3)	○	○	○
Downy mildew (*Peronospora lentis*) (8.2.4)	○	○	○
Parasitic weeds (*Orobanche* spp.) (8.5)	○	○	○
Dry root rot (*Rhizoctonia solani*)	○	○	○
Collar rot (*Sclerotium rolfsii*)	○	○	○
Stem rot (*Sclerotinia sclerotium*)	○	○	○
Root-knot nematode (*Meloidogyne* spp.)	○	○	○
Powdery mildew (*Erysiphe polygoni*)	○	○	○
Dodder (*Cuscuta campestris*)	○	○	○
Thrips (*Kakothrips robustus*)	○	○	○
Bean leaf roll virus	○	○	○
Bean yellow mosaic virus	○	○	○

If you consider that an essential trait important for crop improvement and production is missing from this list, or, if any of the descriptors listed is not clearly useful to promote utilization, please indicate it here along with a substantiated justification.

NOTE: Please remember, this list is the starting point and will grow over time, as required.

THANK YOU VERY MUCH FOR YOUR PARTICIPATION

Annex V – List of respondents to the survey

ROLE	NAME	POSITION	ORGANIZATION	COUNTRY
Crop Leader	**Mishra, S.K.**	Head of Germplasm Evaluation Division	National Bureau of Plant Genetic Resources (NBPGR)	India
Crop Leader	**Sarker, Ashutosh**	Regional Coordinator for South Asia and Food Legume Breeder	International Center for Agricultural Research in the Dry Areas (ICARDA)	India
CAG	Agrawal, Shiv Kumar	Lentil Breeder	International Center for Agricultural Research in the Dry Areas (ICARDA)	Syria
CAG	de la Rosa, Lucía	Researcher	Centro de Recursos Fitogenéticos, Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA)	Spain
CAG	Lohwasser, Ulrike	Genebank taxonomist	Leibniz Institute of Plant Genetics and Crop Plant Research (IPK)	Germany
CAG	Rana, J.C.	Principal Scientist	National Bureau of Plant Genetic Resources (NBPGR)	India
Reviewer	Ahmad, M.	Principal Scientist	South Australian Research and Development Institute (SARDI)	Australia
Reviewer	Ahmad, Zahoor	Senior Director, crop sciences	National Agricultural Research Centre (NARC)	Pakistan
Reviewer	Atikyilmaz, Nuket	Governmental organization	Aegean Agricultural Research Institute (AARI)	Turkey
Reviewer	Benkova, Michaela	Research Worker	Plant Production Research Centre Piešťany	Slovak Republic
Reviewer	Boulineau, François	Directeur d'unité	Groupe d'Etude et de contrôle des Variétés et des Semences (GEVES), International Union for the Protection of New Varieties of Plants (UPOV)	France
Reviewer	Caminero Saldaña, Constantino	Legume breeder	Instituto Tecnológico Agrario de Castilla y León	Spain
Reviewer	Dua, R.P.	Network Coordinator (UUC)	National Bureau of Plant Genetic Resources (NBPGR)	India
Reviewer	Furman, Bonnie J.	Curator/Lead Scientist	United States Department of Agriculture, Agricultural Research Service (USDA-ARS)	USA
Reviewer	Holly, László	National Coordinator	Research Centre for Agrobotany, Central Agriculture Office (RCA, CAO)	Hungary
Reviewer	Laghetti, Gaetano	Senior Researcher	CNR (National Research Council)	Italy
Reviewer	Redden, Bob	Curator, Australian Temperate Field Crops Collection	Department of Primary Industries Victoria	Australia
Reviewer	Solanki, R.K.	Scientist	Indian Institute of Pulses Research - Kanpur	India
Reviewer	Street, Kenneth	Legume germplasm curator	International Center for Agricultural Research in the Dry Areas (ICARDA)	Syria
Reviewer	Suso, María José	Tenure scientist	Instituto de Agricultura Sostenible, Consejo Superior de Investigaciones Científicas (CSIC)	Spain
Reviewer	Xuxiao, Zong	Prof. & PhD.	Institute of Crop Sciences, Chinese Academy of Agricultural Sciences	China

Annex VI – List of descriptors proposed in the survey ranked by rating average sent to the Core Advisory Group for their selection

Descriptor	Your Selection	Rating Average
Characterization		
100-seed weight [g] (4.3.2)		**4.89**
Plant height [cm] (at maturity stage) (4.1.4)		**4.65**
Ground colour of seed testa (4.3.3)		**4.41**
Plant growth habit		**4.28**
Days to 90% maturity [d] (4.2.2)		**4.28**
Days to 50% flowering [d] (4.2.1)		**4.00**
Cotyledon colour (4.3.6)		**3.83**
Number of seeds per pod (4.3.1)		**3.78**
Colour of pattern on seed testa (4.3.5)		3.06
Flower ground colour (4.2.3)		2.94
Dry seed width [mm]		2.89
Pattern of seed testa (4.3.4)		2.83
Pod pigmentation (4.2.4)		2.78
Tendrilness (present/absent) (4.1.5)		2.71
Seed shape		2.67
Anthocyanin colour in the hypocotyl (4.1.1)		2.56
Leaflet size (4.1.3)		2.47
Plant pubescence (4.1.2)		2.39
Dry seed profile in longitudinal cross-section		1.72
Evaluation		
Seed yield per plant [g] (6.3.1)		**4.32**
Drought (7.3)		**4.32**
Pod shedding (6.2.3)		**4.21**
Frost tolerance (7.1.2)		**4.21**
Biological yield per plant [g] (6.1.2)		**4.05**
Lodging susceptibility (6.1.1)		**3.95**
Pod dehiscence (6.2.4)		**3.94**
Harvest index		**3.68**
Vascular wilts (*Fusarium oxysporum* f. sp. *lentis*) (8.2.3)		**3.63**
Height of lowest pod [cm] (6.2.2)		**3.58**
Seed protein content [%] (6.3.2)		3.58
High temperature (7.2)		**3.58**
Blight (*Ascochyta* spp.) (8.2.2)		3.53
Number of pods per peduncle (6.2.1)		3.42
Rust (*Uromyces fabae*) (8.2.1)		3.33
Salinity (7.5)		3.11
Low temperature (7.1)		3.05

Aphids (*Aphis craccivora*) (8.1.1)		2.79
Seed cooking time (6.3.4)		2.58
High soil moisture (7.4)		2.58
Weevils (*Sitona* spp.) (8.1.2)		2.58
Weevils (*Bruchus* spp.) (8.1.3)		2.58
Stem rot (*Sclerotinia sclerotium*)		2.26
Stemphylium blight (*Stemphylium botryosum)*		2.21
Dry root rot (*Rhizoctonia solani*)		2.11
Seed iron content [%]		2.05
Seed zinc content [%]		1.89
Downy mildew (*Peronospora lentis*) (8.2.4)		1.89
Collar rot (*Sclerotium rolfsii*)		1.89
Root-knot nematode (*Meloidogyne* spp.)		1.79
Parasitic weeds (*Orobanche* spp.) (8.5)		1.78
Powdery mildew (*Erysiphe polygoni*)		1.74
Bean leaf roll virus		1.74
Bean yellow mosaic virus		1.63
Thrips (*Kakothrips robustus*)		1.17
Dodder (*Cuscuta campestris*)		0.63

Annex VII – Additional traits proposed in the survey

Lentil descriptor		Name of expert					
Additional traits	**N. of times selected**	**M. Ahmad (SARDI, Australia)**	**R.K. Solanki (Indian Inst. Pulses Res., India)**	**U. Lohwasser (Leibniz Inst. Plant Gen. Crop Plant Res., Germany)**	**C. Caminero Saldaña (Inst.Tecn. Agr. Castilla y León, Spain)**	**L. Holly (RCA CAO, Hungary)**	**L. De la Rosa (INIA, Spain)**
Number of pods per plant is a key factor in determining the yield potential of any lentil accession/line. There are large differences in pod number per plant within each species of the genus *Lens* therefore, in my view, pod number per plant must be included here.	**1**	X					
Leaf colour (Justification: In dark green leaves black aphid incidence was found to be more as compared to light green).	**1**		X				
Primary leaflet shape or **leaflet length/width ratio** appears to be a rather stable character.	**1**					X	
Seed type/race: macrosperma and microsperma.	**1**						X
Extention of seed ornamentation.	**1**						X
Branching, number of basal branch. As far as we know, branching capability is quite important not just because this character determines yield diferential expression, but also becasue it is involved in the time needed to get complete soil coverage, which is important in weed competition and herbicide costs.	**1**				X		
Comments							
In Germany the last diseases no problem but maybe for other regions.				X			
I am not really sure about plant height must be consider as really highly heritable. It is true that not strong GxE interaction exists when compared genotypes clearly different for this trait, but when this difference is weak, GxE becomes important, so may be better to include **Plant height** in the evaluation descriptor set.					X		

Annex VIII – First priority set of descriptors for lentil utilization resulting from the survey sent to the Core Advisory Group for their approval

1. **Plant height** [cm] (at maturity stage) (4.1.4)
2. **Plant growth habit** (4.1.X)
3. **Days to 50% flowering** [d] (4.2.1)
4. **Days to 90% maturity** [d] (4.2.2)
5. **Number of seeds per pod** (4.3.1)
6. **100-seed weight** [g] (4.3.2)
7. **Ground colour of seed testa** (4.3.3)
8. **Cotyledon colour** (4.3.6)
9. **Lodging susceptibility** (6.1.1)
10. **Biological yield per plant** [g] (6.1.2)
11. **Harvest index** (6.1.X)
12. **Number of pods per peduncle** (6.2.1)
13. **Height of lowest pod** [cm] (6.2.2)
14. **Pod shedding** (6.2.3)
15. **Pod dehiscence** (6.2.4)
16. **Seed yield per plant** [g] (6.3.1)
17. **Frost tolerance** (7.1.2)
18. **Drought** (7.3)
19. **Blight** (*Ascochyta* spp.) (8.2.2)
20. **Vascular wilts** (*Fusarium oxysporum* f. sp. *lentis*) (8.2.3)

Annex IX – List of descriptors for lentil utilization amended as per inputs suggested by the Core Advisory Group and included in the key set sent to the whole group of experts for their final validation

Plant height [cm] (at maturity stage) (4.1.4)
Plant growth habit (4.1.X)
Days to 50% flowering [d] (4.2.1)
Days to physiological maturity [d] (4.2.2)
Number of seeds per pod (4.3.1)
100-seed weight [g] (4.3.2)
Ground colour of seed testa (4.3.3)
Pattern of seed testa (4.3.4)
Cotyledon colour (4.3.6)
Lodging susceptibility (6.1.1)
Biological yield per plant [g] (6.1.2)
Harvest index (6.1.X)
Number of pods per peduncle (6.2.1)
Height of lowest pod [cm] (6.2.2)
Pod shedding (6.2.3)
Pod dehiscence (6.2.4)
Number of pods per plant (6.2.X)
Seed yield per plant [g] (6.3.1)
Frost (7.1.2)
Drought (7.3)
Rust (*Uromyces fabae*) (8.2.1)
Blight (*Ascochyta* spp.; *Stemphyilium* spp.) (8.2.2)
Vascular wilts (*Fusarium oxysporum* f. sp. *lentis*) (8.2.3)

Key access and utilization descriptors for lentil genetic resources

This list consists of an initial set of characterization and evaluation descriptors for lentil genetic resources utilization. This strategic set of descriptors, together with passport data, will become the basis for the global accession level information portal being developed by Bioversity International with the financial support of the Global Crop Diversity Trust (the Trust). It will facilitate access to and utilization of lentil accessions held in genebanks and does not preclude the addition of further descriptors, should data subsequently become available.

Based on the comprehensive list 'Lentil Descriptors' published by ICARDA and IBPGR (now Bioversity International) in 1985, the list was subsequently compared with a number of sources such as 'UPOV technical guidelines for Lentil' (2003); 'Descriptors for LENTIL' (USDA, ARS, GRIN); 'Methodology to establish a composite collection: case study in lentil'[1] (ICARDA, 2005); 'Global Strategy for the *Ex Situ* Conservation of Lentil (*Lens* Miller)' (the Trust, 2008); as well as with those descriptors that were awarded funds for further research by the Trust in 2008 Evaluation Awards Scheme (EAS). The initial list was further refined during a crop-specific consultation meeting held at the National Bureau of Plant Genetic Resources (NBPGR, India) in June 2009. It involved several scientists from NBPGR and the Indian Agricultural Research Institute (IARI).

A worldwide distribution of experts was involved in an online survey to define a first priority set of descriptors to describe, to access and to utilize lentil genetic resources. This key set was afterwards validated by a Core Advisory Group (see 'Contributors') led by Dr Ashutosh Sarker (ICARDA) and Dr Shashi K. Mishra (NBPGR).

Biotic and abiotic stresses included in the list were chosen because of their wide geographic occurrence and significant economic impact at a global level.

Numbers in parentheses on the right-hand side are the corresponding descriptor numbers listed in the 1985 publication. Descriptors with numbers ending in 'letters' are either modified or are new descriptors that were added during the development of the list below.

PLANT DATA

Plant height [cm] (4.1.4)

Height of plant measured from the ground to the tip of the extended foliage, at maturity. Average height of 10 plants

Plant growth habit (4.1.X)

Observed after flowering

1 Prostrate
2 Semi-prostrate
3 Intermediate
4 Upright
5 Erect
99 Other (i.e. 'mixed', specify in the descriptor **Notes**)

[1] Bonnie J. Furman, Plant Genetic Resources, Vol. 4, Issue 1, pp. 2-12, NIAB, 2006

Days to 50% flowering [d] (4.2.1)

Number of days from sowing until 50% of the plants are in flower. However, in dry land areas when planting in dry soils, it is counted from the first day of rainfall or irrigation, which is sufficient for germination

Days to physiological maturity [d] (4.2.2)

Number of days from sowing until 90% of the pods are golden brown. See 4.2.1 for planting in dry soils

Number of seeds per pod (4.3.1)

Average number of seeds of 10 dry pods

100-seed weight [g] (4.3.2)

Average weight of two samples of 100 randomly chosen seeds

Ground colour of seed testa (4.3.3)

To be observed on seeds less than three months old

1 Green
2 Grey
3 Brown
4 Black
5 Pink

Pattern of seed testa (4.3.4)

0 Absent
1 Dotted
2 Spotted
3 Marbled
4 Complex (any combination of 1, 2 and 3)

Cotyledon colour (4.3.6)

To be observed on seeds less than three months old

1 Yellow
2 Orange-red
3 Olive-green

Lodging susceptibility (6.1.1)

Scored at maturity (see 4.2.2) on a scale 1-9

0 None (all plants standing)
3 Low
5 Medium
7 High

Biological yield per plant [g] (6.1.2)

Yield of dried mature plants after pulling

Harvest index [%] (6.1.X)

Number of pods per peduncle (6.2.1)

Maximum number of pods per peduncle on 10 representative plants

Height of lowest pod [cm] (6.2.2)

Estimate of the average height above ground of the lowest pod on unlodged plants at harvest

Pod shedding (6.2.3)

Scored after or during harvesting one week after maturity (see 4.2.2) on a scale 1-9

0 None
3 Low
5 Medium
7 High

Pod dehiscence (6.2.4)

Scored one week after maturity on a scale 1-9

0 None
3 Low
5 Medium
7 High

Number of pods per plant (6.2.X)

Average number of pods. Recorded from randomly selected plants at physiological maturity

Seed yield per plant [g/plant] (6.3.1)

Yield of seed after drying

ABIOTIC STRESSES

Frost (7.1.2)

Drought (7.3)

BIOTIC STRESSES

Rust (*Uromyces fabae*) (8.2.1)

Blight (*Ascochyta* spp., *Stemphylium* spp.) (8.2.2)

Vascular wilts (*Fusarium oxysporum* f. sp. *lentis*) (8.2.3)

CONTRIBUTORS

Bioversity is grateful to all the scientists and researchers who have contributed to the development of this strategic set of 'Key access and utilization descriptors for lentil genetic resources', and in particular to Dr A. Sarker (ICARDA, Syria) and Dr S.K. Mishra (NBPGR, India) for providing valuable scientific direction. Ms Adriana Alercia (Bioversity International) provided technical expertise and guided the entire production process.

CORE ADVISORY GROUP

A. Sarker, International Center for Agricultural Research in the Dry Areas (ICARDA), Syria
S.K. Mishra, National Bureau of Plant Genetic Resources (NBPGR), India
Kumar Shiv Agrawal, International Center for Agricultural Research in the Dry Areas (ICARDA), Syria
Lucía De la Rosa, Centro de Recursos Fitogenéticos, Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA), Spain
Ulrike Lohwasser, Leibniz Institute of Plant Genetics and Crop Plant Research, Germany
J.C. Rana, National Bureau of Plant Genetic Resources (NBPGR), India

REVIEWERS

Australia
Maqbool Ahmad, South Australian Research and Development Institute (SARDI)
Bob Redden, Department of Primary Industries Victoria

China
Zong Xuxiao, Institute of Crop Sciences, Chinese Academy of Agricultural Sciences

France
François Boulineau, Groupe d'Etude et de contrôle des Variétés et des Semences (GEVES)

Hungary
László Holly, Agriculture Research Centre for Agrobotany, Central Agriculture Office (RCA, CAO)

India
R.P. Dua, National Bureau of Plant Genetic Resources (NBPGR)
R.K. Solanki, Indian Institute of Pulses Research, Kanpur

Italy
Gaetano Laghetti, National Research Council

Pakistan
Zahoor Ahmad, National Agricultural Research Centre (NARC)

Slovak Republic
Michaela Benkova, Plant Production Research Centre Piešt'any

Spain
Constantino Caminero Saldaña, Instituto Tecnológico Agrario de Castilla y León
María José Suso, Instituto de Agricultura Sostenible, Consejo Superior de Investigaciones Científicas (CSIC)

Syria
Kenneth Street, International Center for Agricultural Research in the Dry Areas (ICARDA)

Turkey
Nuket Atikyilmaz, Aegean Agricultural Research Institute

USA
Bonnie J. Furman, United States Department of Agriculture, Agricultural Research Service (USDA-ARS)

Methodology for the definition of a key set of characterization and evaluation descriptors for maize (*Zea mays* L.)

Information collection and preparation of the Minimum Descriptor List (MDL)

Information for the definition of a Minimum Descriptor List for maize (*Zea mays* L.) was based on the publication 'Descriptors for Maize' (CIMMYT/IBPGR 1991). The original list contained therein was then weighed against descriptors mentioned in a number of other sources such as UPOV technical guidelines for Maize (1994); Descriptors for MAIZE (USDA, ARS, GRIN); the 'Global Strategy for the *Ex situ* Conservation and Utilization of Maize Germplasm' (the Trust, 2007); Dr Suketoshi Taba's poster presented at the meeting held at the Sociedad Mexicana de Fitogenética (SOMEFI) in September 2008; 'Descriptors for Characterization and Evaluation of Maize' (National Institute of Agrobiological Sciences, Genebank of Japan), as well as with those descriptors that were awarded funds for further research by the Global Crop Diversity Trust in the 2008 Evaluation Awards Scheme (EAS). The initial list also builds on the results of the SGRP Global Public Goods Activity 4.2.1.1, with special attention to breeding traits. The initial list was further refined during a crop-specific consultation meeting held in June 2009 at the National Bureau of Plant Genetic Resources (NBPGR) in India, with the participation of several scientists from NBPGR and the valuable contribution of Dr Sain Dass of the Directorate of Maize Research, Indian Council of Agricultural Research (ICAR).

As result of this exercise, and to assist in the selection of a "reduced" set of traits, a comparison table was prepared to visually identify "most important" descriptors recurring in the above mentioned sources (see Annex I).

Preparation of the List of Experts

The List of Experts was compiled including participants involved in crop-specific consultations for the definition of the 'Global Strategy for the *Ex situ* Conservation and Utilization of Maize Germplasm' (the Trust, 2007). The list was further integrated with experts from the Global Maize Program within the International Maize and Wheat Improvement Center (CIMMYT), from the European Cooperative Programme for Plant Genetic Resources (ECPGR), and with contributors to the publication of 'Regeneration guidelines: Maize' (S. Taba, S. Twumasi-Afriyie, SGRP/the Trust, 2008). Reviewers from the 1991 descriptors list were excluded due to their outdated contact information.

Overall, 80 experts were selected, from 41 countries and 44 different organizations. Out of these, Dr Suketoshi Taba (CIMMYT) was identified as Crop Leader. After consultation with Dr Taba, the Core Advisory Group (CAG), consisting of seven experts was selected to assist in the definition of a key set of descriptors (see Annex II).

Survey preparation and distribution

From the comparison table submitted to Dr Taba, a first list of descriptors was identified and sent to him again for endorsement on 1 June 2009 (see Annex III). The Crop Leader replied with comments and amendments on the same day. The validated list (see Annex IV) was consequently used for preparing a draft survey on maize. After Dr Taba's approval, the final version of the survey was uploaded into the SurveyMonkey application on internet (see Annex V) and sent out to the list of identified experts on 2 June 2009. Participants were invited to validate this initial key set of descriptors of maize accessions to facilitate their use by researchers and asked to make suggestions regarding any characterization or evaluation descriptors that were found to be relevant yet missing from the proposed Minimum List.

The survey deadline was set at 30 June 2009. A first reminder was sent out on 16 June 2009 and a second one on 25 June 2009 to ensure that the greatest possible feedback was obtained.

Survey analysis and refinement of the Minimum List

Of the 80 experts who were identified and involved in the exercise, 36 experts from 23 countries and 26 organizations recorded their comments using the online survey (see Annex VI). Results from the survey were analyzed and descriptors were ranked by rating average and percentage of importance (see Annex VII). The summary results of the survey together with a report containing comments and additional descriptors suggested for inclusion in the key set received from the participants (see Annex VIII) were sent to the Crop Leader in order to reach a consensus on the final list. Dr Taba's feedback was shared with Dr Dass on 30 September 2009 for his additional approval (see Annex IX). A first draft of the key set for maize containing relevant descriptor states was then produced and submitted to the Crop Leader and to the CAG for final validation (see Annex X).

Definition of a final key set of descriptors for maize

The final document approved by the Crop Leader and CAG (see Annex XI), was proofread by an external editor and sent to the Bioversity Publications Unit for layout and on-line publication processes. Furthermore, the publication was shared with the ECPGR Secretariat; the Generation Challenge Programme (GCP) Ontology and the SGRP Crop Genebank Knowledge Base partners. Additionally, data were converted into Excel files for uploading into the GRIN-Global genebank data-management system being developed by USDA and subsequently into the global accession level information portal (GENESYS), linking national, regional and international genebank databases in support of the conservation and use of plant genetic resources for food and agriculture resources for food and agriculture (PGRFA). The Excel files were also provided to the System-wide Information Network for Genetic Resources (SINGER) and to EURISCO.

Acknowledgement

Bioversity is grateful to all the scientists and researchers who have contributed to the development of the strategic set of ‘Key access and utilization descriptors for maize genetic resources’, and to the Global Crop Diversity Trust for their financial support. Particular recognition goes to the Crop Leader, Dr Suketoshi Taba (CIMMYT, Mexico) and to Dr Sain Dass for providing valuable scientific direction. Ms Adriana Alercia provided technical expertise and guided the entire production process.

Annex I – Summary comparison table weighing up important descriptors for maize drawn from different sources[i]

CIMMYT/ IBPGR Desc. no.	CIMMYT/IBPGR Descriptor name	CIMMYT/ IBPGR 1991	UPOV	ARS-USDA	Evaluation Awards	Maize Strategy	Taba's Poster	GPG2 (Taba's selection)	Breeding traits (GPG2)	NIAS
4.1.1	Days to 50% tasseling (male flowering)	*	*	*						*
4.1.2	Days to 50% silking (female flowering) (5.1)	*		*			*	*		*
4.1.3	Days to ear leaf senescence in 50% of the plants	*					*	*		
4.1.4	Plant height [cm] (5.2)	*				*	*	*		*
4.1.5	Ear height [cm] (5.4)	*					*	*		*
4.1.6	Foliage (total leaf surface)	*						*		
4.1.7	Number of leaves above the uppermost ear including ear leaf	*						*		
4.1.8	Tillering index	*		*				*		*
4.1.9	Stem colour	*						*		
4.1.10	Root lodging [%]	*		*		*		* (not %)		
4.1.11	Stalk lodging [%]	*				*	*	* (not %)		
4.1.12	Sheath pubescence	*						*		
4.1.13	Tassel type	*						*		
4.2.1	Ear Husk cover	*						*		
4.2.2	Ear damage	*						*		
4.2.3	Ear kernel row arrangement	*		*				*		
4.2.4	Number of ear kernel rows	*		*			*	*		*
4.3.1	Kernel type/Type of grain	*	*	*				*		*
4.3.2	Kernel colour/Colour of top of grain	*	*	*				*		*
4.3.3	1000 kernel weight [g]	*		*				*		* 100
6.2.2	Ear length [cm]	*	*	*			*	*		*
6.2.4	Ear diameter [cm]	*		*			*	*		*
6.2.10	Shape of uppermost ear	*		*				*		
6.3.1	Kernel length [mm]	*					*	*		
6.3.2	Kernel width [mm]	*					*	*		
7.5	Drought	*			*				*	
8.1.1	*Diplodia maydis; Gibberella zeae; Fusarium moniliforme* (Ear rot, stalk rot)	*		*				*	*	

8.1.2	*Puccinia sorghi; Puccinia polysora* (Southern Rust)	*		*	*				*	*
8.1.3	*Peronosclerospora* spp.; *Sclerophthora* spp. (Downy mildew)	*				*			*	*
8.2.1	Corn stunt spiroplasma (CSS) (Corn stunt)	*			*				*	
8.3.2	*Chilo* spp. (Borer)	*				*			*	
8.3.6	*Sesamia* spp. (Borer)	*				*			*	*
	Grain yield						*		*	
6.1.1	Total number of leaves per plant	*								*
6.1.2	Leaf length [cm]	*								*
6.1.3	Leaf width [cm]	*								*
6.1.4	Leaf venation index	*								
6.1.5	Leaf orientation	*								
6.1.6	Presence of leaf ligule	*								
6.1.7	Root volume	*								
6.1.8	Tassel length [cm]	*	*							*
6.1.9	Tassel peduncle length [cm]	*								
6.1.10	Tassel branching space [cm]	*								
6.1.11	Number of primary branches on tassel	*	*							
6.1.12	Number of secondary branches on tassel	*								
6.1.13	Number of tertiary branches on tassel	*								
6.1.14	Tassel size	*								
6.1.15	Growing Degree Units (GDU) to 50% female flowering	*								
6.1.16	GDU to 50% male flowering	*								
6.1.17	Stay green	*								
6.2.1	Prolificacy index of ears	*								
6.2.3	Ear peduncle length [cm]	*								
6.2.5	Cob diameter [cm]	*								
6.2.6	Ear rachis diameter [cm]	*								
6.2.7	Number of ear bracts	*								
6.2.8	Number of kernels per row	*								
6.2.9	Cob colour	*	*	*						*
6.2.11	Grain shedding of ear [%]	*								
6.3.3	Kernel thickness [mm]	*								

6.3.4	Shape of upper surface of kernel	*		*						
6.3.5	Kernel pericarp colour	*		*						
6.3.6	Kernel aleurone colour	*		* **(combined with pattern)**						*
6.3.7	Kernel endosperm colour	*		*						*
7.1	Low temperature	*							*	*
7.2	Frost damage susceptibility	*								
7.3	Aluminium toxicity	*							*	
7.4	Low Nitrogen	*								
8.1.4	*Helminthosporium maydis; Helminthosporium turcicum* (Leaf blight - Southern Corn)	*		*		*				*
8.1.5	*Ustilago maydis* (Smut)	*		*					*	*
8.1.6	*Sphacelotheca reiliana* (Tassel smut)	*								
8.1.7	*Phyllachora maydis* (Tar spot)	*								
8.2.2	Corn streak virus (CSV) (Corn streak)	*								
8.2.3	Maize fine stripe virus (MRFV) (Fine striping disease)	*								
8.2.4	Maize bushy stunt mycoplasma (MBSD) (Maize bushy stunt)	*							*	
8.2.5	Maize dwarf mosaic virus (MDM) (Maize dwarf virus)	*		*						*
8.3.1	*Busseola* spp. (Borer)	*							*	
8.3.3	*Diatrea* spp. (Borer)	*							*	
8.3.4	*Heliothis zea; Heliothis armigera* (Ear worm)	*							*	
8.3.5	*Ostrinia* spp. (Borer)	*		*					*	*
8.3.7	*Spodoptera* spp. (Armyworm)	*							*	*
8.3.8	*Diabrotica* spp. (Root worm)	*		*						
8.3.9	*Sitophilus* spp. (Weevil)	*							*	
8.3.10	*Prostephanus* (Grain borer)	*							*	
	Kernel yield and fodder yield								*	
	Phaeosphaeria leaf spot (PLS) (*Phaeosphaeria maydis; Phoma maydis*)				*					
	Combining ability (How well it crosses among varieties)				*					
	Maize streak virus					*				

	Resistance to *Striga hermontica*					*				
	Ratio of ear leaf senescence and days to silking						*			
	Ear quality (1-5)						*			
	Ratio grain yield and grain moisture at harvest [%]						*			
	Selection index						*			
	Fertility							*		
	Field germination							*		
	Adaptation							*		
	Kernel							*		
	Seed moisture							*		
	Agronomic scale							*		
	Race class							*		

[i] 'Descriptors for Maize' (CIMMYT/IBPGR 1991); UPOV technical guidelines for Maize; 'Descriptors for MAIZE' (USDA, ARS, GRIN); Recommendations for further research under the Evaluation Award Scheme (EAS); 'Global Strategy for the *Ex situ* Conservation and Utilization of Maize Germplasm' (the Trust, 2007); Dr Taba's poster presented at the meeting held at SOMEFI in September 2008; Dr Taba's choice of descriptors within the ones identified in the SGRP Global Public Goods Activity 4.2.1.1 (GPG2, 2008); results of the GPG2 for the breeding traits exercise; 'Descriptors for Characterization and Evaluation of Maize' (National Institute of Agrobiological Sciences, Genebank of Japan).

Annex II – List of experts identified to participate to the survey

ROLE	*NAME*	*ORGANIZATION*	*COUNTRY*
Crop Leader	**Taba, Suketoshi**	CIMMYT	Mexico
CAG	Dass, Sain	Director (Directorate of Maize Research)	India
CAG	Grau, Michael	Genebank Dept Leibniz Institute (IPK)	Germany
CAG	Guiard, Joël	GEVES (UPOV)	France
CAG	Muthamia, Zachary K.	Kenya Agricultural Research Inst. Nat. Genebank of Kenya	Kenya
CAG	Payne, Thomas	CIMMYT	Mexico
CAG	Satyavathi, C. Tara	Indian Agricultural Research Institute	India
CAG	Sharma, Shyam Kumar	NBPGR	India
Global Maize Program	Afriyie, Twumasi Strafford	CIMMYT	Ethiopia
Crop Strategy Expert	Ahmad, Zahoor	Plant Genetic Resources Programme Nat. Agric. Res. Center	Pakistan
Crop Strategy Expert	Antohe, Ion	Agricultural Research and Development Institute	Romania
Crop Strategy Expert	Aragón Cuevas, Flavio	INIFAP - Oaxaca	Mexico
Global Maize Program	Araus Ortega, José Luis	CIMMYT	Mexico
Global Maize Program	Atlin, Gary	CIMMYT	Mexico
ECPGR	Barata da Silva, Ana Maria	Banco Portugues de Germoplasma Vegetal (BPGV)	Portugal
Crop Strategy Expert	Bas, Noor	Centre for Genetic Resources, The Netherlands	The Netherlands
Crop Strategy Expert	Benediková, Daniela	Gene Bank, Research Inst. of Plant Production	Slovak Republic
Global Maize Program	Beyene, Yoseph	CIMMYT	Kenya
Maize project INRA	Boerner, Andreas	IPK, Genebank Dept, Leibniz Institute	Germany
Crop Strategy Expert	Budiarti, Sri Gajatri	ICABIO GRAD	Indonesia
Crop Strategy Expert	Cesar Tapia/Alvaro Monteros	INIAP-DENAREF	Ecuador
Crop Strategy Expert	Chura Chuquija, Julián	Universidad Nacional Agraria La Molina	Peru
Crop Strategy Expert	Chytilova, Vera	RICP Prague-Ruzyne	Czech Republic
Crop Strategy Expert	Condon, Federico	INIA	Uruguay
Global Maize Program	Diallo, Alpha O.	CIMMYT	Kenya
Crop Strategy Expert	Dumet, Dominique	IITA	Nigeria

Maize project INRA	Evgenidis, Georgios	National Agricultural Research Foundation (NAGREF)	Greece
Crop Strategy Expert	Ferrer, Marcelo Edmundo	INTA	Argentina
Crop Strategy Expert	Firat, A. Ertug	Aegean Agricultural Research Institute (AARI)	Turkey
Global Maize Program	Friesen, Dennis	CIMMYT	Ethiopia
Crop Strategy Expert	Fuentes López, Mario Roberto	Instituto de Ciencia y Tecnología Agrícolas (ICTA)	Guatemala
ECPGR	Gogas, D.	Cereal Institute - National Agricultural Research Foundation	Greece
Crop Strategy Expert	Guzman, Lorena	Centro de Invest. Fitoecogenéticas de Pairumani	Bolivia
Crop Strategy Expert	Has, Ioan	Agricultural Research and Station TURDA	Romania
Crop Strategy Expert	Hernández Casillas, Juan Manuel	INIFAP - Mexico	Mexico
Crop Strategy Expert	Jampatong, Sansern	National Corn and Sorghum Research Center, Kasetsart University	Thailand
Crop Strategy Expert	Kainz, Wolfgang	AGES	Austria
Global Maize Program	Kanampiu, Fred	CIMMYT	Kenya
Reviewer	Kaul, Jyoti	Directorate of Maize Research	India
Reviewer	Kumar, Ashok	NBPGR	India
Crop Strategy Expert	Kuz'myshyna, Natalia	NCPGRU	Ukraine
Crop Strategy Expert	Lawrence, Peter	Australian Tropical Crops & Forages Germplasm Collection	Australia
Crop Strategy Expert	Lu, Xinxiong	CAAS	China
Global Maize Program	MacRobert, John	CIMMYT	Zimbabwe
Global Maize Program	Magorokosho, Cosmos	CIMMYT	Zimbabwe
Global Maize Program	Mahuku, George	CIMMYT	Mexico
Global Maize Program	Makumbi, Dan	CIMMYT	Kenya
Maize Collection Curator	Matveeva, Galina	N.I. Vavilov Research Institute of Plant Industry (VIR)	Russian Federation
Maize Breeder	Menkir, Abebe	IITA	Nigeria
Maize Researcher	Mironova, Maria	N.I. Vavilov Research Institute of Plant Industry (VIR)	Russian Federation
Reviewer	Mishra, S.K.	NBPGR	India
ECPGR	Moreno Gonzales, Jesus	Centro Investigaciones Agrarias de Mabegondo	Spain
ECPGR/ Maize DB	Motto, Mario	Unità di ricerca per la maiscoltura	Italy

Global Maize Program	Mugo, Stephen	CIMMYT	Kenya
Crop Strategy Expert	Murariu, Danela	Suceava Genebank	Romania
Global Maize Program	Narro, Luis Alberto	CIMMYT	Colombia
Crop Strategy Expert	Navas Arboleda, Alejandro Alberto	CORPOICA	Colombia
Crop Strategy Expert	Noldin, Orlando J.	CRA	Paraguay
Maize project INRA	Ordas, Amando	Consejo Superior de Investigaciones Cientificas (CSIC)	Spain
Crop Strategy Expert/ECPGR	Ordás, Armando	Misión Biológica de Galicia (CSIC)	Spain
New Reviewer	Ortiz, Rodomiro	CIMMYT	Mexico
Global Maize Program	Ortíz-Ferrara, Guillermo	CIMMYT, South Asia Regional Office	Nepal
Global Maize Program	Palacios, Natalia	CIMMYT	Mexico
Global Maize Program	Pixley, Kevin	CIMMYT	Mexico
Reviewer	Rana, J.C.	NBPGR, Regional station, Shimla	India
Maize project INRA	Ruaud, Pierre	Limagrain Group	France
Crop Strategy Expert	Salazar Suazo, Erika	Instituto de Investigaciones Agropecuarias	Chile
Crop Strategy Expert	Segovia, Victor	INIA - CENIAP	Venezuela
Global Maize Program	Setimela, Peter	CIMMYT	Zimbabwe
Crop Strategy Expert	Sevilla-Panizo, Ricardo	Universidad Nacional Agraria La Molina	Peru
Crop Strategy Expert/ECPGR	Srinivasan, Kalyani	National Bureau of Plant Genetic Resources	India
Crop Strategy Expert/ECPGR	Stehno, Zdenek	Research Institute of Crop Production of Prague	Czech Republic
EAS expert/Crop Strategy	Teixeira, Flavia Franca	EMBRAPA	Brazil
ECPGR	Visser, Bert	Centre for Genetic Resources, The Netherlands (CGN)	The Netherlands
Global Maize Program	Vivek, Bindiganavile	CIMMYT	Zimbabwe
Crop Strategy Expert/ECPGR	Wedelsbäck Bladh, Katarina	Nordic Gene Bank	Sweden
Global Maize Program	Zaidi, Pervez H.	Asian Regional Maize Program, CIMMYT	India
Crop Strategy Expert/ECPGR	Zanetto, Anne	INRA	France
Crop Strategy Expert/ECPGR	Zurab, Jinjik Hadze		Georgia

Annex III – First list of characterization and evaluation descriptors for maize submitted to the Crop Leader on 1 June 2009

1. Days to 50% tasseling (male flowering)
2. Days to 50% silking (female flowering)
3. Days to ear leaf senescence in 50% of the plants
4. Plant height [cm]
5. Ear height [cm]
6. Foliage (total leaf surface)
7. Number of leaves above the uppermost ear including ear leaf
8. Tillering index
9. Stem colour
10. Root lodging [%]
11. Stalk lodging [%]
12. Sheath pubescence
13. Tassel type
14. Ear Husk cover
15. Ear damage
16. Ear kernel row arrangement
17. Number of ear kernel rows
18. Kernel type / Type of grain
19. Kernel colour / Colour of top of grain
20. 1000 kernel weight [g]
21. Ear length [cm]
22. Ear diameter [cm]
23. Shape of uppermost ear
24. Kernel length [mm]
25. Kernel width [mm]
26. Grain yield
27. Drought
28. *Diplodia maydis*; *Gibberella zeae*; *Fusarium moniliforme* (Ear rot, stalk rot)
29. *Puccinia sorghi*; *Puccinia polysora* (Southern Rust)
30. *Peronosclerospora* spp.; *Sclerophthora* spp. (Downy mildew)
31. Corn stunt spiroplasma (CSS) (Corn stunt)
32. *Chilo* spp. (Borer)
33. *Sesamia* spp. (Borer)

Annex IV – Initial key set of characterization and evaluation descriptors for maize validated by the Crop Leader on 1 June 2009, uploaded to the SurveyMonkey

1. Days to 50% tasseling (male flowering)
2. Days to 50% silking (female flowering)
3. Days to ear leaf senescence in 50% of the plants
4. Plant height [cm]
5. Ear height [cm]
6. Foliage (total leaf surface) (rating)
7. Number of leaves above the uppermost ear including ear leaf
8. Tillering index
9. Stem colour
10. Root lodging [%]
11. Stalk lodging [%]
13. Tassel type
14. Ear Husk cover
15. Ear damage (rating) or ear quality
17. Number of ear kernel rows
18. Kernel type / Type of grain
19. Kernel colour / Colour of top of grain
20. 1000 kernel weight [g]
21. Ear length [cm]
22. Ear diameter [cm]
23. Shape of uppermost ear
24. Kernel length [mm]
25. Kernel width [mm]
26. Drought
27. *Diplodia maydis; Gibberella zeae; Fusarium moniliforme* (Ear rot, stalk rot)
28. *Puccinia sorghi* (common rust in temperate and highland environments); *Puccinia polysora* (Southern Rust in tropics)
29. *Bipolaris maydis*, syn. *Helminthosporium maydis* (Maydis leaf blight); *Exserohilum turcicum*, syn. *Helminthosporium turcicum* (Turcicum leaf blight)
30. *Peronosclerospora* spp.; *Sclerophthora* spp. (Downy mildew)
31. Corn Stunt Spiroplasma (CSS) (Corn stunt)
32. *Chilo* spp. (Borer)
33. *Sesamia* spp. (Borer)
34. Grain yield

Annex V – Survey to choose a key set of descriptors for maize (*Zea mays* L.)

WELCOME

Welcome to the survey for the selection of a key set of characterization and evaluation descriptors to support an international information system to enhance the utilization of germplasm held in genebanks.

Your knowledge and experience are being sought to select this initial 'key set of descriptors' of maize accessions to identify traits important to crop production and to facilitate their use by researchers.

Your participation in it is highly appreciated. The deadline for this survey is **30 June 2009**.

This key set of characterization and evaluation descriptors will be made available through a global facility for identifying sets of accessions for evaluation and use. For characterization, the aim is a key set of maximally differentiating traits that provide the most impact in discriminating between accessions. For evaluation, the aim is to focus on a few important traits for production, such as those related to biotic stresses of cosmopolitan nature.

The list presented here has been refined under the scientific direction of Dr Suketoshi Taba (CIMMYT).

This survey consists of two parts:

- PART I: Lists important characterization descriptors for maize. Based on your experience, please rate the descriptors according to their importance in identifying accessions. It also allows you to indicate if any essential descriptor that can contribute to its use is missing from the minimum list presented.

- PART II: Lists important evaluation descriptors for maize. Please, rate these traits in order of importance at the global level. It also allows you to indicate if any essential trait for production is missing from the minimum list presented or indicate any that may not be very significant to global production.

We thank you in advance for investing your time and expertise in selecting this initial, key set of descriptors.

Please allow us to acknowledge your contribution by completing your full contact details below:

Name:
Position:
Organization:
Country:
Email:

PART I: Characterization descriptors

These traits enable easy and quick discrimination between phenotypes. They are generally highly heritable, can be easily seen by the eye and are equally expressed in all environments.

*Numbers in parentheses on the right-hand side are the corresponding descriptors numbers as published in the CIMMYT/IBPGR publication 'Descriptors for Maize (*Zea mays* L.)' (1991).

	Not important	Important	Very important
Days to 50% tasseling (male flowering) (4.1.1)	○	○	○
Days to 50% silking (female flowering) (4.1.2)	○	○	○
Days to ear leaf senescence in 50% of the plants (4.1.3)	○	○	○
Plant height [cm] (4.1.4)	○	○	○
Ear height [cm] (4.1.5)	○	○	○
Foliage (total leaf surface) (rating) (4.1.6)	○	○	○
Number of leaves above the uppermost ear including ear leaf (4.1.7)	○	○	○
Tillering index (4.1.8)	○	○	○
Stem colour (4.1.9)	○	○	○
Root lodging [%] (4.1.10)	○	○	○
Stalk lodging [%] (4.1.11)	○	○	○
Tassel type (4.1.13)	○	○	○
Ear Husk cover (4.2.1)	○	○	○
Ear damage (rating) or ear quality (4.2.2)	○	○	○
Number of ear kernel rows (4.2.4)	○	○	○
Kernel type/Type of grain (4.3.1)	○	○	○
Kernel colour/Colour of top of grain (4.3.2)	○	○	○
1000 kernel weight [g] (4.3.3)	○	○	○

If you consider that an essential trait is missing from this list, please indicate it here along with a substantiated justification.

PART II: Evaluation descriptors

These descriptors include characters such as grain yield and biotic stresses. They are the most interesting traits in crop improvement. Please consider the following factors relating to the trait when making your final decision: (i) Global impact, (ii) Initial strategic set, (iii) Importance for germplasm utilization, (iv) Data availability, (v) True economic damage and (vi) Wide geographical occurrence.

	Not important	Important	Very important
Ear length [cm] (6.2.2)	○	○	○
Ear diameter [cm] (6.2.4)	○	○	○
Shape of uppermost ear (6.2.10)	○	○	○
Kernel length [mm] (6.3.1)	○	○	○
Kernel width [mm] (6.3.2)	○	○	○
Grain yield	○	○	○
Drought (7.5)	○	○	○
Ear rot, stalk rot (*Diplodia maydis*; *Gibberella zeae*; *Fusarium moniliforme*) (8.1.1)	○	○	○
Common rust in temperate and highland environments (*Puccinia sorghi*); Southern Rust in tropics (*Puccinia polysora*) (8.1.2)	○	○	○
Downy mildew (*Peronosclerospora* spp.; *Sclerophthora* spp.) (8.1.3)	○	○	○
Maydis leaf blight (*Bipolaris maydis*, syn. *Helminthosporium maydis*)	○	○	○
Turcicum leaf blight (*Exserohilum turcicum*, syn. *Helminthosporium turcicum*) (8.1.4)	○	○	○
Corn stunt (Corn stunt spiroplasma (CSS)) (8.2.1)	○	○	○
Borer (*Chilo* spp.) (8.2.3)	○	○	○
Borer (*Sesamia* spp.) (8.3.6)	○	○	○

If you consider that an essential trait important for crop improvement and production is missing from this list, or, if any of the descriptors listed is not clearly useful to promote utilization, please indicate it here along with a substantiated justification.

NOTE: Please remember, this list is the starting point and will grow over time, as required.

THANK YOU VERY MUCH FOR YOUR PARTICIPATION.

Annex VI – List of respondents to the survey

ROLE	NAME	ORGANIZATION	COUNTRY
Crop Leader	Taba, Suketoshi	CIMMYT	Mexico
CAG	Dass, Sain	Directorate of Maize Research	India
CAG	Guiard, Joël	GEVES	France
CAG	Payne, Thomas	CIMMYT	Mexico
CAG	Tara Satyavathi, C.	Indian Agricultural Research Institute	India
Reviewer	Adeleke, R.A.	IITA IBADAN	Nigeria
Reviewer	Antohe, Ion	NARDI	Romania
Reviewer	Aragón Cuevas, Flavio	INIFAP	Mexico
Reviewer	Barata, Ana Maria	INRB/BPGV	Portugal
Reviewer	Beyene, Yoseph	CIMMYT	Kenya
Reviewer	Börner, Andreas	Leibniz Institute of Plant Genetics and Crop Plant Research (IPK)	Germany
Reviewer	Dillon, Sally	Queensland Primary Industries and Fisheries	Australia
Reviewer	Erdal, Sekip	BATEM (Bati Akdeniz Agricultural Resarch Institute)	Turkey
Reviewer	Evgenidis, G.	NAGREF-Cereal Institute	Greece
Reviewer	Ferrer, Marcelo Edmundo	INTA (Instituto Nacional de Tecnología Agropecuaria)	Argentina
Reviewer	Fuentes, Mario	OID	Guatemala
Reviewer	Jampatong, Sansern	National Corn and Sorghum Research Center	Thailand
Reviewer	Johnson, Scott S.	Pegasus Genetics; CRD Advisors	USA
Reviewer	Kainz, Wolfgang	AGES	Austria
Reviewer	Kaul, Jyoti	Directorate of Maize Research	India
Reviewer	Kumar, Ashok	NBPGR	India
Reviewer	Kuz'myshyna, Natalia	National Centre for Plant Genetic Resources of Ukraine	Ukraine
Reviewer	MacRobert, John	CIMMYT	Zimbabwe
Reviewer	Magorokosho, Cosmos	CIMMYT	Zimbabwe
Reviewer	Mahuku, George	CIMMYT	Mexico
Reviewer	Matveeva, Galina	N.I. Vavilov Research Institute of Plant Industry (VIR)	Russian Federation
Reviewer	Murariu, Danela	Suceava Genebank	Romania
Reviewer	Narro, Luis	CIMMYT	Peru
Reviewer	Ordas, Amando	Spanish Council for Scientific Research (CSIC)	Spain
Reviewer	Ortiz, Rodomiro	CIMMYT	Mexico

Reviewer	Pixley, Kevin	CIMMYT	Mexico
Reviewer	Rana, J.C.	National Bureau of Plant Genetic Resources Regional Station	India
Reviewer	Ruaud, Pierre	Limagrain Group	France
Reviewer	Salazar Suazo, Erika	INIA (Instituto de Investigaciones Agropecuarias)	Chile
Reviewer	Teixeira, Flavia França	EMBRAPA Maize and Sorghum	Brazil
Reviewer	Tracy, William	University of Wisconsin-Madison	USA
Reviewer	Zaidi, P.H.	CIMMYT	India

Annex VII – List of descriptors proposed in the survey ranked by rating average and evaluation descriptors ranked by percentage of importance sent to the Crop Leader for validation

Descriptor	Rating Average	Dr Taba's selection
Characterization		
Kernel type/Type of grain (4.3.1)	4.26	
Days to 50% tasseling (male flowering) (4.1.1)	4.00	
Days to 50% silking (female flowering) (4.1.2)	3.97	
Kernel colour/Colour of top of grain (4.3.2)	3.88	
Number of ear kernel rows (4.2.4)	3.73	
Ear height [cm] (4.1.5)	3.56	
1000 kernel weight [g] (4.3.3)	3.44	
Plant height [cm] (4.1.4)	3.38	
Tassel type (4.1.13)	3.38	
Ear Husk cover (4.2.1)	3.18	
Stalk lodging [%] (4.1.11)	3.03	
Ear damage (rating) or ear quality (4.2.2)	2.88	
Root lodging [%] (4.1.10)	2.88	
Tillering index (4.1.8)	2.41	
Number of leaves above the uppermost ear including ear leaf (4.1.7)	2.38	
Stem colour (4.1.9)	2.24	
Days to ear leaf senescence in 50% of the plants (4.1.3)	2.06	
Foliage (rating of total leaf surface) (4.1.6)	1.78	
Evaluation		
Ear rot, stalk rot (*Diplodia maydis; Gibberella zeae; Fusarium moniliforme*) (8.1.1)	4.23	
Grain yield	4.13	
Drought (7.5)	3.94	
Maydis leaf blight (*Bipolaris maydis*, syn. *Helminthosporium maydis*); Turcicum leaf blight (*Exserohilum turcicum*, syn. *Helminthosporium turcicum*) (8.1.4)	3.90	
Common rust in temperate and highland environments (*Puccinia sorghi*); Southern Rust in tropics (*Puccinia polysora*) (8.1.2)	3.77	
Ear length [cm] (6.2.2)	3.65	
Borer (*Sesamia* spp.) (8.3.6)	3.50	
Downy mildew (*Peronosclerospora* spp.; *Sclerophthora* spp.) (8.1.3)	3.48	
Borer (*Chilo* spp.) (8.3.2)	3.37	
Kernel length [mm] (6.3.1)	3.26	
Ear diameter [cm] (6.2.4)	3.13	
Corn stunt (Corn Stunt Spiroplasma (CSS)) (8.2.1)	3.00	
Kernel width [mm] (6.3.2)	2.94	
Shape of uppermost ear (6.2.10)	1.97	

Descriptor	Important	Very important
Evaluation		
Grain yield	35.5%	61.3%
Ear rot, stalk rot (*Diplodia maydis*; *Gibberella zeae; Fusarium moniliforme*) (8.1.1)	38.7%	61.3%
Drought (7.5)	45.2%	51.6%
Maydis leaf blight (*Bipolaris maydis,* syn. *Helminthosporium maydis*); Turcicum leaf blight (*Exserohilum turcicum*, syn.; *Helminthosporium turcicum*) (8.1.4)	54.8%	45.2%
Ear length [cm] (6.2.2)	51.6%	41.9%
Kernel length [mm] (6.3.1)	38.7%	41.9%
Common rust in temperate and highland environments (*Puccinia sorghi*); Southern Rust in tropics (*Puccinia polysora*) (8.1.2)	61.3%	38.7%
Downy mildew (*Peronosclerospora* spp.; *Sclerophthora* spp.) (8.1.3)	51.6%	38.7%
Borer (*Sesamia* spp.) (8.3.6)	50.0%	40.0%
Ear diameter [cm] (6.2.4)	45.2%	35.5%
Kernel width [mm] (6.3.2)	38.7%	35.5%
Borer (*Chilo* spp.) (8.3.2)	56.7%	33.3%
Corn stunt (Corn stunt spiroplasma (CSS)) (8.2.1)	50.0%	30.0%
Shape of uppermost ear (6.2.10)	54.8%	6.5%

Annex VIII – Additional descriptors included in the open-ended section of the survey

Additional descriptors	Name of expert																	
	No. times proposed	**M.E. Ferrer**	**G. Mahuku**	**P.H. Zaidi**	**J. MacRobert**	**D. Muriaru**	**N. Kuz'myshyna**	**S. Dass**	**S.S. Johnson**	**J. Guiard**	**M. Fuentes**	**I. Antohe**	**F. França Teixeira**	**W. Kainz**	**S. Jampatong**	**P. Ruaud**	**E. Salazar Suazo**	**K. Pixley**
Additional characterization traits																		
Total number of leaves per plant	**1**	**X**																
Largo y ancho de la hoja de la mazorca superior	**1**	**X**																
Anthesis-sliking interval (=Days to 50% silking - Days to 50% Anthesis)	**1**			**X**														
Hairiness of leaves	**1**						**X**											
Hairiness of stalks	**1**						**X**											
Stalk colour at harvest	**1**						**X**											
Wrap leafiness ear	**1**						**X**											
Consistence ear cover	**1**						**X**											
Height of fastening of an upper productive cprn-cob, cm	**1**						**X**											
Stalk, diameter above earcorn	**2**						**X**										**X**	
Height of main stalk, cm	**1**						**X**											
Leaf angle	**1**							**X**										
Leaf Anthocyanin of sheath	**1**							**X**										
Tassel: Anthocyanin coloration at the base of glume	**2**						**X**	**X**										
Tassel: Anthocyanin coloration of anthers	**3**						**X**	**X**								**X**		
Tassel: Density of spikelets	**1**							**X**										
Tassel: Attitude of lateral branches	**2**							**X**		**X**								

Attitude of leaves	**1**									**X**								
Ear: Anthocyanin colouration of silks	**3**							**X**				**X**				**X**		
Ear diameter	**1**							**X**										
Grain Type	**2**							**X**				**X**						
Ear: Anthocyanin colouration of glumes of cob	**3**							**X**				**X**				**X**		
Ear: Shape: (conical, cylindrical)	**1**							**X**										
Kernel row arrangement	**1**							**X**										
Kernel: Shape – shrunken, round, toothed or flat	**1**							**X**										
Leaf colour	**1**										**X**							
Anthocyanin coloration of brace roots indirect information on resistance to some pests	**1**											**X**						
Number of ears per plant	**1**														**X**			
COMMENTS																		
Days to flower and senescence should be expressed in growing degree days, not in days.																		**X**
General remark: the recent revision of UPOV test guidelines on Maize includes all the characteristics with a good discrimination power, those with an asterisk are really the best ones										**X**								
I think a rating of root and/or stalk lodging is much too environment-dependent to be very useful									**X**									
Additional evaluation traits																		
Leaf width (6.1.3)	**3**							**X**						**X**			**X**	
Instead of Foliage rating I would suggest Leaf length [cm]	**1**													**X**				
Venation Index (6.1.4)	**1**																**X**	
Tassel branching space (6.1.10)	**1**																**X**	

Number of tassel primary ramifications (6.1.11)	**1**																**X**	
Rachis diameter (6.2.6)	**1**																**X**	
Ustilago Maydis	**1**	**X**																
Gray leaf spot (*Cercospora zea-maydis)*	**2**		**X**		**X**													
Maize streak virus (MSV)	**2**		**X**		**X**													
Low temperature - it is very important for northern extremity of maize crops. This descriptor gives the opportunity to identify accessions which can be used in the breeding program for precocity.	**1**					**X**												
Salt tolerance	**1**								**X**									
Tolerance to low Nitrogen	**1**								**X**									
Earliness at flowering and at harvest time	**1**									**X**								
Type of endosperme	**1**									**X**								
Lodging resistance	**1**									**X**								
Digestibility of entire plant for silage type	**1**									**X**								
Heterotic pattern	**1**												**X**					
Grain disease (micotoxin)	**1**												**X**					
Corn root worm (*Diabrotica*)	**1**															**X**		
European corn borer (*Ostrinia*)	**1**															**X**		
Corn ear worm (*Helicoverpa)*	**1**															**X**		
Fall armyworm (*Spodoptera*)	**1**															**X**		
Grain nutritional components	**1**												**X**					

Provitamin A	**1**																**X**	
Content oil	**1**																**X**	
Content cell wall digestibility	**1**																**X**	
Endosperm creaminess	**1**																**X**	
Pericarp softness	**1**																**X**	
S. No. Characteristics States 1. (+) Leaf: Angle between blade and stem (on leaf just above upper ear) Small (<45°) Wide (>45°) 2 (+) Leaf: Attitude of blade (on leaf just above upper ear) Straight Drooping 3. (S) Stem: Anthocyanin colouration of brace roots) Absent Present 4. (*) Tassel: Time of anthesis (on middle third of main axis, 50 % of plants) Very early (<45 days) Early (45-50 days) Medium (50-55 days) Late (>55 days) 5. (+)(S) Tassel: Anthocyanin colouration of glumes excluding base (in middle third of main axis) Absent Present 6. (S) Tassel: Anthocyanin colouration of glumes excluding base (in middle third of main axis) Absent Present 7. (S) Tassel: Anthocyanin colouration of anthers (in middle third of mairr axis on fresh anthers) Absent Present 8 Tassel: Density of spikelets (in middle third of main axis) Sparse Dense 9. (*) (+) Tassel: Angle between main axis and lateral branches Narrow (< 45°) Wide (> 45°) 10. (*)(+) Tassel: Attitude of lateral branches (in lower third of tassel) Straight Curved Strongly curved 11 Ear: Time of silk emergence (50% plants) Very early (<48 days) Early (48-53 days) Medium (53-58 days) Late (>58 days) 12. (*) Ear: Anthocyanin colouration of silks (on day of emergency) Absent Present 13 Leaf: Anthocyanin colouration of sheath (below the ear) Absent Present 14 Tassel: Length of main axis above lowest side branch Short (<20 cm) Medium (20-30 cm) Long (> 30 cm) 15.1 (*) Inbred lines only: Plant : Length (up to flag leaf) Short (<120 cm) Medium (120-150 cm) Long (>150 cm) 15.2 (*) Hybrids and open pollinated varieties only: Plant : Length (up to flag leaf) Short (<150 cm) Medium (150-180 cm) Long (181-210 cm) Very long (>210 cm) 16 Plant: Ear placement Low Medium High 17 Leaf: Width of blade (leaf of upper ear) Narrow (<8 cm) Medium (8-9 cm) High (>9 cm) 18. (*) Ear: Length without husk Short (<10 cm) Medium (10-15 cm) Long (>15 cm) 19 Ear: Diameter without husk (in middle) Small (<4 cm) Medium (4-5 cm) Large (>5 cm) 20. (+) Ear: Shape Conical Conico-cylinderical Cylindrical 21 Ear: Number of rows of grains Few (< 8) Medium (10-12) Many (>14) 22. (*) Ear: Type of grain (in middle third of ear) Flint Semi flint/ Semi dent Dent 23. (*) Ear: Colour of top of grain White White with cap Yellow Yellow with cap Orange Red Other (specify) 24. (*) Ear: Anthocyanin colouration of glumes of cob White Light purple Dark purple 25. (+) Kernel: Row arrangement (middle of ear) Straight Spiral Irregular 26 Kernel: Poppiness Absent Present 27 Kernel: Sweetness Absent Present 28 Kernel: Waxiness Absent Present 29 Kernel: Opaqueness Absent Present 30. (+) Kernel: Shape Shrunken Round Indented Toothed Pointed 31 Kernel: 1000 kernel weight) Very small (<100g) Small (100-200 g) Medium (200-300 g) Large (>300 g)								**X**										

Annex IX – Dr Taba's comments on the survey results shared with Dr Dass on 30 September 2009

Descriptor	Rating Average	Dr Taba's selection
Characterization		
Kernel type/Type of grain (4.3.1)	4.26	x
Days to 50% tasseling (male flowering) (4.1.1)	4.00	x
Days to 50% silking (female flowering) (4.1.2)	3.97	x
Kernel colour/Colour of top of grain	3.88	x
Number of ear kernel rows (4.2.4)	3.73	x
Ear height [cm] (4.1.5)	3.56	x
1000 kernel weight [g] (4.3.3)	3.44	x
Plant height [cm] (4.1.4)	3.38	x
Tassel type (4.1.13)	3.38	x
Ear Husk cover (4.2.1)	3.18	x
Stalk lodging [%] (4.1.11)	3.03	x
Ear damage (rating) or ear quality (4.2.2)	2.88	**X** This is rating of kernel health for most part and uniformity of ears. There is no trait to indicate plant health among chosen minimum descriptors. At least this can be included.
Root lodging [%] (4.1.10)	2.88	**X** This trait is to indicate root strength and standability.
Tillering index (4.1.8)	2.41	This is rather confined to Mexican highland and northern flint races. If genebank does not have these germplasm, this is less interest.
Number of leaves above the uppermost ear including ear leaf (4.1.7)	2.38	**X** This is again more racial traits: most improved materials have a little difference. I still think this is worth while, as plant efficiency indicated by the trait to some extent.
Stem colour (4.1.9)	2.24	This is again specific interest, as a large part of germplasm does not have coloured stems, except in CIMMYT where Mexican landraces often have coloured stems.
Days to ear leaf senescence in 50% of the plants (4.1.3)	2.06	**X** (this is not popular in the survey, but there is no data to indicate plant adaptation and health at characterization, this is a reason I use in CIMMYT. This is one of the best parameters to differentiate accessions in general performance in selection index). The ratio of leaf senescence and days to silk is very good indicator for grain filling period.
Foliage (rating of total leaf surface) (4.1.6)	1.78	Again, this is a racial trait for most part, indicating large broad leaf and leaf numbers> Forage maize may be indicative of high rating of this trait. So location specific. CIMMYT will need it anyway. It also indicates a general plant structure in combination with plant height and ear height.

Descriptor	Rating Average	Dr Taba's selection
Evaluation		
Ear rot, stalk rot (*Diplodia maydis; Gibberella zeae; Fusarium moniliforme*) (8.1.1)	4.23	**x**
Grain yield	4.13	**x**
Drought (7.5)	3.94	**x**
Maydis leaf blight (*Bipolaris maydis*, syn. *Helminthosporium maydis*); Turcicum leaf blight *(Exserohilum turcicum*, syn. *Helminthosporium turcicum*) (8.1.4)	3.90	**x**
Common rust in temperate and highland environments (*Puccinia sorghi*); Southern Rust in tropics (*Puccinia polysora*) (8.1.2)	3.77	**x**
Ear length [cm] (6.2.2)	3.65	**x**
Borer (*Sesamia* spp.) (8.3.6)	3.50	**x**
Downy mildew *(Peronosclerospora* spp.; *Sclerophthora* spp.) (8.1.3)	3.48	**x**
Borer *(Chilo* spp.) (8.3.2)	3.37	**x**
Kernel length [mm] (6.3.1)	3.26	**x**
Ear diameter [cm] (6.2.4)	3.13	**x**
Corn stunt (Corn stunt spiroplasma (CSS)) (8.2.1)	3.00	**x**
Kernel width [mm] (6.3.2)	2.94	**x**
Shape of uppermost ear (6.2.10)	1.97	**X** This is a racial trait and a bit of heterotic pattern of inbreds. I would think this is still some indication of kernel arrangement, kernel numbers, cob formation. Conico and cylindrical send a message to a good corn breeder as to heterotic pattern how he uses in parent if no other information is available. Now it is testcross bases, that everyone assumes cylindrical ears. Shelling cylindrical ears are seen normally that was very minimum, I suppose. Evaluation does not include test crosses in this case, I will keep it.

Annex X – Key access and utilization descriptors for maize sent to the Crop Leader and CAG for validation[i]

PLANT DATA

Days to tasseling (male flowering) (4.1.1)
Number of days from sowing to when 50% of the plants have shed pollen

Days to silking (female flowering) (4.1.2)
Number of days from sowing to when silks have emerged on 50% of the plants

Days to ear leaf senescence (4.1.3)
Number of days from sowing to when 50% of the plants have a dry ear leaf

Plant height [cm] (4.1.4)
From ground level to the base of the tassel. After milk stage

Ear height [cm] (4.1.5)
From ground level to the node bearing the uppermost ear. After milk stage

Foliage rating (4.1.6)
(Rating of total leaf surface)

Number of leaves above the uppermost ear including ear leaf (4.1.7)
Counted on at least 20 representative plants. After milk stage

Root lodging [%] (4.1.10)
Percentage of plants root-lodged. (This trait indicates root strength and standability). Two weeks before harvest

Stalk lodging (4.1.11)
Percentage of plants stalk-lodged. Two weeks before harvest

Tassel type (4.1.13)
At milk stage

1 Primary
2 Primary-secondary
3 Primary-secondary-tertiary

Ear husk cover (4.2.1)

3 Poor
5 Intermediate
7 Good

Ear damage (4.2.2)
(Rating of kernel health). Amount of ear damage caused by ear rot and/or insects, etc.

0 None
3 Little
7 Severe

Number of kernel rows (4.2.4)
Count number of kernel rows in the central part of the uppermost ear

Kernel type (4.3.1)
Indicate up to three kernel types in the order of frequency

1 Floury
2 Semi-floury (morocho), with an external layer of hard endosperm
3 Dent
4 Semi-dent, intermediate between dent and flint but closer to dent
5 Semi-flint, flint with a soft cap
6 Flint
7 Pop
8 Sweet
9 Opaque 2/QPM
10 Tunicate
11 Waxy

Kernel colour (top of grain) (4.3.2)
Indicate up to three colours in the order of frequency

1 White
2 Yellow
3 Purple
4 Variegated
5 Brown
6 Orange
7 Mottled
8 White cap
9 Red

1000-kernel weight [g] (4.3.3)
Adjusted to 10% moisture content

Ear length [cm] (6.2.2)

Ear diameter [cm] (6.2.4)
Measured at the central part of the uppermost ear

Shape of uppermost ear (6.2.10)

1 Cylindrical
2 Cylindrical-conical
3 Conical
4 Round

Kernel length [mm] (6.3.1)
Average of 10 consecutive kernels from one row in the middle of the uppermost ear, measured with a calliper

Kernel width [mm] (6.3.2)
Measured on the same 10 kernels as 6.3.1

Grain yield (6.3.X)

ABIOTIC STRESSES

Drought (7.5)
Reflected in seed yield relative to control

BIOTIC STRESSES

Ear rot, stalk rot (*Diplodia maydis*, *Gibberella zeae*, *Fusarium moniliforme*) (8.1.1)

Common rust in temperate and highland environments (*Puccinia sorghi*) (8.1.2a)

Southern rust in tropics (*Puccinia polysora*) (8.1.2b)

Downy mildew (*Peronosclerospora* spp.; *Sclerophthora* spp.) (8.1.3)

Maydis leaf blight (*Bipolaris maydis* syn. *Helminthosporium maydis*) (8.1.4a)

Turcicum leaf blight (*Exserohilum turcicum*, syn. *Helminthosporium turcicum*) (8.1.4b)

Corn stunt (Corn stunt spiroplasma (CSS) (8.2.1)

Borer (*Chilo* spp.) (8.3.2)

Borer (*Sesamia* spp.) (8.3.6)

Ear: Anthocyanin colouration of silks (on day of emergency) Absent Present

Ear: Anthocyanin colouration of glumes of cob (White, Light purple, Dark purple)

6.1.3 Leaf width [cm]

---

[i] Descriptors highlighted in light blue are new or modified; Descriptors highlighted in yellow were proposed by participants in the survey

Annex XI – Final key set of descriptors for maize genetic resources

Key access and utilization descriptors for maize genetic resources

This list consists of an initial set of characterization and evaluation descriptors for maize utilization. This strategic set of descriptors, together with passport data, will become the basis for the global accession level information portal being developed by Bioversity International with the financial support of the Global Crop Diversity Trust (the Trust). It will facilitate access to and utilization of maize accessions held in genebanks and does not preclude the addition of further descriptors, should data subsequently become available.

Based on the comprehensive list ‘Descriptors for Maize’ published by CIMMYT and IBPGR (now Bioversity International) in 1991, the list was subsequently compared with a number of sources such as UPOV technical guidelines for Maize (1994), ‘Descriptors for MAIZE’ (USDA, ARS, GRIN), ‘Global Strategy for the *Ex situ* Conservation and Utilization of Maize Germplasm’ (the Trust, 2007), Dr Taba’s poster presented at the meeting held at the Sociedad Mexicana de Fitogenética (SOMEFI) in September 2008, ‘Descriptors for Characterization and Evaluation of Maize’ (National Institute of Agrobiological Sciences, Genebank of Japan), as well as with those descriptors that were awarded funds for further research by the Trust in 2008 Evaluation Awards Scheme (EAS). The initial list also builds on the results of the SGRP Global Public Goods Activity 4.2.1.1, with special attention to breeding traits. It was further refined during a meeting held at the National Bureau of Plant Genetic Resources (NBPGR, India) in June 2009. It involved several scientists from NBPGR and the valuable contribution of Dr Sain Dass of the Directorate of Maize Research, Indian Council of Agricultural Research (ICAR).

A worldwide distribution of experts was involved in an online survey to define a first priority set of descriptors to describe, to access and to utilize maize genetic resources. This key set was afterwards validated by a Core Advisory Group (see ‘Contributors’) led by Dr Suketoshi Taba of the International Maize and Wheat Improvement Center (CIMMYT).

Biotic and abiotic stresses included in the list were chosen because of their wide geographic occurrence and significant economic impact at a global level.

Numbers in parentheses on the right-hand side are the corresponding descriptor numbers listed in the 1991 publication. Descriptors with numbers ending in ‘letters’ are either modified or new descriptors that were added during the development of the list below.

PLANT DATA

Days to tasseling (male flowering) (4.1.1)
Number of days from sowing to when 50% of the plants have shed pollen

Days to silking (female flowering) (4.1.2)
Number of days from sowing to when silks have emerged on 50% of the plants

Days to ear leaf senescence (4.1.3)
Number of days from sowing to when 50% of the plants have a dry ear leaf

Plant height [cm] (4.1.4)
From ground level to the base of the tassel. After milk stage

Ear height [cm] (4.1.5)
From ground level to the node bearing the uppermost ear. After milk stage

Foliage rating (4.1.6)
Rating of total leaf surface

Number of leaves above the uppermost ear including ear leaf (4.1.7)
Counted on at least 20 representative plants. After milk stage

Root lodging [%] (4.1.10)
Percentage of plants root-lodged. This trait indicates root strength and standability. Two weeks before harvest

Stalk lodging [%] (4.1.11)
Percentage of plants stalk-lodged. Two weeks before harvest

Tassel type (4.1.13)
At milk stage

1 Primary
2 Primary-secondary
3 Primary-secondary-tertiary

Ear husk cover (4.2.1)

3 Poor
5 Intermediate
7 Good

Ear damage (4.2.2)
Rating of kernel health. Amount of ear damage caused by ear rot and/or insects, etc.

0 None
3 Little
7 Severe

Number of kernel rows (4.2.4)
Count number of kernel rows in the central part of the uppermost ear

Kernel type (4.3.1)
Indicate up to three kernel types in order of frequency

1 Floury
2 Semi-floury (morocho), with an external layer of hard endosperm
3 Dent
4 Semi-dent, intermediate between dent and flint but closer to dent
5 Semi-flint, flint with a soft cap
6 Flint
7 Pop
8 Sweet
9 Opaque 2/QPM
10 Tunicate
11 Waxy

Kernel colour (top of grain) (4.3.2)
Indicate up to three colours in order of frequency
1 White
2 Yellow
3 Purple
4 Variegated
5 Brown
6 Orange
7 Mottled
8 White cap
9 Red

1000-kernel weight [g] (4.3.3)
Adjusted to 10% moisture content

Ear length [cm] (6.2.2)

Ear diameter [cm] (6.2.4)
Measured at the central part of the uppermost ear

Shape of uppermost ear (6.2.10)
1 Cylindrical
2 Cylindrical-conical
3 Conical
4 Round

Kernel length [mm] (6.3.1)
Average of 10 consecutive kernels from one row in the middle of the uppermost ear, measured with a calliper

Kernel width [mm] (6.3.2)
Measured on the same 10 kernels as 6.3.1

Grain yield (6.3.X)

ABIOTIC STRESSES

Drought (7.5)
Reflected in seed yield relative to control

BIOTIC STRESSES

Ear rot, stalk rot (*Diplodia maydis*, *Gibberella zeae*, *Fusarium moniliforme*) (8.1.1)

Common rust in temperate and highland environments (*Puccinia sorghi*) (8.1.2a)

Southern rust in tropics (*Puccinia polysora*) (8.1.2b)

Downy mildew (*Peronosclerospora* spp., *Sclerophthora* spp.) (8.1.3)

***Maydis* leaf blight** (*Bipolaris maydis* syn., *Helminthosporium maydis*) (8.1.4a)

Turcicum leaf blight (*Exserohilum turcicum* syn., *Helminthosporium turcicum*) (8.1.4b)

Corn stunt (Corn stunt spiroplasma) (CSS) (8.2.1)

Borer (*Chilo* spp.) (8.3.2)

Borer (*Sesamia* spp.) (8.3.6)

CONTRIBUTORS

Bioversity is grateful to all the scientists and researchers who have contributed to the development of this strategic set of 'Key access and utilization descriptors for maize genetic resources', and in particular to Dr Suketoshi Taba (CIMMYT, Mexico) for providing scientific direction. Ms Adriana Alercia (Bioversity International) provided technical expertise and guided the entire production process.

CORE ADVISORY GROUP

Suketoshi Taba, International Maize and Wheat Improvement Center (CIMMYT), Mexico
Sain Dass, Directorate of Maize Research, Indian Council of Agricultural Research (ICAR), India
Joël Guiard, Groupe d'Etude et de Controle de Varietes et des Semences (GEVES), France
Thomas Payne, International Maize and Wheat Improvement Center (CIMMYT), Mexico
C. Tara Satyavathi, Indian Agricultural Research Institute, India

REVIEWERS

Argentina
Marcelo Edmundo Ferrer, Instituto Nacional de Tecnología Agropecuaria (INTA)

Australia
Sally Dillon, Queensland Primary Industries and Fisheries

Austria
Wolfgang Kainz, Austrian Agency for Health and Food Safety (AGES)

Brazil
Flavia França Teixeira, Empresa Brasileira de Pesquisa Agropecuária (Embrapa Maize and Sorghum)

Chile
Erika Salazar Suazo, Instituto de Investigaciones Agropecuarias (INIA)

France
Pierre Ruaud, Limagrain Group

Germany
Andreas Börner, Leibniz Institute of Plant Genetics and Crop Plant Research (IPK)

Greece
G. Evgenidis, National Agricultural Research Foundation, Cereal Institute (NAGREF)

Guatemala
Mario Fuentes, Organización Integral de Desarrollo (OID)

India
Jyoti Kaul, Directorate of Maize Research, Indian Council of Agricultural Research (ICAR)
Ashok Kumar, National Bureau of Plant Genetic Resources (NBPGR)
J.C. Rana, National Bureau of Plant Genetic Resources Regional Station, Phagli, Shimla (NBPGR)
P.H. Zaidi, International Maize and Wheat Improvement Center (CIMMYT)

Kenya
Yoseph Beyene, International Maize and Wheat Improvement Center (CIMMYT)

Mexico
Flavio Aragón Cuevas, Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP)
George Mahuku, International Maize and Wheat Improvement Center (CIMMYT)
Rodomiro Ortiz, International Maize and Wheat Improvement Center (CIMMYT)
Kevin Pixley, International Maize and Wheat Improvement Center (CIMMYT)

Nigeria
R.A. Adeleke, International Institute of Tropical Agriculture (IITA), Ibadan

Peru
Luis Narro, International Maize and Wheat Improvement Center (CIMMYT)

Portugal
Ana Maria Barata, Instituto Nacional de Recursos Biológicos, Banco Português de Germoplasma Vegetal (INRB/BPGV)

Romania
Ion Antohe, National Agricultural Research and Development Institute (NARDI)
Danela Murariu, Suceava Genebank

Russian Federation
Galina Matveeva, N.I. Vavilov Research Institute of Plant Industry (VIR)

Spain
Amando Ordas, Spanish Council for Scientific Research (CSIC)

Thailand
Sansern Jampatong, National Corn and Sorghum Research Center

Turkey
Sekip Erdal, Bati Akdeniz Agricultural Research Institute (BATEM)

Ukraine
Natalia Kuz'myshyna, National Centre for Plant Genetic Resources of Ukraine

USA
Scott S. Johnson, Pegasus Genetics, CRD Advisors
William Tracy, University of Wisconsin-Madison

Zimbabwe
John MacRobert, International Maize and Wheat Improvement Center (CIMMYT)
Cosmos Magorokosho, International Maize and Wheat Improvement Center (CIMMYT)

Methodology for the definition of a key set of characterization and evaluation descriptors for pearl millet [*Pennisetum glaucum* (L.) R. Br.]

Information collection and preparation of the Minimum Descriptor List (MDL)

Information for the definition of a Minimum Descriptor List for pearl millet was based on the publication 'Descriptors for Pearl Millet [*Pennisetum glaucum* (L.) R. Br.]' published by ICRISAT and IBPGR (now Bioversity International) in 1993. The comprehensive descriptors list included in this publication was compared with descriptors listed in Descriptors for PMILLET (USDA, ARS, GRIN); 'Establishment of a pearl millet [*Pennisetum glaucum* (L.) R. Br.] core collection based on geographical distribution and quantitative traits' [Euphytica (2007) 155:35–45]; 'Pearl millet germplasm at ICRISAT genebank – status and impact' (ICRISAT, Vol. 3, Issue 1, 2007); Guidelines for the conduct of tests for Distinctness, Uniformity and Stability on Pearl millet (*Pennisetum glaucum* (L.) R. Br.) (PPV & FRA, 2007), and with the traits that were awarded funds for further research by the Global Crop Diversity Trust through the Evaluation Award Scheme (the Trust, 2008). The list was then refined during a crop-specific consultation meeting held in June 2009 at the National Bureau of Plant Genetic Resources (NBPGR) in India, following the advice of scientists from NBPGR, Indian Agricultural Research Institute (IARI) and the All India Coordinated Research Project on Pearl Millet (AICRP-Pearl Millet). To assist in the selection of a "reduced" set of traits, a comparison table was prepared to visually identify the "most important" descriptors recurring in the above mentioned sources (see Annex I).

Preparation of the List of Experts

The List of Experts was compiled including experts involved in various crop-specific consultations on millets, representatives of the world major pearl millet collections, plant pathologists and breeders. Overall, 52 experts were selected, coming from 12 countries and 34 different organizations (see Annex II). Out of these, Dr Prem Mathur from Bioversity International was identified as Crop Leader and further to the crop-specific meeting held at NBPGR in June 2009, Dr I.S. Khairwal (AICRP-Pearl Millet) was also identified as Crop Leader. In the final stages of the exercise, Dr Hari D. Upadhyaya from ICRISAT provided valuable advice on the definition of the final key set. A Core Advisory Group, consisting of various experts from different organizations was selected to assist in the definition of a minimum set of descriptors, which was subsequently circulated for validation among a wider group of scientists.

Survey preparation and distribution

During the crop-specific meeting held at the NBPGR in June 2009, the comparison table was analyzed and an initial key set of characterization and evaluation traits was selected (see Annex III). The agreed list, compiled under the scientific guidance of Dr Mathur and Dr Khairwal, was consequently used to prepare a draft survey on pearl millet. Moreover, participants in the meeting were requested to identify – in addition to the key set of descriptors for pearl millet utilization – further descriptors that were considered important for describing and utilizing genetic resources, yet judged 'not essential'. This longer list of descriptors would have contributed to the full characterization and evaluation of pearl millet, to be included in an eventual revised (traditional) list of descriptors for this crop.

The final version of the key set was uploaded into the SurveyMonkey application on internet and sent out to the list of identified experts on 26 June 2006 (see Annex IV). Participants were invited to validate this initial key set of descriptors of pearl millet accessions to facilitate their use by breeders and asked to make suggestions regarding any characterization or evaluation descriptors that were found to be very important yet missing from the proposed Minimum List.

The survey deadline was set at 28 July 2009, therefore a first reminder was sent out on 14 July 2009 and a second on 24 July 2009 to ensure that the greatest possible feedback was obtained.

Survey analysis and refinement of the Minimum List

Of the 52 experts who were identified and involved in the exercise, 25 experts from 16 different organizations and nine countries recorded their comments using the online survey, nine of whom were members of the CAG (see Annex V). Results from the consultation were analyzed and descriptors were ranked by rating average and percentage of importance (see Annex VI). The summary results of the survey together with a report containing comments recorded by the participants (see Annexes VII and VIII) were sent to the Crop Leaders and to the CAG. In order to reach a wider consensus on the final key set of traits, additional members were added to the CAG at this stage. All feedback received from advisory members was compared and harmonized, where possible (see Annex IX). This exercise led to a first draft of the key set for pearl millet that was submitted to the Crop Leaders for final validation (see Annex X). Particularly noteworthy is a comment from one of the Crop Leaders underlining that although drought was considered important in the context of climate change, pearl millet has normally been grown as a rain fed crop. Therefore, he felt that even if the character was important, the possibility genebank curators of screening a large number of collections against drought may not be viable. However, since most of the Core Advisory Group members recommended it, it was decided to include this trait in the list. The same applied to 'Blast', an additional abiotic stress suggested during the survey by many experts from different countries.

Definition of a final key set of descriptors for pearl millet

The approved document, including all the contributors (see Annex XI), was proofread by an external editor and sent to the Bioversity Publications Unit for layout and on-line publication. The publication was later shared with the European Cooperative Programme for Plant Genetic Resources (ECPGR) Secretariat; the Generation Challenge Programme (GCP) Ontology and the SGRP Crop Genebank Knowledge Base partners. Additionally, data were converted into Excel files for uploading into the GRIN-Global genebank data-management system being developed by USDA, and subsequently into the global accession level information portal (GENESYS), linking national, regional and international genebank databases in support of the conservation and use of plant genetic resources for food and agriculture (PGRFA). The Excel files were also provided to the CGIAR System-wide Information Network for Genetic Resources (SINGER) and to EURISCO.

Acknowledgement

Bioversity is grateful to all the scientists and researchers who have contributed to the development of the strategic set of 'Key access and utilization descriptors for pearl millet genetic resources', and to the Global Crop Diversity Trust for their financial support. Particular recognition goes to the Crop Leaders, Dr I.S. Khairwal (AICRP-Pearl Millet), Dr Prem Mathur (Bioversity International) and Dr Hari D. Upadhyaya (ICRISAT) for providing valuable scientific direction. Ms Adriana Alercia provided technical expertise and guided the entire production process.

Annex I - Summary comparison table weighing up important descriptors for pearl millet drawn from different sources[i] [ii]

Bioversity Descr. no.	Descriptor name	IBPGR/ ICRISAT 1993 (1)	UPOV, PPV & FRA, 2007 (2)	USDA (3)	EAS (4)	ICRISAT 2007 (data avail AR) AICPM too (5)	IITA collection- Bhattacharjee 2006 (6)	LONG (NBPGR) (7)	MIN (NBPGR) (8)
4.1.1	Plant height [cm]	*	*** excluding spike**	*		*	*	*	*
4.1.2	Stem diameter [mm]	*		*				*	
4.1.3	Early vigour	*						*	*
4.1.4	Tillering attitude	*						*	
4.1.5	Total number of tillers	*		*				*	
4.1.6	Number of productive tillers	*	*			*	*	*	*
4.1.7	Number of nodal tillers	*		*		*		*	
4.1.8	Plant aspect	*						*	
4.1.9	Lodging susceptibility	*						*	*
4.1.10	Green fodder yield potential	*		*		*			
4.2.1	Spike shape	*	*	*		*** panicle**		*	*
4.2.2	Spikelet shattering/threshing	*							
4.2.3	Bristle length	*		*		*		*	*
4.2.4	Days to 50% flowering	*		*** not 50%**		*	*	*	*
4.2.5	Sensitivity to photoperiod	*				*		*	*
4.2.6	Flowering range	*							
4.2.7	Synchrony of ear maturity	*				*** panicle**		*	*
4.2.8	Restoration response	*						*	

4.2.9	Ear exsertion type	*				*** panicle exsertion**	*** spike**	*	*
4.2.10	Ear exsertion distance [cm]	*							
4.3.1	Spike length [cm]	*	*	*		*** panicle**	*	*	*
4.3.2	Spike thickness [mm]	*	*	*		*** panicle**	*	*	*
4.3.3	Spike density	*	*			*** Spikelet**		*	*
4.4.1	Seed colour (change to grain)	*	*	*		*		*	*
4.4.2	Seed covering	*						*	
4.4.3	Seed shape	*	*	*		*		*	*
4.4.4	Seed weight per spike [g]	*							
4.4.5	1000 Seed weight [g]	*	*			*	*	*	*
4.4.6	Seed volume [cm^3]	*							
4.4.7	Endosperm texture	*				*		*	
4.4.8	Yellow endosperm (rename to colour of endosperm)	*				*		*	
New	Green fodder yield per plant [kg]							*	*
4.4.9	Yield potential (rename to seed Grain yield per plant in g)	*				*		*	*
6.1.1	Leaf length [cm]	*		*				*	*
6.1.2	Leaf width [mm]	*		*				*	*
6.1.3	Leaf attitude	*						*	
6.1.4	Leaf colour	*						*	
6.1.5	Sheath length [cm]	*						*	
6.1.6	Sheath pigmentation	*						*	
6.1.7	Blade pigmentation	*						*	
6.1.8	Sheath pubescence	*		*** 4th leaf**				*	

6.1.9	Senescence	*						*	
6.1.10	Separation [cm]	*							
6.1.11	Number of leaves (rename to nodes)	*						*	*
6.1.12	Stem internode length [cm]	*						*	*
6.1.13	Stalk juiciness	*				*** Sweet stalk**		*	
6.1.14	Juice quality	*							
6.1.15	Node pigmentation	*	*					*	
6.1.16	Internode pigmentation	*	*					*	
6.1.17	Node pubescence	*	*					*	
6.1.18	Internode pubescence	*						*	
6.2.1	Rachis diameter [mm]	*							
6.2.2	Rachis pubescence	*						*	
6.2.3	Rachis tip	*						*	
6.2.4	Involucre stalk length [mm]	*							
6.2.5	Number of fertile spikelets per involucres	*							
6.2.6	Bristle colour	*	*					*	
6.2.7	Bristle ornamentation	*						*	
6.2.8	Mono-aristation length	*							
6.2.9	Poly-aristation density	*						*	
6.2.10	Spikelet glume colour	*	*					*	*
6.2.11	Anther colour	*	*					*	*
6.2.12	Stigma pigmentation	*						*	
6.2.13	Florets per spikelet	*						*	

6.3.1	Seed apex shape	*							
6.3.2	Seed surface	*						*	
6.3.3	Protein content [% DW]	*				*		*	
6.3.4	Lysine content [% DW]	*						*	
6.3.5	Methionine content [% DW]	*						*	
6.3.6	Tryptophane content [% DW]	*						*	
7.1	Reaction to drought	*				**		*	*
7.2	Reaction to salinity	*				*		*	
8.1.1	Downy mildew (*Sderospora graminicola* (Sacc. Schroet.))	*				*		*	*
8.1.2	Rust (*Puccinia penniseti* Zimm.)	*				*		*	*
8.2.1	Ergot (*Claviceps fusiformis* Lov.)	*				*		*	
8.2.2	Smut (*Tolyposporium penicillariae* Bref.)	*				*		*	*
8.3.1	Witchweed (*Striga asiatica* (L.) O. Kuntze *Striga hermonthica* Benth.)	*			*			*	*
8.4.1	White grub (*Holotrichia* spp., *Apogonia* sp.)	*						*	
8.4.2	Wire worm (*Gonocephalum* spp.)	*						?	
8.4.3	Root aphid (*Stibaropus minor* Fabr.)	*							
8.5.1	Pearl millet shoot fly (*Atherigona approximata* Malloch)	*						*	
8.5.2	Pearl millet stem borer (*Coniesta (Acigona) ignefusalis* Hmps.)	*						*	
8.5.3	Spotted stem borer (*Chilo partellus* Swin.)	*						*	
8.5.4	Hairy caterpillars (*Amsacta* sp.)	*						*	
8.5.5	Locust (*Locusta migratoria migratorioides* L.)	*							

8.5.6	Grasshopper (*Hieroglyphus* sp. *Oedaleus senegalensis* Krauss)	*						*	
8.5.7	Desert locust (*Schistocerea gregaria* Forsk.)	*							
8.5.8	Corn leaf aphid (*Rhopalosiphum maidis* Fitch)	*							
8.5.9	Oriental armyworm (*Mythimna separata* Wlk.)	*						*	
8.5.10	African armyworm (*Spodoptera exempta* Wlk.)	*						*	
8.5.11	Fall armyworm (*Spodoptera frugiperda* J.E. Smith)	*						*	
8.5.12	Cutworm (*Agrotis* sp.)	*							
8.6.1	Head caterpillars (*Helicoverpa armigera* Hb. *Cryptoblabes midiella* Mill. *Eublemim* spp.)	*						*	
8.6.2	Pearl millet head caterpillars (*Heliocheilus* (*Raghuva) albipunctella*)	*						*	
8.6.3	Blister beeTles (*Mylabris pustulata* Thunb. *Psallydolytta* sp.)	*							
8.6.4	*Pachnoda* spp.	*							
8.6.5	Pearl millet midge (*Geromyia penniseti* Felt)	*						*	
8.6.6	Head bug (*Calocoris angustatus* Leth.)	*						*	
8.6.7	Cotton stainer (*Dysdercus* sp.)	*							
8.6.8	Thrips (*Haplothrips* sp. *Thrips* sp.)	*						*	
8.6.9	Scarabaeid beetle (*Rhinyptia infuscata* Burin.)	*							

[i] (1) 'Descriptors for Pearl Millet [*Pennisetum glaucum* (L.) r. Br.]' (IBPGR/ICRISAT 1993); (2) 'Guidelines for the conduct of tests for Distinctness, Uniformity and Stability. (Pearl millet (*Pennisetum glaucum* (L.) R. Br.))' (PPV & FRA, 2007); (3) 'Descriptors for PMILLET (USDA, ARS, GRIN)'; (4) Evaluation Award Scheme 2008 (EAS); (5) 'Pearl millet germplasm at ICRISAT genebank – status and impact' (ICRISAT, Vol. 3, Issue 1, 2007); (6) 'Establishment of a pearl millet [*Pennisetum glaucum* (L.) R. Br.] core collection based on geographical distribution and quantitative traits' (Euphytica (2007) 155:35–45); (7) Long list of traits identified during the crop-specific meeting at NBPGR (June 2009); (8) Minimum list of traits identified during the crop-specific meeting at NBPGR (June 2009).

[ii] Descriptors highlighted in yellow are those identified to be proposed in the online survey

Annex II – List of Experts identified to participate in the survey for the definition of a minimum set of descriptors for pearl millet

ROLE	*NAME*	*ORGANIZATION*	*COUNTRY*
Crop Leader	**Khairwal, I.S.**	**AICRP-Pearl Millet**	**India**
Crop Leader	**Mathur, Prem**	**Bioversity**	**India**
CAG	Bhattacharjee, Ranjana	IITA	Nigeria
CAG/NBPGR meeting June 2009	Gowda, Jayarame	AICRP on Small millets, UAS, GKVK, Bangalore	India
CAG	Gupta, Suresh	ICRISAT	India
CAG	Harrison-Dunn, Melanie	ARS/USDA	USA
CAG ontology workshop	Hash, C. Tom	ICRISAT	India
CAG/Core group EAS	Haussmann, Bettina I.G.	ICRISAT	Niger
CAG/Core group	Pacheco, Luis	UPOV	Brasil
CAG	Satyavathi, Tara C.	IARI, Genetics	India
CAG	Rai, K.N.	ICRISAT	India
CAG	Reddy, K.N.	ICRISAT	India
CAG/NBPGR meeting June 2009	Seetharam, A.	AICRP on Small millets, UAS, GKVK, Bangalore	India
CAG	Unnikrishnan, K.V.	IARI, Genetics	India
West Africa Community of Practice (CoP WAF) participant	Aminou, Ali	FUMA Gaskya	Niger
Pearl millet planning Workshop Oct-2002	Angarawai, Ignatius Ijantiku	Millet research- Lake Chad Research Institute	Nigeria
Intsormil team	Atokple, I. Inoussa	Savanna Agric. Res. Inst.	Ghana
Contact sent by Franca Neto, Jose	Bonamigo Luiz	Adriana Seed Company	Brazil
West Africa Community of Practice (CoP WAF) participant	Boye, Tahirou	ICRISAT	Niger
Core collection	Bramel, Paula J.	IITA	India
IRC contacts	Chopra, Kuldip Raj	Biostadt MHseeds Ltd	India
IRC contacts	Franca Neto, José	EMBRAPA	Brazil
(INTSORMIL CRSP)	Gebeyehu, Geremew	Nazret Research Center	Ethiopia
Pearl millet breeder	Gonda, Jada	INRAN	Niger
IRC contacts	Gopal, B.	Zuari Seeds Ltd	India
IRC contacts	Gupta, Suresh	Advantaindia Seed Company	India
IRC contacts	Jyalekha, A.K.	Bayer Bioscience/Proagro Seeds	India
IRC contacts	Katrien, Devos	UGA	USA
Reviewer	Kumar, Ashok	NBPGR	India

Collection and evaluation of pearl millet (*Pennisetum glaucum*) germplasm from the arid regions of Tunisia (2008)	Loumerem, M.	Institut des Régions Arides	Tunisia
IRC contacts	Mahala, R.S.	Pioneer Overseas	India
Reviewer	Mishra	NBPGR	India
IRC contacts	Naik, Sunil	Emergent Genetics	India
	Nouri, Maman	INRAN	Niger
	Ousseini, Boubacar	Farmer representative	Niger
IRC contacts	Pareek, Satish	Pioneer Overseas	India
IRC contacts	Parzies, Heiko	Univ. of Hohenheim	Germany
West Africa Community of Practice (CoP WAF) participant	Rattunde, Fred	ICRISAT	Mali
SINGER Survey (Genebank data manager)	Reddy, M. Thimma	ICRISAT	India
IRC contacts	Sankar	Kaveri Seed Co	India
(INTSORMIL CRSP)	Sanogo, Moussa Daouda	CRRA de Niono, Programme Mil	Mali
Suggested by H. Knüpffer	Schmidt, Baerbel	IPK-Genebank Dept	Germany
IRC contacts	Shelke, G.V.	Ankur Seeds	India
	Singh, B.B.	IARI, Genetics	India
West Africa Community of Practice (CoP WAF) participant	Souley, Soumana	INRAN	Niger
Pearl millet breeder	Sy, Ousmane	Institut Sénégalais de Recherches Agricoles (ISRA)	Senegal
Intsormil team	Taonda, S.J. Baptiste	INERA	Burkina Faso
IRC contacts	Thakur, Ram	ICRISAT	India
ICRISAT	Upadhyaya, Hari D.	ICRISAT	India
Collection and evaluation of pearl millet (*Pennisetum glaucum*) germplasm from the arid regions of Tunisia (2008)	Van Damme, P.	UGent-FBSE	Belgium
	Verma, V.D.	NBPGR Regional Station, Phagli, Shimla	India
IRC contacts	Warathe, Shailendra	Syngenta India	India
IRC contacts	Wilson, Jeff	USDA, GA	USA
IRC contacts	Xinzhi, Ni	USDA, GA	USA

Annex III – Initial minimum key set of characterization and evaluation descriptors for pearl millet identified during the crop-specific meeting held at NBPGR in June 2009

Plant height [cm] (4.1.1)
Early vigour (4.1.3)
Number of productive tillers (4.1.6)
Lodging susceptibility (4.1.9)
Green fodder yield per plant [kg] (4.1.10)
Spike shape (4.2.1)
Bristle length (4.2.3)
Days to 50% flowering (4.2.4)
Sensitivity to photoperiod (4.2.5)
Synchrony of ear maturity (4.2.7)
Ear exsertion type (4.2.9)
Spike length [cm] (4.3.1)
Spike thickness [mm] (4.3.2)
Spike density (4.3.3)
Grain colour (4.4.1)
Seed shape (4.4.3)
1000-seed weight [g] (4.4.5)
Seed grain yield per plant [g] (4.4.9)
Leaf length [cm] (6.1.1)
Leaf width [mm] (6.1.2)
Number of nodes (6.1.11)
Stem internode length [cm] (6.1.12)
Spikelet glume colour (6.2.10)
Anther colour (6.2.11)
Reaction to drought (7.1)
Downy mildew (*Sderospora graminicola*) (8.1.1)
Rust (*Puccinia penniseti*) (8.1.2)
Smut (*Tolyposporium penicillariae*) (8.2.2)
Witchweed (*Striga asiatica; Striga hermonthica*) (8.3.1)

Annex IV – Survey to choose a key set of descriptors for pearl millet utilization

WELCOME

Welcome to the survey for the selection of a key set of characterization and evaluation descriptors for pearl millet to support an international information system to enhance the utilization of germplasm held in genebanks.

Your knowledge and experience are being sought to define an initial ‘**key set**’ of descriptors that identify traits important to crop production and facilitate the use of accessions by researchers.

Your participation in it is highly appreciated. The deadline for this survey is
28 July 2009.

This key set of descriptors will be made available through a global portal for identifying sets of accessions for evaluation and use. For characterization, the aim is a key set of maximally differentiating traits that provide the most impact in discriminating between accessions. For evaluation, the aim is to focus on a few important traits for production, such as those related to abiotic or biotic stresses of cosmopolitan nature.

By selecting descriptors as **'very important'**, you are helping us define the key set that will be instrumental for assisting researchers to more easily utilize Pearl millet accessions.

This survey consists of two parts:

- PART I: Characterization descriptors

- PART II: Evaluation descriptors

We thank you in advance for investing your time and expertise in selecting the set of descriptors.

***Please allow us to acknowledge your contribution by completing your full contact details below:**

Name:	
Position:	
Organization:	
Country:	
Email:	

PART I: Characterization descriptors

These traits enable easy and quick discrimination between phenotypes. They are generally highly heritable, can be easily seen by the eye and are equally expressed in all environments.

Based on your experience, please select descriptors that provide the most impact in discriminating between accessions. It also allows you to indicate if any essential descriptor that can contribute to its use is missing from the minimum list presented.

*Numbers in parentheses on the right-hand side are the corresponding descriptors numbers as published in the IBPGR/ICRISAT publication 'Descriptors for Pearl millet [*Pennisetum glaucum* (L.) R. Br.]' (1993).

	Not important	Important	Very important
Plant height [cm] (4.1.1)	◉	○	○
Early vigour (4.1.3)	○	○	○
Number of productive tillers (4.1.6)	○	○	○
Lodging susceptibility (4.1.9)	○	○	○
Green fodder yield per plant [kg] (4.1.10)	○	○	○
Spike shape (4.2.1)	○	○	○
Bristle length (4.2.3)	○	○	○
Days to 50% flowering (4.2.4)	○	○	○
Sensitivity to photoperiod (4.2.5)	○	○	○
Synchrony of ear maturity (4.2.7)	○	○	○
Ear exsertion type (4.2.9)	○	○	○
Spike length [cm] (4.3.1)	○	○	○
Spike thickness [mm] (4.3.2)	○	○	○
Spike density (4.3.3)	○	○	○
Grain colour (4.4.1)	○	○	○
Seed shape (4.4.3)	○	○	○
1000-seed weight [g] (4.4.5)	○	○	○
Seed grain yield per plant [g] (4.4.9)	○	○	○

If you consider that an essential trait is missing from this list, please indicate it here along with a substantiated justification.

PART II: Evaluation descriptors

These descriptors include characters such as biotic and abiotic stresses. They are the most interesting traits in crop improvement. Please consider the following factors relating to the trait when making your final decision: (i) Global impact, (ii) Initial strategic set, (iii) Importance for germplasm utilization, (iv) Data availability, (v) True economic damage and (vi) Wide geographical occurrence.

Please, rate these traits in order of importance at the global level. It also allows you to indicate if any essential trait for production is missing from the minimum list presented or indicate any that may not be very significant to global production.

	Not Important	Important	Very important
Leaf length [cm] (6.1.1)	○	○	○
Leaf width [mm] (6.1.2)	○	○	○
Number of nodes (6.1.11)	○	○	○
Stem internode length [cm] (6.1.12)	○	○	○
Spikelet glume colour (6.2.10)	○	○	○
Anther colour (6.2.11)	○	○	○
Reaction to drought (7.1)	○	○	○
Downy mildew (*Sderospora graminicola*) (8.1.1)	○	○	○
Rust (*Puccinia penniseti*) (8.1.2)	○	○	○
Smut (*Tolyposporium penicillariae*) (8.2.2)	○	○	○
Witchweed (*Striga asiatica*; *Striga hermonthica*) (8.3.1)	○	○	○

If you consider that an essential trait important for crop improvement and production is missing from the list above, please indicate it here along with a substantiated justification.

NOTE: Please remember, this list is the starting point and will grow over time, as required.

THANK YOU VERY MUCH FOR YOUR PARTICIPATION.

Annex V – Survey respondents

Role	*Name*	*Organization*	*Country*
Crop Leader	**Khairwal, I.S.**	AICRP-Pearl Millet	India
Crop Leader	**Mathur, Prem**	Bioversity	India
Crop Leader	**Upadhyaya, Hari D.**	ICRISAT	India
CAG	Gupta, S.K.	ICRISAT	India
CAG	Harrison-Dunn, Melanie	USDA, NPGS	USA
CAG	Hash, C. Tom	ICRISAT	India
CAG	Haussmann, Bettina I.G.	ICRISAT	Niger
CAG	Pacheco, Luís Gustavo Asp	Ministry of Agriculture	Brazil
CAG	Rai, K.N.	ICRISAT	India
CAG	Reddy, Narismha K.	ICRISAT	India
CAG	Seetharam, A.	Indian Council of Agricultural Research (ICAR)	India
CAG	Tara Satyavathi, C.	Indian Agricultural Research Institute	India
Reviewer	Asfaw Adugna	EIAR	Ethiopia
Reviewer	Gopal, B.	Zuari Seeds Limited	India
Reviewer	Jayalekha, A.K.	Bayer Bioscience Pvt Ltd	India
Reviewer	Lohwasser, Ulrike	Leibniz Institute of Plant Genetics and Crop Plant Research	Germany
Reviewer	Loumerem, Mohamed	Institut des Régions Arides-Tunisia	Tunisia
Reviewer	Mare, Marco	Crop Breeding Institute (C.B.I.)	Zimbabwe
Reviewer	Ni, Xinzhi	USDA-ARS	USA
Reviewer	Parzies, Heiko K.	University of Hohenheim, Inst. of Plant Breeding	Germany
Reviewer	Reddy, M. Thimma	ICRISAT	India
Reviewer	Sy, Ousmane	ISRA (Institut sénégalais de recherches agricoles)	Senegal
Reviewer	Thakur, R.P.	ICRISAT	India
Reviewer	Warathe, Shailendra	Syngenta India Ltd.	India
Reviewer	Wilson, Jeffrey P.	USDA-ARS	USA

Annex VI – Survey results ranked by rating average and percentage of importance

Descriptor	Rating Average
Characterization	
Days to 50% flowering (4.2.4)	4.62
Spike length [cm] (4.3.1)	4.50
Grain colour (4.4.1)	4.33
Plant height [cm] (4.1.1)	4.24
1000-seed weight [g] (4.4.5)	4.19
Spike thickness [mm] (4.3.2)	4.06
Spike density (4.3.3)	4.00
Number of productive tillers (4.1.6)	3.90
Seed grain yield per plant [g] (4.4.9)	3.81
Green fodder yield per plant [kg] (4.1.10)	3.38
Spike shape (4.2.1)	3.37
Ear exsertion type (4.2.9)	3.32
Sensitivity to photoperiod (4.2.5)	3.20
Seed shape (4.4.3)	3.06
Lodging susceptibility (4.1.9)	2.80
Bristle length (4.2.3)	2.68
Synchrony of ear maturity (4.2.7)	2.60
Early vigour (4.1.3)	2.47
Evaluation	
Downy mildew (*Sderospora graminicola*) (8.1.1)	4.35
Reaction to drought (7.1)	3.68
Rust (*Puccinia penniseti*) (8.1.2)	3.45
Smut (*Tolyposporium penicillariae*) (8.2.2)	3.40
Witchweed (*Striga asiatica*; *Striga hermonthica*) (8.3.1)	3.25
Leaf length [cm] (6.1.1)	2.21
Leaf width [mm] (6.1.2)	2.21
Anther colour (6.2.11)	2.21
Number of nodes (6.1.11)	2.16
Stem internode length [cm] (6.1.12)	1.94
Spikelet glume colour (6.2.10)	1.89

Descriptor	% Importance (important)	% Importance (very important)
Characterization		
Days to 50% flowering (4.2.4)	19.0% (4)	81.0% (17)
Spike length [cm] (4.3.1)	25.0% (5)	75.0% (15)
Grain colour (4.4.1)	33.3% (7)	66.7% (14)
1000-seed weight [g] (4.4.5)	28.6% (6)	66.7% (14)
Plant height [cm] (4.1.1)	38.1% (8)	61.9% (13)
Seed grain yield per plant [g] (4.4.9)	23.8% (5)	61.9% (13)
Spike thickness [mm] (4.3.2)	33.3% (6)	61.1% (11)
Number of productive tillers (4.1.6)	30.0% (6)	60.0% (12)
Spike density (4.3.3)	36.8% (7)	57.9% (11)
Green fodder yield per plant [kg] (4.1.10)	33.3% (7)	47.6% (10)
Spike shape (4.2.1)	42.1% (8)	42.1% (8)
Sensitivity to photoperiod (4.2.5)	40.0% (8)	40.0% (8)
Lodging susceptibility (4.1.9)	35.0% (7)	35.0% (7)
Ear exsertion type (4.2.9)	57.9% (11)	31.6% (6)
Seed shape (4.4.3)	55.6% (10)	27.8% (5)
Synchrony of ear maturity (4.2.7)	45.0% (9)	25.0% (5)
Early vigour (4.1.3)	47.4% (9)	21.1% (4)
Bristle length (4.2.3)	63.2% (12)	15.8% (3)
Evaluation		
Downy mildew (*Sderospora graminicola*) (8.1.1)	20.0% (4)	75.0% (15)
Reaction to drought (7.1)	26.3% (5)	57.9% (11)
Smut (*Tolyposporium penicillariae*) (8.2.2)	55.0% (11)	35.0% (7)
Witchweed (*Striga asiatica*; *Striga hermonthica*) (8.3.1)	50.0% (10)	35.0% (7)
Anther colour (6.2.11)	21.1% (4)	31.6% (6)
Rust (*Puccinia penniseti*) (8.1.2)	65.0% (13)	30.0% (6)
Stem internode length [cm] (6.1.12)	27.8% (5)	22.2% (4)
Number of nodes (6.1.11)	36.8% (7)	21.1% (4)
Leaf length [cm] (6.1.1)	47.4% (9)	15.8% (3)
Leaf width [mm] (6.1.2)	47.4% (9)	15.8% (3)
Spikelet glume colour (6.2.10)	36.8% (7)`	15.8% (3)

Annex VII – Additional descriptors and comments proposed in the open-ended section of the survey

Additional descriptors	Name of expert															
	N. times proposed	M. Harrison-Dunne	B. Gopal	M. Loumerem	A. Adugna	B. Haussmann	R.P. Thakur	S.K. Gupta; K.N. Rai	O. Sy	A.K. Jayalekha	C.T. Hash	J. Wilson	H.K. Parzies	L.G. Pacheco	A. Seetharam	H.D. Upadhyaya
Characterization traits																
Pigmentation on leaf/node which may sometimes indicate a seedling marker to identify the accession at seedling stage.	**3**		**X**	X Node pigmentation (6.1.15) I think there is correlation between node pigmentation and juice quality						**X**						
Bristle colour (6.2.6)	**1**			**X**												
Days to 100% flowering it is better than flowering range (4.2.6) is needed by plant breeder.	**1**			**X**												
Seed covering (4.4.2).	**1**			**X**												
The grain volumetric weight (g/cm³) is an important trait for African farmers who sell the grain in volume units (and not kg units). A high volumetric weight is appreciated, as this will also yield more flour.	**1**					**X**										

Instead of green fodder yield (which would be a destructive measure) I would prefer dry stover weight (g/m²) as indicator of fodder plant types.	2					X					X Dry fodder yield is more important than green fodder yield, and is not that much more complicated to assess- requiring in addition only fresh and oven-dry weights of a subsample to determine the dry matter fraction of the green fodder					
Spike tip sterility: Absent, Present	2							X								
Spike bristle: Absent, Present	2							X								
Node pubescence	1									X						
Agronomical appreciation (farmers and technicians)	2					X A general agronomic or farmer preference score, possibly given by farmers (separately for women and men) during a participatory evaluation.			X							

Endosperm texture: Texture of endosperm visually scored on a 1-9 scale. 1 = Highly corneous and 9 = Highly starchy.	**3**							X High starch: nowadays distilleries and brewers are looking for such traits in millet					**X**			
Number of nodal tillers (4.1.7)	**1**												**X**			
Total number of tillers (4.1.5) Strongly related to the fodder yield	**1**															**X**
Evaluation traits																
Reaction to blast as it is emerging as an important biotic stress in certain parts of India.	**6**	**X**	**X**				X Blast/Leaf spot (*Pyricularia grisea*)- damages foliage	X Reaction to Blast: Increased incidence of this disease in India, the major cultivator of pearl millet				**X**				
High Iron and Zinc: much sought after trait to check nutrient malnutrition in rural households	**2**							**X**								

Susceptibility to chinch bugs has been a problem for me in the southeastern United States when regenerating material for germplasm increase. The chinch bugs produce severe damage greatly affecting crop yield. Because of geographical limitation of this problem at present, it most likely does not warrant inclusion on this list. However, I wanted to bring this problem to your attention in the case chinch bugs become problematic in other countries/areas in the future.	**1**	**X**														
Leaf colour (6.1.4)	**1**			**X**												
Presence or absence of awn is important	**1**				**X**											
Adaptation to low soil fertility (eg low-P soils in West Africa)	**1**					**X**										
Responsiveness to fertilizer application are further traits of high interest to farmers	**1**					**X**										
Stemborer resistance is very important, e.g. in Nigeria	**1**					**X**										
Headminer resistance can be very important, depending on the region of interest	**1**					**X**										
Reaction to head caterpillar (8.6.1)	**1**															**X**
Susceptibility to flower-damaging insects (e.g. *cantarides*) can be very important, depending on the	**1**					**X**										

region of interest																
Rust (*Puccinia substriata* var. *indica)*	**1**						**X**									
Smut (*Moesziomyces penicillariae*)	**1**						**X**									
Stay green trait after maturity: important trait to identify forage type genotypes under moisture stress conditions	**2**							**X**								
Reaction to salinity tolerance: very important trait as the soils of central Asia are saline and pearl millet is finding niche area there	**3**							**X**								X Reaction to salinity
Seedling: leaf sheath: anthocyanin coloration of base	**1**													**X**		
Leaf sheath: pubescence	**1**													**X**		
Culm: anthocyanin coloration of internode	**1**													**X**		
Culm: diameter	**1**													**X**		
Glume: anthocyanin coloration (excluding tips)	**1**													**X**		
Ergot is an important disease of pearl millet in some areas	**3**						X Ergot (*Claviceps fusiformis*)- infects panicles, replaces grains with sclerotia and produces mycotoxins-								**X**	X Ergot (*Claviceps fusiformis* Loveless) (8.2.1). Occurs widely

Shoot fly is the only major pest of pearl millet in tropics	**1**														**X**	
Grain quality descriptors such as seed oil content might be useful	**1**														**X**	
Protein content [% DW] (6.3.3)	**2**														X (Grain quality descriptors such as protein content might be useful)	X Seed protein content (%)
COMMENTS																
Reaction to drought is too general - what type of drought do we mean here?						**X**										
Number of leaves ((6.1.11) not number of nodes - mistake)				**X**												

Annex VIII – Summary results sent to the Crop Leaders and CAG for validation

Descriptor	Rating Average	Your selection
Characterization		
Days to 50% flowering (4.2.4)	**4.62**	
Spike length [cm] (4.3.1)	**4.50**	
Grain colour (4.4.1)	**4.33**	
Plant height [cm] (4.1.1)	**4.24**	
1000-seed weight [g] (4.4.5)	**4.19**	
Spike thickness [mm] (4.3.2)	**4.06**	
Spike density (4.3.3)	**4.00**	
Number of productive tillers (4.1.6)	**3.90**	
Seed grain yield per plant [g OR g/cm3?] (4.4.9)	**3.81**	
DRY fodder yield per plant [kg] (4.1.10)	3.38	
Spike shape (4.2.1)	3.37	
Ear exsertion type (4.2.9)	3.32	
Sensitivity to photoperiod (4.2.5)	3.20	
Seed shape (4.4.3)	3.06	
Lodging susceptibility (4.1.9)	2.80	
Bristle length (4.2.3)	2.68	
Synchrony of ear maturity (4.2.7)	2.60	
Early vigour (4.1.3)	2.47	
Evaluation		
Downy mildew (*Sderospora graminicola*) (8.1.1)	**4.35**	
Reaction to drought (7.1)	**3.68**	
Rust (*Puccinia penniseti*) (8.1.2)	**3.45**	
Smut (*Tolyposporium penicillariae*) (8.2.2)	3.40	
Witchweed (*Striga asiatica*; *Striga hermonthica*) (8.3.1)	3.25	
Leaf length [cm] (6.1.1)	2.21	
Leaf width [mm] (6.1.2)	2.21	
Anther colour (6.2.11)	2.21	
Number of nodes (6.1.11)	2.16	
Stem internode length [cm] (6.1.12)	1.94	
Spikelet glume colour (6.2.10)	1.89	

Annex IX – Replies received from Crop Leaders and CAG on the survey results

Pearl millet descriptor	Name of Expert								
	Rating Average	I.S. Khairwal	B. Haussmann	T.C. Satyavathi	C.T. Hash	A. Seetharam	M. Harrison Dunn	H.D. Upadhyaya	P. Mathur
Characterization									
Days to 50% flowering (4.2.4)	4.62	X	X	X	X	X		X	X
Spike length [cm] (4.3.1)	4.50	X	X	X	X	X		X	X
Grain colour (4.4.1)	4.33	X	X	X		X		X	X
Plant height [cm] (4.1.1)	4.24	X	X	X	X			X	X
1000-seed weight [g] (4.4.5)	4.19	X	X	X	X	X	X	X	X
Spike thickness [mm] (4.3.2)	4.06	X	X	X	X			X	X
Spike density (4.3.3)	4.00	X	X	X				X	X
Number of productive tillers (4.1.6)	3.90	X	X	X	X	X		X	X
Seed grain yield per plant [g] (4.4.9)	3.81	X	X	X	X	X		X	X
Green fodder yield per plant [kg] (4.1.10)	3.38	X	X	X	X	X		X	X
Spike shape (4.2.1)	3.37	X							
Ear exsertion type (4.2.9)	3.32	X							
Sensitivity to photoperiod (4.2.5)	3.20	X			X		X		
Seed shape (4.4.3)	3.06	X							
Lodging susceptibility (4.1.9)	2.80	X							
Bristle length (4.2.3)	2.68	X			X				
Synchrony of ear maturity (4.2.7)	2.60	X							
Early vigour (4.1.3)	2.47	X							
Evaluation									
Downy mildew (*Sderospora graminicola*) (8.1.1)	4.35	X	X	X	X	X		X	X
Reaction to drought (7.1)	3.68			X	X		X	X	
Rust (*Puccinia penniseti*) (8.1.2)	3.45			X	X				
Smut (*Tolyposporium penicillariae*) (8.2.2)	3.40				X		X	X	

Witchweed (*Striga asiatica*; *Striga hermonthica*) (8.3.1)	3.25						X		
Leaf length [cm] (6.1.1)	2.21								
Leaf width [mm] (6.1.2)	2.21								
Anther colour (6.2.11)	2.21								
Number of nodes (6.1.11)	2.16								
Stem internode length [cm] (6.1.12)	1.94								
Spikelet glume colour (6.2.10)	1.89								
Additional traits									
Blast		X		X	X		X		
Ergot				X					

NB. Descriptors highlighted in yellow are those that received a wide consensus amongst experts (according to rating averages and feedback received from CAG) and were submitted to the Crop Leaders.

Annex X – Draft of the key access and utilization descriptors for pearl millet sent to the Crop Leaders for final validation

PLANT DATA

Plant height [cm] (4.1.1)
From the ground level to the tip of the spike. At dough stage

Number of productive tillers (4.1.6)
Number of spikes which bear seed at dough stage. Spikes younger than the dough stage are not counted

Green fodder yield per plant [kg] (4.1.10)
At flowering

Days to 50% flowering (4.2.4)
Number of days from field emergence to when 50% of plants flower. Stigma emergence on the main spike is considered as flowering

Spike length [cm] (4.3.1)
At dough stage

Spike thickness [mm] (4.3.2)
Maximum diameter of the spike, excluding bristles. At dough stage

Spike density (4.3.3)
At maturity

3 Loose
5 Intermediate
7 Compact

Grain colour (4.4.1)
After threshing. Royal Horticultural Society (RHS) colour codes are given in parentheses beside descriptor states

1 Ivory (yellow-white group 158A)
2 Cream (orange-white group 159A)
3 Yellow (yellow group 8C)
4 Grey (grey group 201)
5 Deep grey (black group 202B)
6 Grey brown (brown group 199)
7 Brown (brown group 200)
8 Purple (purple group 79B)
9 Purplish black
10 A mixture of white and grey grains (on the same spike)

1000-seed weight [g] (4.4.5)
At 12% moisture content

Grain yield per plant [g] (4.4.9)

ABIOTIC STRESSES

Reaction to drought (7.1)

BIOTIC STRESSES

Downy mildew (*Sclerospora graminicola*) (8.1.1)

Blast (*Pyricularia grisea*) (8.1.X)

Annex XI – Final key set for characterization and evaluation of pearl millet genetic resources including descriptor states and contributors

Key access and utilization descriptors for pearl millet genetic resources

This list consists of an initial set of characterization and evaluation descriptors for pearl millet genetic resources utilization. This strategic set of descriptors, together with passport data, will become the basis for the global accession level information portal being developed by Bioversity International with the financial support of the Global Crop Diversity Trust (the Trust). It will facilitate access to and utilization of pearl millet accessions held in genebanks and does not preclude the addition of further descriptors, should data subsequently become available.

Based on the comprehensive list 'Descriptors for Pearl millet [*Pennisetum glaucum* (L.) R. Br.]' published by ICRISAT and IBPGR (now Bioversity International) in 1993, the list was subsequently compared with a number of sources such as 'Descriptors for PMILLET' (USDA, ARS, GRIN), 'Establishment of a pearl millet [*Pennisetum glaucum* (L.) R. Br.] core collection based on geographical distribution and quantitative traits' (Euphytica (2007) 155:35–45), 'Pearl millet germplasm at ICRISAT genebank – status and impact' (ICRISAT, Vol. 3, Issue 1., 2007), 'Guidelines for the Conduct of Test for Distinctness, Uniformity and Stability on Pearl millet (*Pennisetum glaucum* (L.) R. Br.)' (PPV & FRA, 2007), as well as with those descriptors that were awarded funds for further research by the Global Crop Diversity Trust in 2008 Evaluation Award Scheme (EAS). The initial list was further refined during a crop-specific consultation meeting held at the National Bureau of Plant Genetic Resources (NBPGR, India) in June 2009. It involved several scientists from the National Bureau of Plant Genetic Resources (NBPGR), Indian Agricultural Research Institute (IARI) and All India Coordinated Research Project on Pearl Millet (AICRP-Pearl Millet).

A worldwide distribution of experts was involved in an online survey to define a first priority set of descriptors to describe, to access and to utilize pearl millet genetic resources. This key set was afterwards validated by a Core Advisory Group (see 'Contributors') led by Dr Prem Mathur of Bioversity International, Dr I. S. Khairwal, Project Coordinator, AICRP-Pearl Millet and Dr Hari D. Upadhyaya of International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

Biotic and abiotic stresses included in the list were chosen because of their wide geographic occurrence and significant economic impact at a global level.

Numbers in parentheses on the right-hand side are the corresponding descriptor numbers listed in the 1993 publication. Descriptors with numbers ending in 'letters' are either modified or new descriptors that were added during the development of the list below.

PLANT DATA

Plant height [cm] (4.1.1)

From the ground level to the tip of the spike. At dough stage

Number of productive tillers (4.1.6)

Number of spikes which bear seed at dough stage. Spikes younger than the dough stage are not counted

Green fodder yield per plant [kg] (4.1.10)

At flowering

Days to 50% flowering (4.2.4)

Number of days from field emergence to when 50% of plants flower. Stigma emergence on the main spike is considered as flowering

Spike length [cm] (4.3.1)

At dough stage

Spike thickness [mm] (4.3.2)

Maximum diameter of the spike, excluding bristles. At dough stage

Spike density (4.3.3)

At maturity

3 Loose
5 Intermediate
7 Compact

Grain colour (4.4.1)

After threshing. Royal Horticultural Society (RHS) colour codes are given in parentheses beside descriptor states

1 Ivory (yellow-white group 158A)
2 Cream (orange-white group 159A)
3 Yellow (yellow group 8C)
4 Grey (grey group 201)
5 Deep grey (black group 202B)
6 Grey brown (brown group 199)
7 Brown (brown group 200)
8 Purple (purple group 79B)
9 Purplish black
10 A mixture of white and grey grains (on the same spike)

1000-seed weight [g] (4.4.5)

At 12% moisture content

Grain yield per plant [g] (4.4.9)

ABIOTIC STRESSES

Reaction to drought (7.1)

BIOTIC STRESSES

Downy mildew (*Sclerospora graminicola*) (8.1.1)

Blast (*Pyricularia grisea*) (8.1.X)

CONTRIBUTORS

Bioversity is grateful to all the scientists and researchers who have contributed to the development of this strategic set of 'Key access and utilization descriptors for pearl millet genetic resources', and in particular to Dr I.S. Khairwal (AICRP-Pearl Millet), Dr Prem Mathur (Bioversity International) and Dr Hari D. Upadhyaya (ICRISAT) for providing valuable scientific direction. Adriana Alercia provided technical expertise and guided the entire production process.

CORE ADVISORY GROUP

Prem Mathur, Bioversity International, India
I.S. Khairwal, All India Coordinated Research Project on Pearl Millet (AICRP-Pearl Millet), India
Hari D. Upadhyaya, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India
S.K. Gupta, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India
Melanie Harrison-Dunn, United States Department of Agriculture, National Plant Germplasm System (USDA, NPGS), USA
Tom C. Hash, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India
Bettina I.G. Haussmann, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Niger
Luís Gustavo Asp Pacheco, Ministry of Agriculture, Brazil
K.N. Rai, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India
K. Narismha Reddy, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India
A. Seetharam, Ex-Project Coordinator, All India Coordinated Research Project on Small Millets, India
C. Tara Satyavathi, Indian Agricultural Research Institute (IARI), India

REVIEWERS

Ethiopia
Asfaw Adugna, Ethiopian Institute of Agricultural Research (EIAR)

Germany
Ulrike Lohwasser, Leibniz Institute of Plant Genetics and Crop Plant Research
Heiko K. Parzies, University of Hohenheim, Institute of Plant Breeding

India
B. Gopal, Zuari Seeds Limited
A.K. Jayalekha, Bayer Bioscience Pvt. Ltd.
M. Thimma Reddy, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
R.P. Thakur, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
Shailendra Warathe, Syngenta India Ltd.

Senegal
Ousmane Sy, Institut Sénégalais de Recherches Agricoles (ISRA)

Tunisia
Mohamed Loumerem, Institut des Régions Arides

USA
Xinzhi Ni, United States Department of Agriculture, Agricultural Research Service (USDA-ARS)
Jeffrey P. Wilson, United States Department of Agriculture, Agricultural Research Service (USDA-ARS)

Zimbabwe
Marco Mare, Crop Breeding Institute (CBI)

Methodology for the definition of a key set of characterization and evaluation descriptors for pigeonpea [*Cajanus cajan* (L.) Millsp.]

Information collection and preparation of the Minimum Descriptor List (MDL)

Information for the definition of a Minimum Descriptor List for pigeonpea was drawn from the publication 'Descriptors for Pigeonpea [*Cajanus cajan* (L.) Millsp.]' published by IBPGR (now Bioversity International) and ICRISAT in 1993. A table was prepared comparing the descriptors listed in the above publication to important traits mentioned in the 'Development of a Strategy for the Global Conservation of Pigeonpea Genetic Resources' (August 2006) and to those used in ICRISAT to identify accessions. Furthermore, these were weighed against Descriptors for PIGEON-PEA (USDA, ARS, GRIN) and important traits resulting from the SGRP GPG2 exercise. The list was further discussed and refined during a crop-specific consultation meeting held in India in June 2009, at the National Bureau of Plant Genetic Resources (NBPGR). The consultation, which involved several experts from NBPGR and the Indian Agricultural Research Institute (IARI), chaired by Adriana Alercia, resulted in the definition of a preliminary key set of descriptors for pigeonpea to be included in the survey for review (see Annex I). The long list of descriptors was also revised during the consultation meeting.

Preparation of the List of Experts

The List of Experts was prepared including experts drawn from the list of participants in the crop-specific consultations for the definition of the 'Development of a Strategy for the Global Conservation of Pigeonpea Genetic Resources' (August 2006). It was then integrated with the names of experts found in pigeonpea websites such as the NBPGR website, FAO WIEWS and the Purdue University website. An internet search was also performed to integrate this list and to obtain the greatest number of experts. The List of Experts was further refined during the crop-specific meeting held at NBPGR in June 2009.

Overall, 51 experts were identified, from 17 countries and 29 different organizations. Out of these, Dr Ram Prakash Dua (NBPGR, India) and Dr Hari D. Upadhyaya (International Crops Research Institute for the Semi-Arid Tropics-ICRISAT, India) were selected as Crop Leaders and a Core Advisory Group (CAG) consisting of 11 experts was identified to assist in the definition of a key set of descriptors. In order to reach a wider group of experts, ten organizations were added to the established list, inviting the relevant expert within the organization to participate (see Annex II).

Survey preparation and distribution

A draft survey of pigeonpea was prepared listing the descriptors as approved by consultations with the Core Advisory Group. Once the list was refined (see Annex III), during the meeting at NBPGR in June 2009, the final draft of the survey was uploaded into the SurveyMonkey application on the internet (see Annex IV). On 22 July 2009 an invitation email with the link to the survey was sent to the list of identified experts.

They were invited to validate this initial 'Minimum set of descriptors' of pigeonpea accessions to facilitate their use by researchers and asked to make suggestions regarding any characterization or evaluation descriptors that were found to be relevant yet missing from the proposed Minimum List. The survey deadline was set at 31 August 2009. A first reminder was sent out on the 31 July 2009, a second on the 27 August 2009 and a third one the same day of the deadline, to ensure that the greatest possible feedback was obtained.

Survey analysis and refinement of Minimum List

Of the 51 experts identified and involved in the exercise, 20 experts from 7 countries and 13 organizations recorded their comments using the online survey (see Annex V). Results from the survey were analyzed and descriptors were ranked by rating average and percentage of importance (see Annex VI). The summary results of the survey together with a report containing comments received by the participants (see Annex VII) were sent to the Core Advisory Group asking them to select the descriptors that should be included in the final list. Feedback received by the experts was harmonized and integrated to compile an initial list of important traits. A first draft of the key set for pigeonpea, containing the aforesaid descriptors, with relevant methods and states, references and the complete list of contributors, was submitted to the CAG for their approval (see Annex VIII). Due to the inconsistency of comments sent by experts regarding the descriptors 'Base colour of flower (4.2.5)', 'Pod colour (4.2.11)' and 'Protein content (6.2.1)', it became necessary to ask Crop Leaders to advice on the inclusion of these traits.

It was agreed to follow Dr Hari Upadhyaya's advice to keep in the key set the trait 'Protein content' as a large variation (13-31%) has been observed for this trait and pigeonpea, as a pulse crop, is being grown mainly for this purpose. It was also agreed to leave off the list the other two descriptors that have therefore been excluded. Dr Hari Upadhyaya also made us aware of the names of two experts who had given their contribution along with him.

Definition of a final key set of descriptors for pigeonpea

The final document approved by the Crop Leaders and the CAG including all the contributors (see Annex IX), was proofread by an external editor and sent to the Bioversity Publications Unit for layout and on-line publication processes. Furthermore, the publication was shared with the ECPGR Secretariat; the Generation Challenge Programme (GCP) Ontology and the SGRP Crop Genebank Knowledge Base partners. Additionally, data were converted into Excel files for uploading into the GRIN-Global genebank data-management system being developed by USDA, and subsequently into the global accession level information portal (GENESYS), linking national, regional and international genebank databases in support of the conservation and use of plant genetic resources for food and agriculture (PGRFA). The Excel files were also provided to the System-wide Information Network for Genetic Resources (SINGER) and to EURISCO.

Acknowledgement

Bioversity is grateful to all the scientists and researchers who have contributed to the development of the strategic set of 'Key access and utilization descriptors for pigeonpea genetic resources', and to the Global Crop Diversity Trust for their financial support. Particular recognition goes to the Crop Leaders, Dr Hari D. Upadhyaya from ICRISAT, India and Dr Ram Prakash Dua from NBPGR, India, for providing valuable scientific direction. Ms Adriana Alercia provided technical expertise and guided the entire production process.

Annex I – Comparison table for the definition of a minimum set of descriptors for pigeonpea drawn from different sources[i]

Desc. no.	Descriptor name	IBPGR/ ICRISAT (a)	GPG2 (b)	Strategy (c)	USDA /ARS (d)	ICRISAT Accession identifiers (e)	Long (NBPGR) (f)	Min (NBPGR) (f)
4.1.1	Growth habit	*			*	*	*	*
4.1.2	Plant height [cm]	*	*		*	*	*	*
4.1.3	Plant stand	*					Delete	
4.1.4	Number of branches	*					Delete	
4.1.4.1	Number of primary branches	*	*			*	*	*
4.1.4.2	Number of secondary branches	*	*			*	*	*
4.1.4.3	Number of tertiary branches	*	*			*	*	*
4.1.5	Stem colour	*			*		*	*
4.1.6	Stem thickness [mm]	*				*	*	
4.1.7	Leaf size [cm^2]	*				*	Delete	
4.1.8	Leaflet shape	*				*	*	*
4.1.9	Leaf hairiness (lower surface of the leaves)	*				*	*	*
4.2.1	Days to 50% flowering	*	*		*	*	*	*
4.2.2	Duration of flowering	*					Delete	
4.2.3	Early vigour	*				*	*	
4.2.4	Days to 75% maturity	*	*			*	*	*
4.2.5	Base colour of flower	*	*		*	* (flower colour)	*	*
4.2.6	Second flower colour	*					*	*
4.2.7	Pattern of streaks	*				*	*	*
4.2.8	Flowering pattern	*	*			*	*	*
4.2.9	Raceme number	*	*			*	*	
4.2.10	Seeds per pod	*	*		*	*	*	*
4.2.11	Pod colour	*				*	*	*
New	Pod stripes colour						*	*
4.2.12	Pod form	*				*	*	*
4.2.13	Pod hairiness	*	*			*	*	
4.2.14	Pod bearing length [cm]	*	*			*	*	*
4.3.1	Seed colour pattern	*				*	*	*
4.3.2	Base colour of seed	*	*			*	*	*
4.3.3	Seed secondary colour	*	*			*	*	
4.3.4	Seed eye colour	*				*	*	
4.3.5	Seed eye width	*				*	Delete	
4.3.6	Seed shape	*				*	*	
4.3.7	Hilum	*				*	*	
4.3.8	100-seed weight [g]	*	*			*	*	*
6.1	Seed yield per plant [g]	*	*			*	*	*
6.1.1	Harvest index	*	*			*	*	*
6.1.2	Shelling percentage [%]	*	*			*	*	*
6.2.1	Protein content [%]	*	*			*	*	*
6.2.2	Dhal milling [%]	*					*	
6.2.3	Cooking time	*					*	
6.2.4	Cookability of dry seeds	*					Delete	

7.1	Reaction to low temperature	*					*	
7.2	Reaction to high temperatures	*					*	
7.3	Reaction to drought	*					*	
7.4	Reaction to excess soil moisture	*					*	
7.5	Reaction to soil salinity	*	*				*	*
7.6	Reaction to soil acidity	*					*	
8.1.1	*Grapholita critica* (Leaf tier)	*					*	
8.1.2	*Megalurothrips usitatus* (Flower thrips)	*					*	
8.1.3	*Mylabris pustulata* (Flower beetle)	*					*	
8.1.4	*Indozocladius asperulus* (Bud weevil)	*					*	
8.1.5	*Clavigralla gibbosa; Nezara viridul; Anoplocnemis* spp. (Pod-sucking bug)	*					*	
8.1.6	*Helicoverpa armigera; Etiella zinckenella; Maruca testulalis* (Legume pod borer)	*	*	*			*	*
8.1.7	*Lampides boeticus* (L.); *Catochrysops strabo* (Blue butterfly)	*					*	
8.1.8	*Melanagromyza obtusa* (Mall.) (Podfly)	*	*	*			*	*
8.1.9	*Exelastis atomosa* (Wals.) (Plume moth)	*					*	
8.1.10	*Callosobruchus chinensis* (L.) (Bruchid)	*					*	*
8.1.11	*Otinotus oneratus* W. (Cow bugs)	*					*	
8.1.12	*Empoasca kerri* Pruthi (Jassids)	*					*	
8.1.13	*Tanaostigmodes caianinae* LaSalle (Pod wasp)	*	*				*	*
8.2.1	*Phytophthora drechsleri* f.sp. *caiani* (Phytophthora blight)	*				*	*	*
8.2.2	*Rhizoctonia bataticola*; *Macrophomina phaseolina* (Dry root rot)	*					*	
8.2.3	*Sclerotium rolfsii* Sacc. (Collar rot)	*					*	
8.2.4	*Alternaria alternata* (Alternaria blight)	*					*	
8.2.5	*Cercospora cajan; Mycovellosiella caiani* (Cercospora leaf spot)	*					*	
8.2.6	*Oidiopsis taurica*; *Leveillula taurica* (Powdery mildew)	*					*	
8.2.7	*Fusarium udum*, *F. oxysporum* f.sp. u*dum* *(*Wilt*)*	*	*	*		* (Wilt field) (wilt pot)	*	*
8.3.1	*Xanthomonas campestris* pv. *cajani* (Bacterial leaf spot and stem canker)	*					*	
8.4.1	Sterility mosaic virus (SMV)	*	*			*	*	*
8.4.2	Witches' broom (Mycoplasma)	*					*	
8.4.3	Yellow mosaic virus (YMV)	*					*	
8.5.1	*Heterodera cajani* Koshy (Cyst nematode)	*					*	

8.5.2	*Meloidogyne incognita* (Root knot nematode)	*					*	
8.5.3	*Rotylenchus reniformis* (Reniform nematode)	*					*	
	Pod length (cm)		*		*	*	*	*
	Pod number (Number of pods per plant)		*			*	*	*
	Plant width				*		Not required	

[i](a) ‘Descriptors for Pigeonpea [*Cajanus cajan* (L.) Millsp.]’ (IBPGR and ICRISAT, 1993);
(b) Important traits resulting from the GPG2 exercise;
(c) ‘Development of a Strategy for the Global Conservation of Pigeonpea Genetic Resources’ (August 2006);
(d) ‘Descriptors for PIGEON-PEA’ (USDA, ARS, GRIN);
(e) Traits used in ICRISAT to identify accessions;
(f) Long and Minimum List of descriptors identified by participants in the crop-specific meeting held at NBPGR in June 2009.

Annex II – List of experts identified to participate in the survey

ROLE	***NAME***	***ORGANIZATION***	***COUNTRY***
Crop Leader	**Upadhyaya, Hari D**.	ICRISAT	India
Crop Leader	**Dua, Ram Prakash**	NBPGR	India
CAG	Bharadwaj, C.	IARI	India
CAG	Debouk, Daniel	CIAT	Colombia
CAG	Gowda, M. Byre	University of Agricultural Sciences	India
CAG suggested by H. Knüpffer	Kotter, Matthias	IPK Genebank Dept. Leibniz Institute	Germany
CAG Crop Strategy	Lawrence, Peter	Australian Tropical Crops Genetic Resources	Australia
CAG	Lobo Burle, Marília	EMBRAPA	Brazil
CAG	Pieretti, Isabelle	CIRAD	France
CAG Ontology workshop	Rai, K.N.	ICRISAT	India
CAG	Raje, R.S.	IARI	India
CAG	Rao, Srinivas C.	ARS/USDA	USA
CAG	Saxena, K.	ICRISAT	India
Crop Strategy	Aung, Toe	Department of Agricultural Research – CARI	Myanmar
Purdue website	Bhardwaj, Harbans L.	Virginia State University	USA
Internet	Bing Bing (Engle)	Asian Vegetable Research and Development Center (AVRDC)	Taiwan
NBPGR website	Bisht, Ishwari Singh	NBPGR	India
WIEWS	Blartey, S.	Plant Genetic Resources Research Institute	Ghana
Purdue website	Ching, Alejandro	Northwest Missouri State University	USA
Crop Strategy	Dharmaraj, P.S.	Agricultural Research Station	India
Crop Strategy	Graner, Andreas	Leibniz Institute of Plant Genetics and Crop Plant Research (IPK)	Germany
Crop Strategy	Gupta, S.	ICAR	India
Crop Strategy	Kaloki, Peter	ICRISAT	Kenya
Internet	de Lima Nechet, Kátia	EMBRAPA	Brazil
Crop Strategy	Madhavi Latha, K.	(GT Crop improvement) ICRISAT	India
Crop Strategy	Majumder, N.D.	Indian Institute of Pulses Research (IIPR)	India

NBPGR website	Mishra, S.K.	NBPGR	India
Crop Strategy	Mligo, Joseph K.	Ilonga Agricultural Research Institute	Tanzania
Crop Strategy	Murthi, Anishetty N.	Retired Senior Officer - Seed & Plant Genetic Resources (FAO)	India
Crop Strategy	Nadarajan, N.	Department of Pulses - Center for Plant Breeding and Genetics	India
NBPGR (Project coordinator)	Nizar, M. Abdul	NBPGR	India
Crop Strategy	Pathmanathan Umaharan	University of West Indies, St. Augustine	Trinidad & Tobago
Crop Strategy	Rao, S.K.	Jawaharlal Nehru Agricultural Univ.	India
Crop Strategy	Reddy, K.N.	(GT Crop improvement) ICRISAT	India
Crop Strategy	Reddy L.J.	(GT Crop improvement) ICRISAT	India
Crop Strategy	Reddy, V.G.	(GT Crop improvement) ICRISAT	India
Crop Strategy	Roy, S.K.	Pulses & Oilseeds Research Station	India
Crop Strategy	Salas, Manuel J.	Instituto Nacional de Investigaciones Agricola (INIA)	Venezuela
Crop Strategy	Sastry, D.V.S.S.R.	(GT Crop improvement) ICRISAT	India
ICRISAT Legumes pathology	Sharma, Matma	ICRISAT	India
Crop Strategy	Sharma, S.K.	NBPGR	India
Crop Strategy	Siambi, Moses	ICRISAT	Malawi
Crop Strategy	Singh, A.K.	NBPGR	India
Crop Strategy	Singh, Bir	IITA	Nigeria
Crop Strategy	Singh, D.P.	GB Pant University of Agril. & Technology	India
Crop Strategy	Singh, Sube	(GT Crop improvement) ICRISAT	India
ICRISAT Pigeonpea Breeding	Srivatsava, Rakesh K.	ICRISAT	India
Crop Strategy	Tikle, A.N.	AICRPP, RAK College of Agriculture	India
Internet	Van der Maesen, L.J.G.	Wageningen Agricultural University	The Netherlands
Crop Strategy	Verma, B.N.	Zambia Seed Company	Zambia
Crop Strategy	Wanjari, K.B.	Department of Botany	India

Crop Strategy	Dean	Facultad de Agronomia, Universidad de Zuila	Venezuela
Crop Strategy	Director	Crops and Horticulture Research Nepal Agriculture Research council	Nepal
Crop Strategy	Director	Agricultural Research Organization	Israel
Crop Strategy	Director	Plant Genetic Resources Research Institute	Ghana
Crop Strategy	Director of Research	Serere Agricultural & Animal Production Research Institute (SAARI)	Uganda
WIEWS		ILRI	Ethiopia
WIEWS		CENARGEN-EMBRAPA	Brasil
WIEWS		Chitedze Agricultural Research Station	Malawi
WIEWS		Facultad de Ciencias Agropecuarias, Universidad de Panamá	Panama
WIEWS		Institute of Plant Breeding, University of the Philippines, Los Baños College	Philippines

Annex III – Set of descriptors for pigeonpea as included in the survey (July 2009)

1.	Growth habit	4.1.1
2.	Plant height [cm]	4.1.2
3.	Number of primary branches	4.1.4.1
4.	Number of secondary branches	4.1.4.2
5.	Number of tertiary branches	4.1.4.3
6.	Stem colour	4.1.5
7.	Leaflet shape	4.1.8
8.	Leaf hairiness (lower surface of the leaves)	4.1.9
9.	Days to 50% flowering	4.2.1
10.	Days to 75% maturity	4.2.4
11.	Base colour of flower	4.2.5
12.	Second flower colour	4.2.6
13.	Pattern of streaks	4.2.7
14.	Flowering pattern	4.2.8
15.	Seeds per pod	4.2.10
16.	Pod number (Number of pods per plant)	New
17.	Pod colour	4.2.11
18.	Pod stripes colour	New
19.	Pod form	4.2.12
20.	Pod bearing length [cm]	4.2.14
21.	Pod length [cm]	New
22.	Seed colour pattern	4.3.1
23.	Base colour of seed	4.3.2
24.	100-seed weight [g]	4.3.8
25.	Seed yield per plant [g]	6.1
26.	Harvest index	6.1.1
27.	Shelling percentage [%]	6.1.2
28.	Protein content [%]	6.2.1
29.	Reaction to soil salinity	7.5
30.	*Helicoverpa armigera*; *Etiella zinckenella*; *Maruca testulalis* (Legume pod borer)	8.1.6
31.	*Melanagromyza obtusa* (Podfly)	8.1.8
32.	*Callosobruchus chinensis* (Bruchid)	8.1.10
33.	*Tanaostigmodes caianinae* (Pod wasp)	8.1.13
34.	*Phytophthora drechsleri* f.sp. *caiani* (Phytophthora blight)	8.2.1
35.	*Fusarium udum* (*Fusarium oxysporum* f.sp. *udum*) (Wilt)	8.2.7
36.	Sterility mosaic virus (SMV)	8.4.1

Annex IV – Survey to choose a key set of descriptors for pigeonpea utilization

WELCOME

Welcome to the survey for the selection of a key set of characterization and evaluation descriptors for pigeonpea to support an international information system to enhance the utilization of germplasm held in genebanks.

Your knowledge and experience are being sought to define an initial **'key set'** of descriptors that identify traits important to crop production and facilitate the use of accessions by researchers.

Your participation in it is highly appreciated. The deadline for this survey is **31 August 2009**.

This key set of descriptors will be made available through a global portal for identifying sets of accessions for evaluation and use.

This survey consists of two parts:
- PART I: Characterization descriptors

- PART II: Evaluation descriptors

We thank you in advance for investing your time and expertise in selecting the set of descriptors.

*** Please allow us to acknowledge your contribution by completing your full contact details below:**

Name:

Position:

Organization:

Country:

Email:

PART I: Characterization descriptors

These traits enable easy and quick discrimination between phenotypes. They are generally highly heritable, can be easily seen by the eye and are equally expressed in all environments.

Based on your experience, please select descriptors that provide the most impact in discriminating between accessions. It also allows you to indicate if any essential descriptor that can contribute to its use is missing from the minimum list presented.

*Numbers in parentheses on the right-hand side are the corresponding descriptors numbers as published in the IBPGR/ICRISAT publication 'Descriptors for Pigeonpea' (1993).

	Very important	Important	Not important
Growth habit (4.1.1)	○	○	○
Plant height [cm] (4.1.2)	○	○	○
Number of primary branches (4.1.4.1)	○	○	○
Number of secondary branches (4.1.4.2)	○	○	○
Number of tertiary branches (4.1.4.3)	○	○	○
Stem colour (4.1.5)	○	○	○
Leaflet shape (4.1.8)	○	○	○
Leaf hairiness (lower surface of the leaves) (4.1.9)	○	○	○
Days to 50% flowering (4.2.1)	○	○	○
Days to 75% maturity (4.2.4)	○	○	○
Base colour of flower (4.2.5)	○	○	○
Second flower colour (4.2.6)	○	○	○
Pattern of streaks (4.2.7)	○	○	○
Flowering pattern (4.2.8)	○	○	○
Seeds per pod (4.2.10)	○	○	○
Pod number (Number of pods per plant)	○	○	○
Pod colour (4.2.11)	○	○	○
Pod stripes colour	○	○	○
Pod form (4.2.12)	○	○	○
Pod bearing length [cm] (4.2.14)	○	○	○
Pod length [cm]	○	○	○
Seed colour pattern (4.3.1)	○	○	○
Base colour of seed (4.3.2)	○	○	○
100-seed weight [g] (4.3.8)	○	○	○

If you consider that an essential trait is missing from this list, please indicate it here along with a substantiated justification.

PART II: Evaluation descriptors

These descriptors include characters such as yield and biotic stresses. They are the most interesting traits in crop improvement. Please consider the following factors relating to the trait when making your final decision: (i) Global impact, (ii) Initial strategic set, (iii) Importance for germplasm utilization, (iv) Data availability, (v) True economic damage and (vi) Wide geographical occurrence.

Please, rate these traits in order of importance at the global level. It also allows you to indicate if any essential trait for production is missing from the minimum list presented or indicate any that may not be very significant to global production.

	Very important	Important	Not Important
Seed yield per plant [g] (6.1)	◯	◯	◯
Harvest index (6.1.1)	◯	◯	◯
Shelling percentage [%] (6.1.2)	◯	◯	◯
Protein content [%] (6.2.1)	◯	◯	◯
Reaction to soil salinity (7.5)	◯	◯	◯
Helicoverpa armigera; *Etiella zinckenella*; *Maruca testulalis* (Legume pod borer) (8.1.6)	◯	◯	◯
Melanagromyza obtusa (Pod fly) (8.1.8)	◯	◯	◯
Callosobruchus chinensis (Bruchid) (8.1.10)	◯	◯	◯
Tanaostigmodes caianinae (Pod wasp) (8.1.13)	◯	◯	◯
Phytophthora drechsleri f.sp. *caiani* (Phytophthora blight) (8.2.1)	◯	◯	◯
Fusarium udum, (*F. oxysporum* f.sp. *udum*) (Wilt) (8.2.7)	◯	◯	◯
Sterility mosaic virus (SMV) (8.4.1)	◯	◯	◯

If you consider that an essential trait important for crop improvement and production is missing from this list, or, if any of the descriptors listed is not clearly useful to promote utilization, please indicate it here along with a substantiated justification.

Annex V – List of respondents to the survey

ROLE	NAME	POSITION	ORGANIZATION	COUNTRY
Crop Leader	**Dua, Ram Prakash**	Network coordinator (UUC)	National Bureau of Plant Genetic Resources (NBPGR)	India
Crop Leader	**Upadhyaya, Hari D.**	Principal Scientist and Head, Genebank	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	India
CAG	Bharadwaj, C.	Senior Scientist (Plant Breeding)	Division of Genetics, Indian Agricultural Research Institute (IARI)	India
CAG	Burle, Marília Lobo	Researcher/Legume Curator	Embrapa Recursos Genéticos e Biotecnologia	Brazil
CAG	Gowda, M. Byre	Principal Scientist	University of Agricultural Sciences, Bangalore	India
CAG	Lohwasser, Ulrike	Genebank Taxonomist	Leibniz Institute of Plant Genetics and Crop Plant Research	Germany
CAG	Raje, R.S.	Senior scientist, Pigeonpea	Division of Genetics, Indian Agricultural Research Institute (IARI)	India
CAG	Saxena, K.B.	Principal Scientist	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	India
Reviewer	Bhardwaj, Harbans	Professor	Virginia State University	USA
Reviewer	Bisht, I.S.	Principal Scientist & Professor, PGR	National Bureau of Plant Genetic Resources (NBPGR), Pusa Campus, New Delhi	India
Reviewer	Myint, Aye Aye	Head of PGR Section	Department of Agricultural Research, Central Agricultural Research Institute (CARI)	Myanmar
Reviewer	Reddy, K.N.		International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	India
Reviewer	Sastry, D.V.S.S.R.	Lead Scientific Officer	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	India
Reviewer	Sharma, Mamta	Scientist	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	India
Reviewer	Sharma, Shivali		International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	India
Reviewer	Srivastava, Rakesh K.	Scientist	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	India
Reviewer	Tikle, Ashok	Senior Scientist	Rajmata Vijayaraje Scindia Agricultural University, Gwalior	India
Reviewer	van der Maesen, L.J.G.	Professor of Plant Taxonomy (em.)	Wageningen University	The Netherlands
Reviewer	Verma, B.N.	Research and Production Director	Zambia Seed Co. Ltd.	Zambia
Reviewer	Wanjari, K.B.	Head, Dept of Agricultural Botany, Dr. P.D.K.V., AKOLA, Maharashtra	Dr Panjabrao Deshmukh Agricultural University	India

Annex VI – List of descriptors proposed in the survey ranked by rating average and sent to the Core Advisory Group for their selection

Descriptor	Your selection	Rating Average
Characterization		
Growth habit (4.1.1)		4.78
100-seed weight [g] (4.3.8)		4.78
Days to 50% flowering (4.2.1)		4.65
Days to 75% maturity (4.2.4)		4.33
Seeds per pod (4.2.10)		4.28
Seed colour pattern (4.3.1)		4.22
Number of primary branches (4.1.4.1)		4.06
Plant height [cm] (4.1.2)		4
Base colour of seed (4.3.2)		3.94
Pod colour (4.2.11)		3.72
Pod number (Number of pods per plant)		3.67
Base colour of flower (4.2.5)		3.61
Pod length [cm]		3.56
Flowering pattern (4.2.8)		3.44
Number of secondary branches (4.1.4.2)		3.19
Stem colour (4.1.5)		2.89
Second flower colour (4.2.6)		2.83
Pod stripes colour		2.83
Pod form (4.2.12)		2.83
Pod bearing length [cm] (4.2.14)		2.81
Pattern of streaks (4.2.7)		2.65
Leaflet shape (4.1.8)		2.41
Leaf hairiness (lower surface of the leaves) (4.1.9)		2.29
Number of tertiary branches (4.1.4.3)		2
Evaluation		
***Helicoverpa armigera*; *Etiella zinckenella*; *Maruca testulalis* (Legume pod borer) (8.1.6)**		4.53
***Fusarium udum* (*F. oxysporum* f.sp. *udum*) (Wilt) (8.2.7)**		4.5
Sterility mosaic virus (SMV) (8.4.1)		4.41
Seed yield per plant [g] (6.1)		4.33
***Phytophthora drechsleri* f.sp. *caiani* (Phytophthora blight) (8.2.1)**		4.13
***Callosobruchus chinensis* (Bruchid) (8.1.10)**		3.88
***Melanagromyza obtusa* (Pod fly) (8.1.8)**		3.69
Protein content [%] (6.2.1)		3.56
Harvest index (6.1.1)		3.39
Reaction to soil salinity (7.5)		2.88
Shelling percentage [%] (6.1.2)		2.65
Tanaostigmodes caianinae (Pod wasp) (8.1.13)		1.69

Annex VII – Additional descriptors included in the open-ended section of the survey

Pigeonpea descriptor		Name of expert							
Additional traits	**N. times selected**	**D.V.S. S.R. Sastry (ICRISAT, India)**	**R.S. Raje (Div. of Genetics, IARI, India)**	**K.B. Wanjari (Dr Panjabrao Deshmukh Agric. Univ., Maharashtra, India)**	**Ashok Tikle (RVS Agric. Univ., Gwalior, India)**	**Hari D. Upadhyaya (ICRISAT, India)**	**Aye Aye Myint (Dep. Agric. Research - CARI, Myanmar)**	**R.P.Dua (NBPGR, India)**	**K. B. Saxena (ICRISAT, India)**
Seedling vigor	**2**	X					X Early vigour		
Broadness of pod against narrow pod may be important for identification and characterization (Pod length)	**1**		X						
Branching pattern: Depending on angle of primary branches to the main stem actual plant type can be classed as erect, semi-erect or spreading while growth habit only classifies as determinate semi-determinate or indeterminate	**1**				X				
Plant stand	**1**						X		
Stem thickness [mm] (4.1.6). related to agro forestry and fodder	**1**					X			
Duration of flowering	**1**						X		
Seed secondary colour (4.6.3)	**1**						X		
Seed eye colour (4.3.4)	**1**						X		
Seed eye width (4.3.5)	**1**						X		
Seed shape (4.3.6)	**2**						X	X Seed shape (4.3.6) is important	
Hilum (4.3.7)	**2**						X	X Presence /absence of hilum (4.3.7) is important	
Photo period sensitivity--It is very important as to determines flowering, maturity, height, no.of pods etc. Planting of sensitive types nears shortest day will have a telescopic effect on overall phenology of the plant and consequently a different agronomy is needed to optimize yield	**2**					X			X
Water logging tolerance is becoming important in pigeonpea	**3**		X	X Tolerance to water logged condition					X Water logging is becoming an important constraint. However not much information is available.
Split Dal recovery in milling	**1**			X					
Quality parameters of split Dal (Cotyledons of matured grains) are important traits for future crop improvement.	**1**			X					
Drought tolerance: Major crop area of pigeonpea is rainfed throughout the world. The terminal drought affects the pigeonpea yield and it has become an essential criterion for assessment	**3**				X	X Reaction to drought (7.3)	X Reaction to drought		
Reaction to excess soil moisture (7.4)	**2**					X	X		
Reaction to low temperature (7.1)	**1**						X		
Reaction to high temperatures (7.2)	**1**						X		
Reaction to soil acidity (7.6)	**1**						X		
Yellow mosaic virus (YMV)	**1**						X		
Alternaira blight (*Alternaria alternate* (Fr.) Keissler) (8.2.4)	**1**					X			
Another important parameter may be considered is **adaptation to intercropping** as most pigeonpea are grown under intercrops.	**1**								X

Annex VIII – Initial key access and utilization descriptors for pigeonpea sent to the Core Advisory Group for validation

Key access and utilization descriptors for pigeonpea genetic resources

This list consists of an initial set of characterization and evaluation descriptors for pigeonpea (*Cajanus cajan* L. Millsp.) genetic resources utilization. This strategic set of descriptors, together with passport data, will become the basis for the global accession level information portal being developed by Bioversity International with the financial support of the Global Crop Diversity Trust (the Trust). It will facilitate access to and utilization of pigeonpea accessions held in genebanks and does not preclude the addition of further descriptors, should data subsequently become available.

Based on the comprehensive list 'Descriptors for Pigeonpea [*Cajanus cajan* (L.) Millsp.]' published by ICRISAT and IBPGR (now Bioversity International) in 1993, the list builds on the results of the SGRP Global Public Goods Activity 4.2.1.1. It was subsequently compared and harmonized with a number of sources such as 'Descriptors for PIGEON-PEA' (USDA, ARS, GRIN); 'Development of a Strategy for the Global Conservation of Pigeonpea Genetic Resources' (the Trust, 2006); as well as with traits provided by the Department of Agricultural Research (DAR) the former CARI from Myanmar. It was further refined during a meeting held at the National Bureau of Plant Genetic Resources (NBPGR, India) in June 2009 that involved several scientists from NBPGR and the Indian Agricultural Research Institute (IARI).

A worldwide distribution of experts was involved in an online survey to define a first priority set of descriptors to describe, to access and to utilize pigeonpea genetic resources. This key set was afterwards validated by a Core Advisory Group (see 'Contributors') led by Dr Hari D. Upadhyaya of International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and Dr Ram Prakash Dua of NBPGR.

Biotic and abiotic stresses included in the list were chosen because of their wide geographic occurrence and significant economic impact at a global level.

Numbers in parentheses on the right-hand side are the corresponding descriptor numbers listed in the 1993 publication. Descriptors with numbers ending in 'letters' are either modified or new descriptors that were added during the development of the list below.

Growth habit (4.1.1)

1 Erect and compact
2 Semi-spreading
3 Spreading
4 Trailing

Plant height [cm] (4.1.2)
At maturity

Number of primary branches (4.1.4.1)

Number of secondary branches (4.1.4.2)

Days to 50% flowering (4.2.1)
From sowing or first irrigation/rainfall to when 50% of plants flower

Days to 75% maturity (4.2.4)
From sowing or first irrigation/rainfall to 75% maturity

Base colour of flower (4.2.5)
Main colour of the petals. Royal Horticultural Society (RHS) colour codes are given in parentheses beside descriptor states

1 Ivory (green-yellow group 1)
2 Light yellow (yellow group 6D)
3 Yellow (yellow-orange group 14A)
4 Orange-yellow (orange-red group 31A)

Flowering pattern (4.2.8)

1 Determinate
2 Semi-determinate
3 Indeterminate

Seeds per pod (4.2.10)
Average number of seeds of 10 randomly selected pods from three randomly selected plants in a row

Pod colour (4.2.11)
Main colour of the pod. Royal Horticultural Society (RHS) colour codes are given in parentheses beside descriptor states

1 Green (yellow-green group 144A)
2 Purple (greyed-purple group 183A)
3 Mixed, green and purple
4 Dark purple (greyed-purple group 187A)

Pod bearing length [cm] (4.2.14)
Distance between lowest and topmost pod on the plant

Pod number (4.2.a)
Number of pods per plant

Pod length [cm] (4.2.b)
Maximum average length of 10 randomly selected mature pods. Recorded at physiological maturity

Seed colour pattern (4.3.1)

1 Plain
2 Mottled
3 Speckled
4 Mottled and speckled
5 Ringed

Base colour of seed (4.3.2)
Royal Horticultural Society (RHS) colour codes are given in parentheses beside descriptor states

1 White (yellow-white group 158C)
2 Cream (greyed-white group 156C)
3 Orange (greyed-orange group 163B)
4 Light brown (yellow-orange group 22C)
5 Reddish-brown (reddish-brown group 200D)
6 Light grey (grey-brown group 199B)
7 Grey (greyed-green group 197A)
8 Purple (greyed-purple group 187A)
9 Dark purple (black group 202A)
10 Dark grey (black group 202B)

100-seed weight [g] (4.3.8)
Estimated from a random sample taken from total row yield

Seed yield per plant [g] (6.1)

Harvest index (6.1.1)
Ratio of total grain yield and total biological yield taken from three randomly selected plants in a row

Shelling percentage [%] (6.1.2)
Calculated from seed-pod ratio of three randomly selected plants in a row

Protein content [%] (6.2.1)
Whole seed crude protein percentage based on dry weight using the dye-binding method or automatic protein analyzer

ABIOTIC STRESSES

Reaction to drought (7.3)

Reaction to excess soil moisture (7.4)

Reaction to soil salinity (7.5)

Reaction to water logging (7.c)

BIOTIC STRESSES

Legume pod borer (*Helicoverpa armigera*; *Etiella zinckenella*; *Maruca testulalis*) (8.1.6)

Pod fly (*Melanagromyza obtusa*) (8.1.8)

Bruchids (*Callosobruchus chinensis*) (8.1.10)

***Phytophthora* blight** (*Phytophthora drechsleri* f. sp. *cajani*) (8.2.1)

***Fusarium* wilt** (*Fusarium oxysporum* f.sp.*udum*) (8.2.7)

Sterility mosaic virus (SMV) (8.4.1)

Annex IX – Final key set of descriptors for pigeonpea genetic resources

Key access and utilization descriptors for pigeonpea genetic resources

This list consists of an initial set of characterization and evaluation descriptors for pigeonpea [*Cajanus cajan* (L.) Millsp.] genetic resources utilization. This strategic set of descriptors, together with passport data, will become the basis for the global accession level information portal being developed by Bioversity International with the financial support of the Global Crop Diversity Trust (the Trust). It will facilitate access to and utilization of pigeonpea accessions held in genebanks and does not preclude the addition of further descriptors, should data subsequently become available.

Based on the comprehensive list 'Descriptors for Pigeonpea [*Cajanus cajan* (L.) Millsp.]' published by ICRISAT and IBPGR (now Bioversity International) in 1993, the list builds on the results of the SGRP Global Public Goods Activity 4.2.1.1 and was subsequently compared and harmonized with a number of sources such as 'Descriptors for PIGEON-PEA' (USDA, ARS, GRIN); as well as 'Development of a Strategy for the Global Conservation of Pigeonpea Genetic Resources' (the Trust, 2006). It was further refined during a meeting held at the National Bureau of Plant Genetic Resources (NBPGR, India) in June 2009 that involved several scientists from NBPGR and the Indian Agricultural Research Institute (IARI).

A worldwide distribution of experts was involved in an online survey to define a first priority set of descriptors to describe, to access and to utilize pigeonpea genetic resources. Survey results were afterwards analyzed and validated by a Core Advisory Group (see 'Contributors') led by Dr Hari D. Upadhyaya of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and Dr Ram Prakash Dua of the National Bureau of Plant Genetic Resources (NBPGR).

Biotic and abiotic stresses included in the list were chosen because of their wide geographic occurrence and significant economic impact at a global level.

Numbers in parentheses on the right-hand side are the corresponding descriptor numbers listed in the 1993 publication. Descriptors with numbers ending in 'letters' are either modified or are new descriptors that were added during the development of the list below.

PLANT DATA

Growth habit (4.1.1)

1 Erect and compact
2 Semi-spreading
3 Spreading
4 Trailing

Plant height [cm] (4.1.2)

At maturity

Number of primary branches (4.1.4.1)

Number of primary branches per plant

Number of secondary branches (4.1.4.2)

Number of secondary branches per plant

Days to 50% flowering (4.2.1)

From sowing or first irrigation/rainfall until 50% of plants flower

Days to 75% maturity (4.2.4)
From sowing or first irrigation/rainfall to 75% maturity

Flowering pattern (4.2.8)
1 Determinate
2 Semi-determinate
3 Indeterminate

Seeds per pod (4.2.10)
Average number of seeds of 10 randomly selected pods from three randomly selected plants in a row

Pod bearing length [cm] (4.2.14)
Distance between lowest and topmost pod on the plant

Pod number (4.2.a)
Number of pods per plant. Recorded at maturity

Pod length [cm] (4.2.b)
Maximum average length of 10 randomly selected mature pods. Recorded at physiological maturity

Seed colour pattern (4.3.1)
1 Plain
2 Mottled
3 Speckled
4 Mottled and speckled
5 Ringed

Seed base colour (4.3.2)
Royal Horticultural Society (RHS) colour codes are given in parentheses beside descriptor states
1 White (yellow-white group 158C)
2 Cream (greyed-white group 156C)
3 Orange (greyed-orange group 163B)
4 Light brown (yellow-orange group 22C)
5 Reddish-brown (reddish-brown group 200D)
6 Light grey (grey-brown group 199B)
7 Grey (greyed-green group 197A)
8 Purple (greyed-purple group 187A)
9 Dark purple (black group 202A)
10 Dark grey (black group 202B)

100-seed weight [g] (4.3.8)
Weight of air dried (10% moisture) seeds estimated from a random sample taken from total row yield

Seed yield per plant [g] (6.1)
Average seed yield of three randomly selected plants

Harvest index (6.1.1)
Ratio of total seed yield and total biological yield taken from three randomly selected plants in a row

Shelling percentage [%] (6.1.2)
Calculated from seed-pod ratio of three randomly selected plants in a row

Seed protein content [%] (6.2.1)

Whole seed crude protein percentage based on dry weight using the dye-binding method or automatic protein analyzer

ABIOTIC STRESSES

Reaction to drought (7.3)

Reaction to excess soil moisture (7.4)

Reaction to soil salinity (7.5)

Reaction to water logging (7.c)

BIOTIC STRESSES

Legume pod borer (*Helicoverpa armigera*; *Etiella zinckenella*; *Maruca testulalis*) (8.1.6)

Pod fly (*Melanagromyza obtusa*) (8.1.8)

Bruchids (*Callosobruchus chinensis*) (8.1.10)

Phytophthora blight (*Phytophthora drechsleri* f.sp. *cajani*) (8.2.1)

***Fusarium* wilt** (*Fusarium oxysporum* f.sp. *udum*) (8.2.7)

Sterility mosaic virus (SMV) (8.4.1)

CONTRIBUTORS

Bioversity is grateful to all the scientists and researchers who have contributed to the development of this strategic set of 'Key access and utilization descriptors for pigeonpea genetic resources', and in particular to Dr Hari D. (ICRISAT) and Dr Ram Prakash Dua (NBPGR) for providing valuable scientific direction. Ms Adriana Alercia (Bioversity International) provided technical expertise and guided the entire production process.

CORE ADVISORY GROUP

Hari D. Upadhyaya, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India

Ram Prakash Dua, National Bureau of Plant Genetic Resources (NBPGR)

C. Bharadwaj, Division of Genetics, Indian Agricultural Research Institute (IARI), India

Marília Lobo Burle, Embrapa Recursos Genéticos e Biotecnologia, Brazil

M. Byre Gowda, University of Agricultural Sciences, Bangalore, India

Ulrike Lohwasser, Leibniz Institute of Plant Genetics and Crop Plant Research (IPK), Germany

R.S. Raje, Division of Genetics, Indian Agricultural Research Institute (IARI), India

K.B. Saxena, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India

REVIEWERS

India
I.S. Bisht, National Bureau of Plant Genetic Resources (NBPGR), Pusa Campus
K.N. Reddy, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
D.V.S.S.R. Sastry, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
Mamta Sharma, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
Shivali Sharma, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
Rakesh K. Srivastava, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
Ashok Tikle, Rajmata Vijayaraje Scindia Agricultural University, Gwalior
K.B. Wanjari, Dr Panjabrao Deshmukh Agricultural University

Myanmar
Aye Aye Myint, Department of Agricultural Research (DAR), the former CARI

The Netherlands
L.J.G. van der Maesen, Wageningen University

USA
Harbans Bhardwaj, Virginia State University

Zambia
B.N. Verma, Zambia Seed Co. Ltd.

Methodology for the definition of a key set of characterization and evaluation descriptors for potato (*Solanum tuberosum*)

Bioversity International

GLOBAL CROP DIVERSITY TRUST
A FOUNDATION FOR FOOD SECURITY

Information collection and preparation of the Minimum Descriptor List (MDL)

Information for the definition of a Minimum Descriptor List for potato (*Solanum tuberosum*) was drawn from the publication 'Descriptors for the Cultivated Potato' (IBPGR, 1977). The original list was compared to descriptors utilized by the International Potato Center (CIP) for the morphological characterization of potatoes and contained in 'Characterization – Cultivated potato minimum descriptor list' (CIP, 1994) and the CIP Morphological guide 'Guía para las Caracterizaciones Morfológicas Básicas en Colecciones de Papas Nativas' (René Gómez, CIP, 2000). Results from the comparison were harmonized with the outcomes of the CGIAR SGRP Global Public Goods 2 (GPG2) Activity 4.2.1.1 on selected crops (2008). The list was further refined after a meeting held on 24 November 2008 at Bioversity Headquarters in Rome, between Dr David Tay (identified Crop Leader) and Ms Adriana Alercia. In particular, evaluation traits (such as important pests and diseases for cultivated potato, tuber quality and other agronomic characteristics) and data availability for selected descriptors were considered a priority (see Annex I) and were included in the descriptor list.

Preparation of the List of Experts

Experts were drawn from participants in the crop-specific consultations for the definition of the 'Global Strategy for the *Ex situ* Conservation of Potato' (the Trust, July, 2006). Reviewers from the 1977 descriptors list were excluded due to their outdated contact information. Overall, 41 experts from 26 countries and 29 different organizations were identified. Out of these, Dr David Tay was identified as Crop Leader and, following his inputs, a Core Advisory Group (CAG) consisting of seven experts was selected to assist in the definition of a key set of descriptors for this crop. Members of the CAG were chosen amongst specialists and experts working for world renowned academic and scientific institutions such as USDA/ARS, the International Potato Center (CIP), the Instituto de Producción y Sanidad Vegetal, Universidad Austral de Chile and Wageningen University (see Annex II).

Survey preparation and distribution

Due to the tight timeframe of the project it was decided to contact Dr David Tay from CIP and ask him for relevant results of the CGIAR SGRP GPG2 activity on potato. The initial set of descriptors for cultivated potato revised and finalized by Dr Tay on 24 November 2008 (see Annex III) was used to prepare the online consultation through the SurveyMonkey web application.

An email invitation to the survey was sent out on 17 March 2009 to the identified List of Experts. They were invited to rate the list of characterization and evaluation descriptors provided, and asked to suggest important descriptors that were found to be relevant yet missing from the proposed Minimum List (see Annex IV). The survey deadline was set at 5 April 2009. A first reminder was sent out on 27 March 2009 and a second one was sent on 2 April 2009. By popular demand, the deadline was extended to 16 April 2009 to ensure that the greatest possible feedback was obtained.

Survey analysis and refinement of the Minimum List

Of the 41 experts who were identified and involved in the exercise, 14 from 12 countries and 12 organizations recorded their comments using the online survey (see Annex V). Results from the survey were analyzed and descriptors ranked by rating average and percentage of importance (see Annex VI). The summary results of the survey together with a report containing comments received by the participants (see Annex VII) were sent to the Crop Leader, Dr Tay. He, subsequently, shared them with his colleagues Dr René Gómez, Dr Alberto Salas and Dr Merideth Bonierbale for the final validation (see Annex VIII).

Definition of a final key set of descriptors for potato

Once the core subset of characterization and evaluation standards for this crop was approved, descriptor states were integrated into the list (see Annex IX). The final document, including also all the contributors names (see Annex X), was proofread and sent to the Bioversity International Publication Unit for layout and on-line publication processes. Furthermore, the final publication was shared with the European Cooperative Programme for Plant Genetic Resources (ECPGR); the Generation Challenge Programme (GCP) Ontology and the SGRP Crop Genebank Knowledge Base. Additionally, data were converted into Excel files for uploading into the GRIN-Global genebank data management system being developed by USDA and into the global accession level information portal (GENESYS), linking national, regional and international genebank databases in support of the conservation and use of plant genetic resources for food and agriculture (PGRFA). The Excel files were also provided to the System-wide Information Network for Genetic Resources (SINGER) and to EURISCO.

After the publication was released, and during the Roots and Tubers Conference held at CIP in November 2009, attended by Ms Adriana Alercia, discussions were held on the final key set publication on cultivated potato and the next CIP crop, sweet potato with Drs David Tay, Rene Gomez and Alberto Salas, the last two experts being potato curators of cultivated and wild potato respectively. CIP experts realized after the release of the publication that a few amendments were required for potato concerning colours. Therefore, the document was amended accordingly and republished in 2010 (see Annex XI).

Acknowledgement

Bioversity is grateful to all the scientists and researchers who have contributed to the development of the strategic set of 'Key access and utilization descriptors for cultivated potato genetic resources', and to the Global Crop Diversity Trust for their financial support. Particular recognition goes to the Crop Leader, Dr David Tay (CIP, Peru) for providing valuable scientific direction.

Annex I – Comparison table for the definition of an initial set of descriptors for cultivated potato drawn from a number of sources[1]

	Descriptor name	*Descr. no. CIP-IBPGR 1977*	*CIP Desc 1994*	*CIP data through GPG2*	*CIP Morpho Guide*	*CIP Key List revised by D. Tay*	*CIP data available*
1st Priority Descriptors	Ploidy level	3.1.2		*		*	*
	Predominant tuber skin colour	3.2.1 (*)	*	*	*	*	*
	Intensity of predominant tuber skin colour	3.2.1b	*	*	*	*	*
	Secondary tuber skin colour	3.2.2 (*)	*	*	*	*	*
	Distribution of secondary skin tuber colour	3.2.3 (*)	*	*	*	*	*
	Predominant tuber flesh colour	3.2.5 (*)	*	*	*	*	*
	Secondary tuber flesh colour	3.2.6 (*)	*	*	*	*	*
	Tuber outline (shape)	3.2.8	*	*	*	*	*
	Odd tuber shapes	3.2.9	*	*	*	*	To be confirmed
	Depth of eyes	3.2.10 (*)	*	*	*	*	*
	Stem pigmentation	3.3.4	*	*	*	*	*
	Stem wing shape	3.3.6	*	*	*	*	*
	Lateral leaflet numbers	3.4.1b	*	*	*	*	*
	Interjected leaflet number in the rachis among lateral leaflets	3.4.1c	*	*	*	*	*
	Flowering degree	3.5.14 (*)	*	*	*	*	*
	Plant Growth Habit	3.6.1	*	*	*	*	*
	Foliar blight (*Phytophtora*)	6.1.1				*	To be confirmed
	Susceptibility to drought	5.2				*	Partly
	Susceptibility to salinity					*	To be confirmed
	High tuber yield			*		*	To be confirmed
2nd Priority Descriptors	Calyx pigmentation	3.5.1	*	*	*		
	Corolla shape	3.5.3	*	*	*		
	Predominant flower colour	3.5.4	*	*	*		
	Intensity of predominant flower colour	3.5.4b	*	*	*		
	Secondary flower colour	3.5.5	*	*	*		
	Distribution of secondary flower colour	3.5.6	*	*	*		
	Pistil pigmentation	3.5.10	*	*	*		
	Pedicel pigmentation		*	*	*		
	Eyes per tuber	3.2.11 (*)					
	Tuber skin type	3.2.4 (*)					
	Distribution of secondary tuber flesh colour	3.2.7 (*)	*		*		
	Predominant sprout colour	3.3.1	*		*		
	Secondary sprout colour	3.3.2	*		*		
	Type of leaf dissection	3.4.1	*		*		

Other descriptors	No. of interjected leaflets on the petiolules	(combined with 3.4.1)	*		*		
	Duration of flowering	3.5.16 (*)					
	Seed set	3.5.24 (*)					
	Pollen production	3.5.9 (*)					
	Tuber set	4.4.1 (*)					
	Tuber size	4.4.2 (*)					
	Tuber defects - Crack	4.4.3.1 (*)					
	Tuber defects - Secondary growth	4.4.3.2 (*)					
	Tuber defects - Hollow heart	4.4.3.3 (*)					
	Tuber defects - Internal necrosis	4.4.3.4 (*)					
	Tuber defects - Lenticels	4.4.3.5 (*)					
	Uniformity of tuber size	4.4.4 (*)		*			
	Stolon length	4.4.5 (*)					
	Foliar blight	6.1.1 (*)		*			
	Wilt	6.1.2 (*)		*			
	Tuber disease	6.1.3 (*)		*			
	Bacterial disease	6.2 (*)		*			
	Viral disease	6.3 (*)		*			
	Nematode	6.4 (*)		*			
	Tuber dry matter content	7.1		*			*
	Tuber total N content (%)	7.2 (*)					
	Tuber protein content			*			*
	Relative nutritive value			*			
	Total tuber Glyco-Alkaloid content (TGA)			*			
	Short duration			*			
	Anther pigmentation		*		*		
	Distribution of secondary sprout colour		*		*		
	Fruit colour		*		*		
	Fruit shape		*		*		
	Fruit Maturity				*		

N.B. Descriptor numbers were drawn from the publication 'Descriptors for the Cultivated Potato' (IBPGR, 1977). Asterisks (*) following the descriptor numbers denote descriptors selected as 'highly important' in the same publication (i.e. 1977). Lowercase letters following descriptor numbers denote revised/new descriptors.

[1] 'Descriptors for the Cultivated Potato' (IBPGR, 1977); 'Potato Descriptors for a minimum characterization of potato collections' (CIP, 1994); the outcomes of the SGRP Global Public Goods 2 (GPG2) activity 4.2.1.1.1 (2008); the CIP Morphological guide 'Guía para las Caracterizaciones Morfológicas Básicas en Colecciones de Papas Nativas' (René Gómez, CIP, 2000); outcomes of the meeting held on 24 November 2008 at Bioversity Headquarters between David Tay (identified Crop Leader) and Adriana Alercia (Bioversity, Rome) and CIP data availability.

Annex II - List of Experts identified for the survey for the definition of a key set of descriptors for cultivated potato

ROLE	***NAME***	***ORGANIZATION***	***COUNTRY***
Crop Leader	**Tay, David**	International Potato Center (CIP)	Peru
CAG	Arbizu, Carlos	International Potato Center (CIP)	Peru
CAG	Bamberg, John	USDA, ARS Potato Introduction Project	USA
CAG	Contreras, Andrés M.	Instituto de Producción y Sanidad Vegetal, Universidad Austral de Chile	Chile
CAG	Gómez, René	International Potato Center (CIP)	Peru
CAG	Hoekstra, Roel	Centre for Genetic Resources, Wageningen University	The Netherlands
CAG	Hunter, Danny	Bioversity International	Italy
CAG	Salas, Alberto	International Potato Center (CIP)	Peru
Strategy (the Trust)	Allaby, Ricky	Potato Research Center, Agriculture and Agri-Food Canada	Canada
Strategy (the Trust)	Bodea, Dimitru answered Silvia Strajeru	Genebank of Suceava	Romania
Strategy (the Trust)	Bradshaw, John	Commonwealth Potato Collection, SCRI	United Kingdom
Strategy (the Trust)	Cadima, Ximena	Fundación PROINPA	Bolivia
Strategy (the Trust)	Carnegie, Stuart	SASA	United Kingdom
Strategy (the Trust)	Chujoy, Enrique	International Potato Center (CIP)	Peru
Strategy (the Trust)	Clausen, Andrea	Instituto Nacional de Tecnología Agropecuaria (INTA)	Argentina
Strategy (the Trust)	Cuevas Sanchez, Jesus A.	Banco Nacional de Germoplasma Veget, Dep. de Fitotecnia, Univ. Aut. de Chapingo	Mexico
Reviewer suggested by Helmut Knüpffer (IPK)	Dehmer, Klaus	Genebank Department, Leibniz Institute of Plant Genetics and Crop Plant Research (IPK)	Germany
Strategy (the Trust)	Dolnicar, Peter	Biotechniska fakulteta	Slovenia
Strategy (the Trust)	Domkárová, Jaroslava	Potato Research Institute	Czech Republic
Strategy (the Trust)	Dos Santos, Fausto Francisco	Centro Nacional de Pesquisa de Hortalizas (CNPH), EMBRAPA	Brazil
Strategy (the Trust)	Ellissèche, Daniel	INRA, Amélioration de la Pomme de Terre	France
Strategy (the Trust)	Espinoza, Alejandro	INIFAP	Mexico
Strategy (the Trust)	Gonzales, Lourdes	Centro de Investigación Agropec. del Estado de Merida, INIA	Venezuela
Strategy (the Trust)	Griffin, Dennis	Teagasc	Ireland
Strategy (the Trust)	Herrera, Rosario	International Potato Center (CIP)	Peru
Strategy (the Trust)	Hosaka, Kazuyoshi	Faculty of Agriculture, Kobe University	Japan
Strategy (the Trust)	Kaiyun, Xie	Chinese Academy of Agricultural Science (IVFCAAS)	China

Strategy (the Trust)	Kiru, Stepan	N.I. Vavilov Research Institute of Plant Industry (VIR) Potato Collection	Russian Federation
Strategy (the Trust)	Monteros, Alvaro	INIAP-DENAREF	Ecuador
Strategy (the Trust)	Moreno, Dilmer	Corporación Colombiana de Investigación Agropecuaria (Corpoica), Centro de Investigación Tibaitatá	Colombia
Strategy (the Trust)	Okuno, Kazutoshi	Graduate School of Life and Environmental Sciences. University of Tsukuba Tennodai 1-1-1	Japan
Strategy (the Trust)	Orrillo, Matilde	International Potato Center (CIP)	Peru
Strategy (the Trust)	Panta, Ana	International Potato Center (CIP)	Peru
Strategy (the Trust)	Podgajetskiy, Anatoly A.	Institute for Potato Production Ukrainian Academy of Agric. Sciences	Ukraine
Reviewer suggested by Lewosz	Prof Kostiw, Michal	Plant Breeding and Acclimatization Institute	Poland
Reviewer suggested by Bradshaw	Ramsay, Gavin	Commonwealth Potato Collection, SCRI	United Kingdom
Strategy (the Trust)	Reynoso, Daniel	International Potato Center (CIP)	Peru
Strategy (the Trust)	Rios, Domingo	Centro de Conservación de la biodiversidad Agrícola de Tenerife	Spain
Strategy (the Trust)	Roca, William	International Potato Center (CIP)	Peru
Strategy (the Trust)	Rossel, Genoveva	International Potato Center (CIP)	Peru
Strategy (the Trust)	Simon, Reinhard	International Potato Center (CIP)	Peru

Annex III – Set of descriptors for cultivated potato validated by Dr David Tay on 24 November 2008 and information on data availability in CIP

	IBPGR	Data available at CIP
1. Ploidy level	(3.1.2)	Yes
2. Predominant tuber skin colour	(3.2.1)	Yes
3. Intensity of predominant tuber skin colour	(3.2.1b)	Yes
4. Secondary tuber skin colour	(3.2.2)	Yes
5. Distribution of secondary skin tuber colour	(3.2.3)	Yes
6. Predominant tuber flesh colour	(3.2.5)	Yes
7. Secondary tuber flesh colour	(3.2.6)	Yes
8. Tuber outline (shape)	(3.2.8)	Yes
9. Odd tuber shapes	(3.2.9)	To be confirmed[1]
10. Depth of eyes	(3.2.10)	Yes
11. Stem pigmentation	(3.3.4)	Yes
12. Stem wing shape	(3.3.6)	Yes
13. Lateral leaflet numbers	(3.4.1b)	Yes
14. Interjected leaflet number in the rachis among lateral leaflets	(3.4.1c)	Yes
15. Flowering degree	(3.5.14)	Yes
16. Plant growth habit	(3.6.1)	Yes
17. High tuber yield	-	To be confirmed[1]
18. Foliar blight (*Phytophtora*)	(6.1.1)	To be confirmed[1]
19. Susceptibility to drought	(5.2)	To be confirmed[1]
20. Susceptibility to salinity	-	To be confirmed[1]

Descriptors as included in the survey
1st priority key descriptors

1. Ploidy level (3.1.2)
2. Predominant tuber skin colour (3.2.1)
3. Intensity of predominant tuber skin colour (3.2.1b)
4. Secondary tuber skin colour (3.2.2)
5. Distribution of secondary skin tuber colour (3.2.3)
6. Predominant tuber flesh colour (3.2.5)
7. Secondary tuber flesh colour (3.2.6)
8. Tuber outline (shape) (3.2.8)
9. Odd tuber shapes (3.2.9)
10. Depth of eyes (3.2.10)
11. Stem pigmentation (3.3.4)
12. Stem wing shape (3.3.6)
13. Lateral leaflet numbers (3.4.1b)
14. Interjected leaflet number in the rachis among lateral leaflets (3.4.1c)
15. Flowering degree (3.5.14)
16. Plant growth habit (3.6.1)
17. High tuber yield
18. Foliar blight (*Phytophtora*) (6.1.1)
19. Susceptibility to drought (5.2)
20. Susceptibility to salinity

[1] Traits were to be confirmed by Dr Tay at a later stage.

Annex IV – Survey to choose a key set of descriptors for cultivated potato (17 March 2009)

WELCOME

Welcome to the survey for the selection of a key set of characterization and evaluation descriptors to support an international information system to enhance the utilization of germplasm held in genebanks.

Your knowledge and experience are being sought to select this initial 'key set of descriptors' of Potato accessions to identify traits important to crop production and to facilitate their use by researchers.

Your participation in it is highly appreciated. The deadline for this survey is 5 April 2009.

This key set of characterization and evaluation descriptors will be made available through a global facility for identifying sets of accessions for evaluation and use. For characterization, the aim is a key set of maximally differentiating traits that provide the most impact in discriminating between accessions. For evaluation, the aim is to focus on a few important traits for production, such as resistance to an important disease or yield.

The list presented here has been drawn from a number of sources such as: 'Descriptors for Cultivated potato' (IBPGR/CIP, 1977), 'Descriptores de la Papa' (CIP, 1994) and 'Guía para las Caracterizaciones Morfológicas Básicas en Colecciones de Papas Nativas' (René Gómez, CIP, 2000) and further harmonized with the results from the GPG2 Activity 4.2.1.1 (Potato descriptors CIP-GPG2), under the scientific direction of Dr David Tay from CIP.

This survey consists of two parts:

- PART I: Lists important characterization descriptors for Potato. Based on your experience, please rate the descriptors according to their importance in identifying accessions. It also allows you to indicate if any essential descriptor that can contribute to its use is missing from the minimum list presented.

- PART II: Lists important evaluation descriptors for Potato. Please, rate these traits in order of importance at the global level. It also allows you to indicate if any essential trait for production is missing from the minimum list presented or indicate any that may not be very significant to global production.

We thank you in advance for investing your time and expertise in selecting this initial, key set of descriptors.

Please allow us to acknowledge your contribution by completing your full contact details below:

Name:
Organization:
Address 1:
City/Town:
State/Province:
ZIP/Postal Code:
Country:
Email Address:

PART I: Characterization descriptors

These traits enable easy and quick discrimination between phenotypes. They are generally highly heritable, can be easily seen by the eye and are equally expressed in all environments.

*Numbers in parentheses on the right-hand side are the corresponding descriptors numbers as published in the CIP-IBPGR publication 'Descriptors for the Cultivated Potato' (1977), those having an additional letter have been drawn form 'Guía para las Caracterizaciones Morfológicas Básicas en Colecciones de Papas Nativas' (René Gómez, CIP, 2000).

Please rate the following descriptors based on their importance in describing and categorizing accessions.

	Not important	Important	Very important
Ploidy level (3.1.2)			
Predominant tuber skin colour (3.2.1)			
Intensity of predominant tuber skin colour (3.2.1b)			
Secondary tuber skin colour (3.2.2)			
Distribution of secondary skin tuber colour (3.2.3)			
Predominant tuber flesh colour (3.2.5)			
Secondary tuber flesh colour (3.2.6)			
Tuber outline (shape) (3.2.8)			
Odd tuber shapes (3.2.9)			
Depth of eyes (3.2.10)			
Stem pigmentation (3.3.4)			
Stem wing shape (3.3.6)			
Lateral leaflet numbers (3.4.1b)			
Interjected leaflet number in the rachis among lateral leaflets (3.4.1c)			
Flowering degree (3.5.14)			
Plant growth habit (3.6.1)			

If you consider that an essential trait is missing from this list, please indicate it here along with a substantiated justification.

PART II: Evaluation descriptors

These descriptors include characters such as yield, biotic and abiotic stresses. They are the most interesting traits in crop improvement.

Please rate the following evaluation traits, bearing in mind current breeding programmes and future production and use of Cultivated potato germplasm at the global level.

	Not Important	Important	Very important
High tuber yield	☐	☐	☐
Foliar blight (*Phytophtora*)	☐	☐	☐
Susceptibility to drought (5.2)	☐	☐	☐
Susceptibility to salinity	☐	☐	☐

If you consider that an essential trait important for crop improvement and production is missing from this list, or, if any of the descriptors listed is not clearly useful to promote utilization, please indicate it here along with a substantiated justification.

NOTE: Please remember, this list is the starting point and will grow over time, as required.

THANK YOU VERY MUCH FOR YOUR PARTICIPATION.

Annex V – Respondents to the survey

ROLE	***NAME***	***ORGANIZATION***	***COUNTRY***
CAG (Strategy, the Trust)	Bamberg, John	US Potato Genebank	USA
CAG (Strategy, the Trust)	Hoekstra, Roel	CGN	The Netherlands
CAG (Bioversity)	Hunter, Danny	Bioversity International	Italy
CAG (Strategy, the Trust)	Salas, Alberto	International Potato Centre (CIP)	Peru
Strategy (the Trust)	Arbizu, Carlos	International Potato Centre (CIP)	Peru
Strategy (the Trust)	Carnegie, Stuart	SASA	United Kingdom
Has replied on behalf of: Ellissèche, Daniel	Chauvin, Jean-Eric	INRA	France
Strategy (the Trust)	Chujoy, Enrique	International Potato Centre (CIP)	Peru
Reviewer suggested by Helmut Knüpffer (IPK)	Dehmer, Klaus J.	IPK / GLKS	Germany
Strategy (the Trust)	Dílmer Moreno-Mendoza, José	Corpoica	Colombia
Strategy (the Trust)	Dolničar, Peter	Agricultural Institute of Slovenia	Slovenia
Strategy (the Trust)	Domkářová, Jaroslava	Potato Research Institute Havlíčkův Brod	Czech Republic
Strategy (the Trust)	Kiru, Stepan	Vavilov Institute of plant Industry, (VIR)	Russian Federation
Strategy (the Trust)	Ríos Mesa, Domingo	Centro de Conservación de la Biodiversidad Agrícola de Tenerife	Spain

Annex VI – Descriptors proposed in the survey ranked by rating average and by percentage of importance

Descriptor	Rating Average
Predominant tuber skin colour (3.2.1)	4.64
Predominant tuber flesh colour (3.2.5)	4.21
Ploidy level (3.1.2)	3.86
Depth of eyes (3.2.10)	3.62
Secondary tuber skin colour (3.2.2)	3.50
Tuber outline (shape) (3.2.8)	3.49
Plant growth habit (3.6.1)	3.31
Flowering degree (3.5.14)	3.23
Secondary tuber flesh colour (3.2.6)	3.21
Distribution of secondary skin tuber colour (3.2.3)	3.00
Odd tuber shapes (3.2.9)	2.92
Lateral leaflet numbers (3.4.1b)	2.50
Stem pigmentation (3.3.4)	2.00
Intensity of predominant tuber skin colour (3.2.1b)	1.93
Interjected leaflet number in the rachis among lateral	1.64
Stem wing shape (3.3.6)	1.00
Foliar blight (*Phytophtora*)	4.71
Susceptibility to drought (5.2)	3.86
High tuber yield	3.64
Susceptibility to salinity	3.00

Descriptor	% Importance (important)	% Importance (Very important)
Predominant tuber skin colour (3.2.1)	0.0	92.9
Predominant tuber flesh colour (3.2.5)	21.4	71.4
Tuber outline (shape) (3.2.8)	7.1	71.4
Ploidy level (3.1.2)	21.4	64.3
Depth of eyes (3.2.10)	30.8	53.8
Secondary tuber skin colour (3.2.2)	57.1	35.7
Odd tuber shapes (3.2.9)	46.2	30.8
Lateral leaflet numbers (3.4.1b)	35.7	28.6
Flowering degree (3.5.14)	69.2	23.1
Distribution of secondary skin tuber colour (3.2.3)	64.3	21.4
Secondary tuber flesh colour (3.2.6)	71.4	21.4
Plant growth habit (3.6.1)	84.6	15.4
Stem pigmentation (3.3.4)	53.8	7.7
Stem wing shape (3.3.6)	21.4	7.1
Interjected leaflet number in the rachis among lateral	42.9	7.1
Intensity of predominant tuber skin colour (3.2.1b)	64.3	0.0
Foliar blight (*Phytophtora*)	14.3	85.7
High tuber yield	50.0	42.9
Susceptibility to drought (5.2)	57.1	42.9
Susceptibility to salinity	64.3	21.4

Annex VII - Additional descriptors included in the open-ended section of the survey

Cultivated potato descriptor		Name of expert					
Additional characterization descriptor	**N. of times selected**	**Enrique Chujoy**	**Carlos Arbizu**	**Alberto Salas**	**Domingo Ríos Mesa**	**Stuart Carnegie**	**Klaus J. Dehmer**
Flower colour	**5**	**X**	**X**	**X**	**X**		**X**
Tuber sprout colour. Sprout colour can be described simply and used to group phenotypes before planting.	**3**		**X**	**X**		**X**	
Tuber sprout shape	**2**		**X**	**X**			
Corolla shape	**2**		**X**	**X**			
Terminal leaflets	**1**				**X**		
Primary lateral leaflets	**1**				**X**		
Calix colour	**1**				**X**		
Number of eyes per tuber	**1**				**X**		
Plant maturity is a key characteristic in differentiating and managing varieties in a collection. Varieties tend to be grouped and harvested according to maturity.	**1**					**X**	
Distribution of secondary tuber flesh colour	**1**						**X**

Cultivated potato descriptor		Name of expert						
Additional evaluation descriptor	**N. of times selected**	**Enrique Chujoy**	**Carlos Arbizu**	**Alberto Salas**	**Stepan Kiru**	**Stuart Carnegie**	**José Dílmer Moreno-Mendoza**	**Klaus J. Dehmer,**
Tuber yield stability	**1**	**X**						
Susceptibility to main viruses (PVX, PVY, PLRV)	**1**	**X**						
Earliness Adaptation to latitude and altitude	**2**		**X**	**X**				
Wart resistance - is most important in the case of recommendation for breeding as valuable source	**1**				**X**			
Susceptibility to potato cancer	**1**							**X**
COMMENT: While the assessment of varieties to disease is desirable, it needs to borne in mind that this can change with time and this is particularly pertinent to late blight. The development of new genotypes of *Phytophthora infestans* in Europe has meant that a variety's response can vary depending on the genotype of pathogen with which it is challenged.						**X**		
COMMENT: I think High tuber yield of commercial sizes is very important for Andean varieties.							**X**	

Annex VIII – Survey results for first priority descriptors of cultivated potato validated by Dr Tay and his colleagues at CIP (July 2009)

Ploidy level (3.1.2)

Predominant tuber skin colour (3.2.1)

Intensity of predominant tuber skin colour (3.2.1a)

Secondary tuber skin colour (3.2.2)

Distribution of secondary skin tuber colour (3.2.3)

Predominant tuber flesh colour (3.2.5)

Secondary tuber flesh colour (3.2.6)

Tuber outline (shape) (3.2.8)

Odd tuber shapes (3.2.9)

Depth of eyes (3.2.10)

Tuber sprout colour (3.3.1)

Stem pigmentation (3.3.4)

Stem wing shape (3.3.6)

Lateral leaflet numbers (3.4.1b)

Interjected leaflet number in the rachis among lateral leaflets (3.4.1c)

Flower colour (3.5.4)

Flowering degree (3.5.14)

Plant growth habit (3.6.1)

Drought (5.2)

Soil salinity (5.d)

Foliar blight (*Phytophtora*) (6.1.1.1)

High tuber yield (7.e)

Annex IX – Final list of characterization and evaluation standards for cultivated potato including descriptor states

PLANT DATA

Ploidy level (3.1.2)
Count of the zygotic (2n) number of chromosomes

Predominant tuber skin colour (3.2.1)
Code indicating the colour which covers most of the surface of the tuber, expressed as:
1 White-cream
2 Yellow
3 Orange
4 Brownish
5 Pink
6 Red
7 Purplish-red
8 Purple
9 Dark purple-black (Blackish)

Intensity of predominant tuber skin colour (3.2.1a)
1 Light
2 Intermediate
3 Intense

Secondary tuber skin colour (3.2.2)
Code describing a secondary colour on the surface of the tuber, expressed as:
0 Absent
1 White-cream
2 Yellow
3 Orange
4 Brownish
5 Pink
6 Red
7 Purplish-black
8 Purple
9 Dark purple-black (Blackish)

Distribution of secondary tuber skin colour (3.2.3)

Code representing the pattern of distribution of the secondary colour on the surface of the tuber, expressed as:

0 Absent
1 Eyes – when the secondary colour is confined to the eyes only
2 Eyebrows – when the secondary colour is present in the eyebrows only
3 Splashed – when the secondary colour is confined to areas around the eyes
4 Scattered – when the secondary colour is distributed at random in one or more areas around the tuber
5 Spectacled – when areas around the eyes do not show secondary colour and the reminder of the tuber is pigmented
6 Stippled – when the surface of the tuber is more or less uniform covered with spots
99 Other (specify in the **Notes** descriptor)

Predominant tuber flesh colour (3.2.5)

Code indicating the flesh colour present in most of the tuber, expressed as:

1 White
2 Cream
3 Yellow-cream
4 Yellow
5 Red
6 Violet
7 Purple
99 Other (specify in the **Notes** descriptor)

Secondary tuber flesh colour (3.2.6)

Code representing a secondary flesh colour in the tuber, expressed as:

0 Absent
1 White
2 Cream
3 Yellow-cream
4 Yellow
5 Red
6 Violet
7 Purple
99 Other (specify in the **Notes** descriptor)

Tuber outline (shape) (3.2.8)

Code describing the tuber outline, expressed as:

1 Compressed (oblate) – major axis is the shortest axis
2 Round – an almost circular outline
3 Ovate – an outline resembling an egg. The broadest part is within 1/3 of the distance from the stolon end
4 Obovate – an outline which is inversely ovate and broadest within 1/3 of the distance from the apical end (rose or eye end)
5 Elliptic – an outline showing the same breadth when measured at equal distance from both the stolon and apical ends. The outline is slightly acute at each end
6 Oblong – an almost rectangular outline with the sides nearly parallel but the corners are rounded. The length/breadth ratio should not be more than 3/2
7 Long-oblong – an oblong outline with a length/breadth ratio closer to 2/1
8 Elongate – a long rectangular outline with a length/breadth ratio equal to or more than 3/1

Odd tuber shapes (3.2.9)

Code representing those variants of tuber shape which cannot be described under tuber outline shape. It is expressed as follows:

0 Absent
1 Flattened – when the length of a transverse section, at any point of the tuber, is more than three times longer than its breadth
2 Clavate – resembling an elongated club, thickened at one end
3 Reniform – shaped like a kidney
4 Fusiform – spindle-shaped, tapering gradually at both ends
5 Falcate – curved or shaped like a sickle or horseshoe
6 Spiral – long and coiled
7 Digitate – resembling a hand or a fist
8 Concertina-shaped – resembling a concertina
9 Tuberosed – covered with few or many small lumps and tubers. It includes those shaped like a pineapple, a cluster of grapes, and raised internodes

Depth of tuber eyes (3.2.10)

Code indicating the depth of the eyes in the tuber, expressed as:

1 Protruding
2 Shallow
3 Medium
4 Deep
5 Very deep

Tuber sprout colour (3.3.1)

Code describing the colour which covers most of the surface of the sprout, expressed as:

1 White-green
2 Pink
3 Red
4 Violet
5 Purple
99 Other (specify in the **Notes** descriptor)

Stem pigmentation (3.3.4)

Code indicating the colour of the stems, expressed as:

1 Green only
2 Red-brown only
3 Purple only
4 Cream with some red-brown
5 Cream with purple
6 Red-brown with some green
7 Purple with some green
99 Other (specify in the **Notes** descriptor)

Stem wing shape (3.3.6)

Code for the presence and shape of the stem wing, expressed as:

0 Absent
1 Straight
2 Undulate
3 Dentate

Lateral leaflet numbers (3.4.1a)

0 Absent
1 One pair
2 Two pairs
3 Three pairs
4 Four pairs
5 Five pairs
6 Six pairs
7 Seven or more pairs

Interjected leaflets number in the rachis among lateral leaflets (3.4.1b)

0 Absent
1 One pair
2 Two pairs
3 Three pairs
4 Four or more pairs

Flower colour (3.5.4)

Code indicating the colour present in most of the corolla, expressed as:

1 White
2 Light red
3 Intense red
4 Light blue
5 Intense blue
6 Light purple
7 Intense purple
8 Yellow

Flowering degree (3.5.14)

Code describing the degree of flowering which should be recorded at the peak of the flowering period, expressed as:

0 No buds
1 Bud abortion
3 Scarce flowering
5 Moderate flowering
7 Profuse flowering

Plant growth habit (3.6.1)

Code indicating the type of growth habit at the beginning of flowering of the accession expressed as:

1 Erect
2 Semi-erect
3 Decumbent, when the stems trail on the ground but they rise at the apex
4 Prostrate, when the stems trail on the ground
5 Semi-rosette
6 Rosette, when all or most leaves arranged at the base of the stem are close to the soil surface

High tuber yield (7.a)

ABIOTIC STRESSES

Drought (5.2)

The method of evaluating is in the process of being defined and the following descriptor states are expected to be used:

1 Very low or no visible sign of susceptibility (Highly tolerant)
3 Low (Tolerant)
5 Intermediate (or slightly tolerant)
7 High (Non-tolerant)

Soil salinity (5.a)

BIOTIC STRESSES

Foliar blight (*Phytophthora* spp.) (6.1.1.1)

NOTES

Any additional information may be specified here, particularly that referring to the category 'Other' present in some of the descriptors above.

Annex X – List of contributors

CORE ADVISORY GROUP

David Tay, International Potato Center (CIP), Peru
Carlos Arbizu, International Potato Center (CIP), Peru
John Bamberg, US Potato Genebank, USA
René Gómez, International Potato Center (CIP), Peru
Roel Hoekstra, CGN, The Netherlands
Danny Hunter, Bioversity International, Italy
Alberto Salas, International Potato Center (CIP), Peru

REVIEWERS

Colombia
José Dílmer Moreno-Mendoza, Corpoica

Czech Republic
Jaroslava Domkárová, Potato Research Institute Havlíkuv Brod

France
Jean-Eric Chauvin, INRA

Germany
Klaus J. Dehmer, IPK/GLKS

Peru
Merideth Bonierbale, International Potato Center (CIP)
Enrique Chujoy, International Potato Center (CIP)

Russian Federation
Stepan Kiru, N.I. Vavilov Research Institute of Plant Industry (VIR)

Slovenia
Peter Dolničar, Agricultural Institute of Slovenia

Spain
Domingo Ríos Mesa, Centro de Conservación de la Biodiversidad Agrícola de Tenerife

United Kingdom
Stuart Carnegie, SASA

Annex XI – Final key access and utilization descriptors for cultivated potato genetic resources, revised and republished in 2010

Key access and utilization descriptors for cultivated potato genetic resources

This list consists of an initial set of characterization and evaluation descriptors for cultivated potato utilization. This strategic set of descriptors, together with passport data, will become the basis for the global accession level information portal being developed by Bioversity International with the financial support of the Global Crop Diversity Trust. It will facilitate access to and utilization of cultivated potato accessions held in genebanks and does not preclude the addition of further descriptors, should data subsequently become available.

Based on the comprehensive 'Descriptors for the Cultivated Potato' published by the International Potato Center (CIP) and IBPGR (now Bioversity International) in 1977, the list was subsequently compared and harmonized, wherever possible, with minimum descriptors listed in 'Descriptores de la Papa' (CIP, 1994), with the 'Guía para las Caracterizaciones Morfológicas Básicas en Colecciones de Papas Nativas' (René Gómez, CIP, 2000), and with those for which data were available. It also builds on the SGRP Global Public Goods (GPG2) activity.

This minimal set defines a first priority set of descriptors to describe, to access and to utilize cultivated potato genetic resources. A worldwide distribution of experts involved in an online survey was assured and the list was afterwards validated by a Core Advisory Group (see 'Contributors') led by Dr David Tay of CIP.

Biotic and abiotic stresses included in the list were chosen because of their wide geographic occurrence and significant economic impact at a global level.

Numbers in parentheses on the right-hand side are the corresponding descriptor numbers listed in the 1977 descriptors. Descriptors with numbers ending in 'letters' are new descriptors that were added during the development of the list below.

PLANT DATA

Ploidy level (3.1.2)

Count of the zygotic (2n) number of chromosomes

Predominant tuber skin colour (3.2.1)

Code indicating the colour which covers most of the surface of the tuber, expressed as:

1 White-cream
2 Yellow
3 Orange
4 Brownish
5 Pink
6 Red
7 Purplish-red
8 Purple
9 Blackish

Intensity of predominant tuber skin colour (3.2.1a)

1 Light
2 Intermediate
3 Intense

Secondary tuber skin colour (3.2.2)

Code describing a secondary colour on the surface of the tuber, expressed as:

0 Absent
1 White-cream
2 Yellow
3 Orange
4 Brownish
5 Pink
6 Red
7 Purplish-red
8 Purple
9 Blackish

Distribution of secondary tuber skin colour (3.2.3)

Code representing the pattern of distribution of the secondary colour on the surface of the tuber, expressed as:

0 Absent
1 Eyes – when the secondary colour is confined to the eyes only
2 Eyebrows – when the secondary colour is present in the eyebrows only or includes eyes
3 Splashed – when the secondary colour is confined to areas around the eyes or includes eyes and eyebrows
4 Scattered – when the secondary colour is distributed at random in one or more areas around the tuber
5 Spectacled – when areas around the eyes do not show secondary colour and the reminder of the tuber is pigmented
6 Stippled – when the surface of the tuber is more or less uniform covered with spots
7 Few spots
99 Other (specify in the **Notes** descriptor)

Predominant tuber flesh colour (3.2.5)

Code indicating the flesh colour present in most of the tuber, expressed as:

1 White
2 Cream
3 Yellow-cream
4 Yellow
5 Red
6 Violet
7 Purple
99 Other (specify in the **Notes** descriptor)

Secondary tuber flesh colour (3.2.6)

Code representing a secondary flesh colour in the tuber, expressed as:

0 Absent
1 White
2 Cream
3 Yellow-cream
4 Yellow
5 Red
6 Violet
7 Purple
99 Other (specify in the **Notes** descriptor)

Tuber outline (shape) (3.2.8)

Code describing the tuber outline, expressed as:

1 Compressed (oblate) – major axis is the shortest axis
2 Round – an almost circular outline
3 Ovate – an outline resembling an egg. The broadest part is within 1/3 of the distance from the stolon end
4 Obovate – an outline which is inversely ovate and broadest within 1/3 of the distance from the apical end (rose or eye end)
5 Elliptic – an outline showing the same breadth when measured at equal distance from both the stolon and apical ends. The outline is slightly acute at each end
6 Oblong – an almost rectangular outline with the sides nearly parallel but the corners are rounded. The length/breadth ratio should not be more than 3/2
7 Long-Oblong – an oblong outline with a length/breadth ratio closer to 2/1
8 Elongate – a long rectangular outline with a length/breadth ratio equal to or more than 3/1

Odd tuber shapes (3.2.9)

Code representing those variants of tuber shape which cannot be described under tuber outline shape. It is expressed as follows:

0 Absent
1 Flattened – when the length of a transverse section, at any point of the tuber, is more than three times longer than its breadth
2 Clavate – resembling an elongated club, thickened at one end
3 Reniform – shaped like a kidney
4 Fusiform – spindle-shaped, tapering gradually at both ends
5 Falcate – curved or shaped like a sickle or horseshoe
6 Spiral – long and coiled
7 Digitate – resembling a hand or a fist
8 Concertina-shaped – resembling a concertina
9 Tuberosed – covered with few or many small lumps and tubers. It includes those shaped like a pineapple, a cluster of grapes, and raised internodes

Depth of tuber eyes (3.2.10)

Code indicating the depth of the eyes in the tuber, expressed as:

3 Shallow
5 Medium
7 Deep
9 Very deep

Tuber sprout colour (3.3.1)

Code describing the colour which covers most of the surface of the sprout, expressed as:

1 White-cream
2 Yellow
3 Pink
4 Red
5 Violet
6 Purple
7 Blackish
99 Other (specify in the **Notes** descriptor)

Stem pigmentation (3.3.4)

Code indicating the colour of the stems, expressed as:

1 Green
2 Cream with some red-brown
3 Cream with purple
4 Red-brown with some green
5 Purple with some green
6 Red-brown
7 Purple
99 Other (specify in the **Notes** descriptor)

Stem wing shape (3.3.6)

Code for the presence and shape of the stem wing, expressed as:

0 Absent
1 Straight
2 Undulate
3 Dentate

Lateral leaflet numbers (3.4.1a)

0 Absent
1 One pair
2 Two pairs
3 Three pairs
4 Four pairs
5 Five pairs
6 Six pairs
7 Seven or more pairs

Interjected leaflets number in the rachis among lateral leaflets (3.4.1b)

0 Absent
1 One pair
2 Two pairs
3 Three pairs
4 Four or more pairs

Flower colour (3.5.4)

Code indicating the colour present in most of the corolla, expressed as:

1 White/cream/yellow
2 Pink
3 Red
4 Light blue
5 Blue
6 Purple
7 Violet

Flowering degree (3.5.14)

Code describing the degree of flowering which should be recorded at the peak of the flowering period, expressed as:

0 No buds
1 Bud abortion
3 Scarce flowering
5 Moderate flowering
7 Profuse flowering

Plant growth habit (3.6.1)
Code indicating the type of growth habit at the beginning of flowering of the accession expressed as:

1 Erect
2 Semi-erect
3 Decumbent, when the stems trail on the ground but they rise at the apex
4 Prostrate, when the stems trail on the ground
5 Semi-rosette
6 Rosette, when all or most leaves arranged at the base of the stem are close to the soil surface

High tuber yield (7.a)

ABIOTIC STRESSES

Drought (5.2)
The method of evaluating is in the process of being defined and the following descriptor states are expected to be used:

1 Very low or no visible sign of susceptibility (Highly tolerant)
3 Low (Tolerant)
5 Intermediate (or Slightly tolerant)
7 High (Non-tolerant)

Soil salinity (5.a)

BIOTIC STRESSES

Foliar blight (*Phytophthora* spp.) (6.1.1.1)

NOTES
Any additional information may be specified here, particularly that referring to the category 'Other' present in some of the descriptors above.

CONTRIBUTORS
Bioversity is grateful to all the scientists and researchers who have contributed to the development of this strategic set of 'Key access and utilization descriptors of cultivated potato genetic resources', and in particular to Dr David Tay (CIP, Peru) who provided scientific direction. Ms Adriana Alercia provided technical expertise and guided the entire production process.

CORE ADVISORY GROUP
David Tay, International Potato Center (CIP), Peru
Carlos Arbizu, International Potato Center (CIP), Peru
John Bamberg, US Potato Genebank, USA
René Gómez, International Potato Center (CIP), Peru
Roel Hoekstra, CGN, the Netherlands
Danny Hunter, Bioversity International, Italy
Alberto Salas, International Potato Center (CIP), Peru

REVIEWERS

Colombia
José Dílmer Moreno-Mendoza, Corpoica

Czech Republic
Jaroslava Domkárová, Potato Research Institute Havlíkuv Brod

France
Jean-Eric Chauvin, INRA

Germany
Klaus J. Dehmer, IPK/GLKS

Peru
Merideth Bonierbale, International Potato Center (CIP)
Enrique Chujoy, International Potato Center (CIP)

Russian Federation
Stepan Kiru, N.I. Vavilov Research Institute of Plant Industry (VIR)

Slovenia
Peter Dolničar, Agricultural Institute of Slovenia

Spain
Domingo Ríos Mesa, Centro de Conservación de la Biodiversidad Agrícola de Tenerife

United Kingdom
Stuart Carnegie, SASA

Methodology for the definition of a key set of characterization and evaluation descriptors for rice (*Oryza* spp.)

Information collection and preparation of a Minimum Descriptor List (MDL)

Information for the definition of a MDL for Rice was based on the publication 'Descriptors for wild and cultivated Rice (*Oryza* spp.)' (Bioversity International, IRRI and WARDA, 2007). The list derived from this publication was compared to important descriptors mentioned in a number of sources such as UPOV technical guidelines (2004); 'Standard Evaluation System for Rice' (IRRI, 2002); 'Descriptor for RICE' (USDA, ARS, GRIN), and relevant descriptors resulting from activity 4.2.1.1 of the SGRP Global Public Goods Phase 2 (GPG2), submitted by IRRI and WARDA. Results from the comparison exercise were subsequently integrated and harmonized with those that were awarded funds for further research by the Global Crop Diversity Trust Evaluation Award Scheme, 2008 (see Annex I). On 20th March 2009 this first Minimum set of descriptors was further discussed with Dr Ruaraidh Sackville Hamilton from the International Rice Research Institute (IRRI) who provided scientific direction for the publication of 'Descriptors for wild and cultivated Rice (*Oryza* spp.)'. It was agreed to build on the Minimum List of Descriptors for rice which contained characterization descriptors, adding traits important to crop production under the scientific guidance of Dr Ed Redoña, Global Rice Coordinator at the International Network for Genetic Evaluation for Rice (INGER).

Preparation of the List of Experts

The list of experts was prepared taking into account reviewers involved in the publication 'Descriptors for wild and cultivated Rice (*Oryza* spp.)' as well as participants to the Expert Consultation Meeting that was held at IRRI, Philippines, in December 2007 to discuss a preliminary draft of the 'Global Strategy for the *Ex-situ* conservation of Rice'. Overall the list was composed of 79 experts, coming from 28 countries and 51 different organizations (see Annex II). Out of these, a Crop Leader, Edilberto D. Redoña, and a Core Advisory Group (CAG) consisting of seven experts were selected to assist in the definition of a minimum set of descriptors for this crop. Members of the CAG were selected from world renowned organizations and research centres focusing on rice conservation such as IRRI, International Center for Tropical Agriculture (CIAT), National Bureau Of Plant Genetic Resources (NBPGR), and INGER.

Survey preparation and distribution

A draft of the survey was proposed to the Crop Leader on 8 May 2009 and subsequently the final revised version (see Annex III) was uploaded into the SurveyMonkey application on internet. On 11 May an email invitation, containing the link to the survey, was sent out to the identified experts who were invited to validate the initial 'Minimum set of descriptors' of rice accessions to promote the utilization of germplasm. Participants were also encouraged to mention any additional traits that were found to be relevant yet missing from the proposed list, along with a substantiated justification for their inclusion. The already approved and published list of highly discriminating Bioversity, IRRI and WARDA descriptors for rice was inserted in the survey for reference (see Annex IV).

The survey deadline was set at 12 June, a first reminder was sent out on 26 May and a second one on 5 June 2009 to ensure that the greatest possible feedback was obtained.

Survey analysis and refinement of the Minimum List

Of the 79 experts who were identified and involved in the exercise, 28, coming from 16 countries and 23 organizations recorded their comments using the online survey; six of them members of the CAG (see Annex V). Results from the survey were analyzed and descriptors ranked by rating average and percentage of importance (see Annex VI). The survey summary results together with a report containing open-ended responds received by the participants (see Annex VII) were shared with the Crop Leader for validation on 4 August 2009. His comments (see Annex VIII) were harmonized and sent again to Dr Redoña for further refinement. The revised minimum list was then sent to the CAG for final approval on 30 September 2009 (see Annex IX).

The approved document, including descriptor states and all the contributors (see Annex X), was proofread by an external editor and sent to the Bioversity Publication Unit for layout and online publication processes. Furthermore, the publication was shared with ECPGR Secretariat; the Generation Challenge Programme (GCP) Ontology and the SGRP Crop Genebank Knowledge Base partners. Additionally, data were converted into Excel files for uploading into the GRIN-Global genebank data-management system being developed by USDA and into the global accession level information portal (GENESYS), linking national, regional and international genebank databases in support of the Conservation and Use of Plant Genetic Resources for Food and Agriculture (PGRFA). The Excel files were also provided to the System-wide Information Network for Genetic Resources (SINGER) and to EURISCO.

Acknowledgement

Bioversity is grateful to all the scientists and researchers who have contributed to the development of the strategic set of 'Key access and utilization descriptors for rice genetic resources', and to the Global Crop Diversity Trust for their financial support. Special thanks go to Dr Edilberto Redoña for his valuable scientific contribution.

Annex I – Comparison table for the definition of a Key set of traits for Rice drawn from a number of sources[i]

	Bioversity descriptor no.	Bioversity descriptor name	Bioversity-IRRI-WARDA	UPOV	USDA, ARS, GRIN	SES	EAS	IRRI GPG2	WARDA GPG2 Data available (*) considered important (**)
Bioversity MDL	7.2.3	Main heading	*				*		
	7.3.11	Auricle: colour	*	*		* (page 32)		*	
	7.3.22	Flag leaf: attitude (early observation)	*	*		* (page 39)		*	
	7.3.25	Culm: length	*	*		* (page 34)		*	
	7.3.28	Culm: anthocyanin colouration on the nodes	*	*					
	7.3.29	Culm: underlying node colour	*			* (page 33)			
	7.3.34	Flag leaf: attitude (late observation)	*	*					
	7.4.2	Stigma: colour	*	*		* (page 38)		*	
	7.4.6	Lemma: colour of apiculus (early observation)	*	*					
	7.4.9	Awns distribution	*	*	*	* (page 33)		*	
	7.4.18	Panicle: length	*	*		* (page 36)		*	**
	7.4.19	Panicle: attitude of main axis	*	*		* (page 36)		*	
	7.4.20	Panicle: attitude of branches (Plant type USDA - Panicle type)	*	*	*	* (page 37)			*
	7.5.4	Lemma and palea: pubescence	*	*	*	* (page 36)			
	7.5.10	Sterile lemma: length	*			* (page 37)		*	
	7.5.11	Longer sterile lemma length	*						
	7.5.13	Sterile lemma: colour	*		*	* (page 37)		*	
	7.5.20	Caryopsis: length	*	*	*				
	7.5.22	Caryopsis: shape (grain shape)	*		*				*
	7.5.23	Caryopsis: pericarp colour (Bran colour USDA?)	*		*				
	8.1.2	Caryopsis scent	*			* (page 37)			
Other descriptors	4.6	Seedling vigour							*
	7.2.2.1	Days from seeding to flowering							**
	7.2.2.2	Days to first heading (Flowering date)							*
	7.2.4	Maturity	*					*	*
	7.2.4.1	Days from seeding to maturity							**
	7.2.3.1	Days to main heading		*					
	7.3.18	Leaf blade length [cm]	*					*	*
	7.3.19	Leaf blade width [cm]	*					*	**
	7.3.27	Culm: diameter at basal internode [mm]							*
	7.3.7	Leaf blade intensity of green colour (colour)							*
	7.3.8	Leaf blade attitude (leaf angle)							*

	Bioversity descriptor no.	Bioversity descriptor name	Bioversity-IRRI-WARDA	UPOV	USDA, ARS, GRIN	SES	EAS	IRRI GPG2	WARDA GPG2 Data available (*) considered important (**)
	7.3.9	Leaf blade pubescence							*
	7.4.1	% Pollen sterility/fertility at anthesis (Male sterility)	*		*		*		
	7.4.17	Panicle number per plant	*				*		
	7.4.21	Panicle: secondary branching	*					*	
	7.4.22	Panicle: exsertion							*
	7.4.5	Lemma and palea colour	*		*			*	
	7.4.8	Awns presence (Awning)							*
	7.5.15	Grain length [mm]							**
	7.5.16	Grain width [mm]	*					*	*
	7.5.18	Grain: 100-grain weight [g]							*
	7.5.2	Panicle threshability	*					*	
	7.5.8	Lemma: colour of apiculus							*
	8.1.1	Lemma: phenol reaction	*						
	8.1.10	Elongation ratio	*			*		*	
	8.1.3	Endosperm amylose content [%]	*		*				
	8.1.4 (?)	Alkali spreading value	?		*				
	8.1.5	Gelatinization Temperature by Differential Scanning	*						
	8.1.6	Gel consistency	*						
	8.1.7	Brown rice protein content [% DW]	*						
	8.1.8	Lysine content [% DW]	*						
	8.1.9	Parboiling loss [% DW]	*						
	9.1	Cold [IS-75]	*			*		*	
	9.2	Heat [IS-76]	*			*		*	
	9.3	Drought [IS-80]	*			*		*	
	9.4	Alkali injury and salt injury [IS-70-71]	*			*		*	
	9.5	Iron toxicity [IS-72]	*			*		*	
	9.6	Phosphorus deficiency [IS-73]	*						
	9.7	Zinc deficiency [IS-74]	*			*			
	9.8	Flood or submergence [IS-86]	*			*		*	
	10.1	Diseases	*			*			
	10.1.1	Leaf blast (*Magnaporthe grisea*)	*		*			*	*
	10.1.2	Panicle blast (*Magnaporthe grisea*)	*		*			*	*
	10.1.3	Brown spot (*Cochliobolus miyabeanus*)							*
	10.1.5	Bacterial leaf streak (*Xanthomonas oryzae* pv. *oryzicola*)	*					*	
	10.2	Diseases caused by viruses and MLOs [IS-36]	*			*			
	10.2.1	Rice grassy stunt (RGSV1 and RGSV2)	*					*	
	10.2.4	Rice Yellow Mottle Virus							*

	Bioversity descriptor no.	Bioversity descriptor name	Bioversity-IRRI-WARDA	UPOV	USDA, ARS, GRIN	SES	EAS	IRRI GPG2	WARDA GPG2 Data available (*) considered important (**)
	10.3	Insects	*			*			
	10.3.1	Brown planthopper (*Nilaparvata lugens*)	*					*	
	10.3.5	Stem borers	*					*	*
	10.3.6	Leaf folder (*Cnaphalocrocis medinalis*)	*					*	
	10.3.7	Gall midge (*Orseolia oryzae*)	*					*	
	12.2	Gelatinisation Temperature	*		*				
	12.3	Fragrance	*						
	13.1	Chromosome number	*						
	13.2	Ploidy level	*						
	13.3	Other cytological characters	*						
		% Seed sterility/fertility					*		
		Diurnal duration of anthesis					*		
		DNA profiles using SSR markers					*		
		Duration of flowering period					*		
		Fertile tillering ability							*
		Grain weight of 1000 grains or rough rice [g]	* (10 and 100)		*				
		Grain yield per plant				* (page 45)	*	*	
		Kernel width			*				
		Phenotypic acceptability				* (page 7)	*		*
		Panicle number per m2							*
		Plant height [cm]			*	*	*	*	*
		Rice tungro bacilliform virus				*		*	
		Sheath blight (*Rhizoctonia solani*) (*Thanatephorus cucumeris*)	*		*				
		Straighthead			*				
		Tillering ability							**
		Time of day of flowering (start/end)					*		

[i] ‘Descriptors for wild and cultivated Rice (*Oryza* spp.)’ (Bioversity International, IRRI and WARDA, 2007), UPOV technical guidelines (2004), ‘Standard Evaluation System for Rice (SES)’ (IRRI, 2002), ‘Descriptors for RICE’ (USDA, ARS, GRIN), Evaluation Awards Scheme (EAS), descriptors submitted by IRRI and WARDA to the GPG2 project.

Annex II - Experts identified to take part to the survey

Role	Name	Organization	Country
Crop Leader	**Redoña, Edilberto D.**	IRRI	Philippines
CAG	Borromeo, Teresita	UPLB	Philippines
CAG	Khin Than, Nwe	Rice Department	Myanmar
CAG	Martínez, César	CIAT	Colombia
CAG	Salaices, Luis	Ministry of Agriculture, Fisheries and Food	Spain
CAG	Sharma, S.K.	NBPGR	India
CAG	Shobha, Rani	Directorate of Rice Research	India
CAG	Tang, Shenxiang	China National Rice Research Institute	China
Reviewer	Alias, Ismail	Malaysian Agricultural Research and Development Institute	Malaysia
Reviewer	Almazan, Socorro	IRRI	Philippines
Reviewer	Amron, Azuan	MARDI	Malaysia
Reviewer	Anishetty, Murthi	FAO/CGIAR	India
Reviewer	Apanich, Nathathai	National Genebank of Thailand	Thailand
Reviewer	Attiogbevi-Somado, Eklou	WARDA	Benin
Reviewer	Banaticla, Maria Celeste	IRRI	Philippines
Reviewer	Bockelman, Harold E.	ARS/USDA	USA
Reviewer	Bounphanousay, Chay	ARC Genebank	Lao PDR
Reviewer	Buu, Bui Chi	Director, Institute of Agricultural Science of South Vietnam (IAS)	Viet Nam
Reviewer	Catibog, Noel	PCARRD	Philippines
Reviewer	Chanphengxay, Monthathip	NAFRI	Lao PDR
Reviewer	Da Silva Mariante, Arthur	EMBRAPA	Brazil
Reviewer	Ennamul, Haque	Bangladesh Rice Research Institute	Bangladesh
Reviewer	Faberova, Iva	Research Institute of Crop Production	Czech Republic
Reviewer	Faylon, Patricio S.	PCARRD	Philippines
Reviewer	Ferreira, Marcio Elias	Embrapa	Brazil
Reviewer	Fesenko, Maria	VIR WEB SITE	Russia
Reviewer	Fitzgerald, Melissa	IRRI	Philippines
Reviewer	Gatot Irianto, M.S., Ir. H. Sumarjo	IAARD	Indonesia
Reviewer	Gosalvitra, Prasert	Rice Dept	Thailand
Reviewer	Haron, Sharif	MARDI	Malaysia
Reviewer	Harun-ur-Rashid, M.	Bangladesh Agricultural Research Center (BARC)	Bangladesh
Reviewer	Htut Oo, U Tin	Dept of Agricultural Planning	Myanmar

Role	Name	Organization	Country
Reviewer	Ilao, Susan Sandra L.	PCARRD	Philippines
Reviewer	Javier, Edwin	IRRI	Philippines
Reviewer	Khan, Inayatullah	Ministry of Food, Agriculture and Livestock	Pakistan
Reviewer	Kim, Je-Kyu	National Institute for Crop Science (NICS)	Korea
Reviewer	Kim, Tae-San	RDA	Korea
Reviewer	Kouang, Douangsila	National Agriculture and Food Research Institute	Lao PDR
Reviewer	Kudagamage, Chandrasiri	Dept Agricolture	Sri Lanka
Reviewer	Kumashiro, Takashi	JIRCAS	Japan
Reviewer	Lal Karna, Parashuram	Nepal Agricultural Research Council	Nepal
Reviewer	Lewin, Laurie	Rice CRC	Australia
Reviewer	Mal, Bhag	Bioversity	India
Reviewer	Misra Lal, Sah	Nepal Agricultural Research Council	Nepal
Reviewer	Mozafari, Javad	NPGB	Iran
Reviewer	Muhammad, Akram	Pakistan Agricultural Reseach Council	Pakistan
Reviewer	Myung Chul Lee	National Agrodiversity Center	Korea
Reviewer	Nafisah. Afif	Indonesian Center for Rice Research	Indonesia
Reviewer	Naredo, Elizabeth	IRRI	Philippines
Reviewer	Lang, Nguyen Thi	Cuu Long Rice Research Institute	Vietnam
Reviewer	Nimal, Dissanayake	Rice Research Institute	Sri Lanka
Reviewer	Okuno, Kazutoshi	Laboratory of Plant Genetics & Breeding Science, Graduate School of Life and Environmental Sciences	Japan
Reviewer	Orapin, Watanesk	Rice Department	Thailand
Reviewer	Ouk, Makara	Cambodian Agricultural Research and Development Institute (CARDI	Cambodia
Reviewer	Padolina, Thelma	PhilRice	Philippines
Reviewer	S.R.Pandravada	NBPGR Regional Station, Rajendranagar, Hyderabad-500 030, Andhra Pradesh	India
Reviewer	Rai, Mangala	ICAR	India

Role	Name	Organization	Country
Reviewer	Ramanantsoanirina, Alain	FOFIFA/CENRADERU	Madagascar
Reviewer	Rana, J.C.	NBPGR	India
Reviewer	Reaño, Renato	IRRI	Philippines
Reviewer	Romanova, Olga	VIR	Russia
Reviewer	Romero, G.	PhilRice	Philippines
Reviewer	Sanni, Kayode	WARDA	Benin
Reviewer	Sanwidi, Abdoulaye	WARDA	Benin
Reviewer	Sarom, Men	Cambodian Agricultural Research and Development Institute (CARDI)	Cambodia
Reviewer	Shihua, Cheng	China National Rice Research Institute	China
Reviewer	N. Shobha Rani	Directorate of Rice Research	India
Reviewer	Shumin, Wang	Chinese Academy of Agricultural Sciences (CAAS)	China
Reviewer	Sie, Moussa	WARDA	Benin
Reviewer	Silitonga, Tiur Sudiati	ICABGRRD Bogor	Indonesia
Reviewer	Tchamba, Albert	WARDA	Benin
Reviewer	Tia, Daniel	WARDA	Benin
Reviewer	Torre do Vale, Carla	IIAM	Mozambique
Reviewer	Viraktamath, B.C.	Hyderabad Directorate of Rice Research (DRR)	India
Reviewer	Wambugu, Peter	NGBK	Kenya
Reviewer	Orapin Watanesk	Bureau of Rice Research and Development	Thailand
Reviewer	Yang, Sae-Jun	National Institute of Crop Science, RDA	Korea
Reviewer	Yeon-Gyu, Kim	National Institute for Crop Science (NICS)	Korea
Reviewer	Zain, Hj. Abdullah Md	University Malaysia Terengganu	Malaysia

Annex III - Evaluation descriptors for Rice selected by Dr Redoña on 5 May 2009

Plant height [cm]	
Endosperm amylose content [%]	8.1.3
Cold [IS-75]	9.1
Heat [IS-76]	9.2
Drought [IS-80]	9.3
Alkali injury and salt injury [IS-70-71]	9.4
Flood or submergence [IS-86]	9.8
Phenotypic acceptability	
Leaf blast (*Magnaporthe grisea*)	10.1.1
Brown spot (*Cochliobolus miyabeanus*)	10.1.3
Bacterial leaf streak (*Xanthomonas oryzae* pv. *oryzicola*)	10.1.5
Rice Yellow Mottle Virus	10.2.4
Sheath blight (*Rhizoctonia solani*) (*Thanatephorus cucumeris*)	10.2.6
Brown planthopper (*Nilaparvata lugens*)	10.3.1
Stem borers	10.3.5
Gall midge (*Orseolia oryzae*)	10.3.7
Rice tungro bacilliform virus	

Annex IV - Survey to choose a key set of descriptors for Rice

Welcome to the survey for the selection of a first priority set of evaluation descriptors of Rice to support an international information system to enhance the utilization of germplasm held in genebanks.

Your participation in it is highly appreciated. The deadline for this survey is **12 th June 2009**

The key set, along with the List of *highly discriminating Bioversity IRRI descriptors for rice* (Annex I, Bioversity/IRRI/WARDA, 2007), which can be found in Part I, will be made available through a global facility for identifying sets of accessions for evaluation and use, and does not preclude the addition of further descriptors, should data subsequently become available.

The list presented here has been drawn from the Bioversity/IRRI/WARDA publication Descriptors for wild and cultivated Rice '(*Oryza* spp.)' (2007), and further harmonized with results from the GPG2 Activity 4.2.1.1; with descriptors that were awarded funds for further research by the Global Crop Diversity Trust
2008 Award Scheme; with UPOV technical guidelines for rice (2004), wherever possible; and with the IRRI publication 'Standard Evaluation System for Rice (SES)' (2002), under the scientific direction of Dr. Edilberto Redoña (IRRI).

This survey consists of two parts:

- PART I: Lists the most important characterization descriptors for Rice, validated and published in 'Descriptors for wild and cultivated Rice (Oryza spp.)' Bioversity/IRRI/WARDA (2007). They are reported here only for reference.

- PART II: Lists important evaluation descriptors for Rice. Please, rate these traits in order of importance at the global level, their wide geographic occurrence and significant economic impact. It also allows you to indicate if any essential trait for production is missing from the minimum list presented or indicate any that may not be very significant to global production.

We thank you in advance for investing your time and expertise in selecting this key set of descriptors.

* Please allow us to acknowledge your contribution by completing your full contact details below:

Name:

Position:

Organization:

Country:

Email:

PART I: Characterization descriptors

List of highly discriminating Bioversity-IRRI descriptors for rice (Annex I, Bioversity/IRRI/WARDA, 2007), already validated and only for reference.

*Numbers on the right-hand side are the corresponding descriptors numbers as published in the Bioversity/IRRI/WARDA publication 'Descriptors for Rice (*Oryza* spp.)' (2007).

Main heading (7.2.3)
Auricle: colour (7.3.11)
Flag leaf: attitude (early observation) (7.3.22)
Culm: length (7.3.25)
Culm: anthocyanin colouration on the nodes (7.3.28)
Culm: underlying node colour (7.3.29)
Flag leaf: attitude (late observation) (7.3.34)
Stigma: colour (7.4.2)
Lemma: colour of apiculus (early observation) (7.4.6)
Awns distribution (7.4.9)
Panicle: length (7.4.18)
Panicle: attitude of main axis (7.4.19)
Panicle: attitude of branches (7.4.20)
Lemma and palea: pubescence (7.5.4)
Sterile lemma: length (7.5.10)
Longer sterile lemma length (7.5.11)
Sterile lemma: colour (7.5.13)
Caryopsis: length (7.5.20)
Caryopsis: shape (7.5.22)
Caryopsis: pericarp colour (7.5.23)
Caryopsis scent (8.1.2)

PART II: Evaluation descriptors

These descriptors include characters such as endosperm amylose content, biotic and abiotic stresses. They are the most interesting traits in crop improvement. Please consider the following factors relating to the trait when making your final decision: (i) Global impact, (ii) Initial strategic set, (iii) Importance for germplasm utilization, (iv) Data availability, (v) True economic damage and (vi) Wide geographical occurrence.

	Not Important	Important	Very important
Endosperm amylose content [%] (8.1.3)	◯	◯	◯
Cold (9.1)	◯	◯	◯
Heat (9.2)	◯	◯	◯
Drought (9.3)	◯	◯	◯
Alkali injury and salt injury (9.4)	◯	◯	◯
Flood or submergence (9.8)	◯	◯	◯
Phenotypic acceptability	◯	◯	◯
Leaf blast (*Magnaporthe grisea*) (10.1.1)	◯	◯	◯
Brown spot (*Cochliobolus miyabeanus*) (10.1.3)	◯	◯	◯
Bacterial leaf streak (*Xanthomonas oryzae* pv. *oryzicola*) (10.1.5)	◯	◯	◯
Rice Yellow Mottle Virus (10.2.4)	◯	◯	◯
Sheath blight (*Rhizoctonia solani*) (*Thanatephorus cucumeris*) (10.2.6)	◯	◯	◯
Brown planthopper (*Nilaparvata lugens*) (10.3.1)	◯	◯	◯
Stem borers (10.3.5)	◯	◯	◯
Gall midge (*Orseolia oryzae*) (10.3.7)	◯	◯	◯
Rice tungro bacilliform virus	◯	◯	◯
Plant height [cm]	◯	◯	◯

If you consider that an essential trait important for crop improvement and production is missing from this list, or, if any of the descriptors listed is not clearly useful to promote utilization, please indicate it here along with a substantiated justification.

NOTE: Please remember, this list is the starting point and will grow over time, as required.

THANK YOU VERY MUCH FOR YOUR PARTICIPATION.

Annex V – Respondents to the survey

Role	*Name*	*Organization*	*Country*
CAG	Borromeo, Teresita H	University of the Philippines Los Baños	Philippines
CAG	Khin Than Nwe	Rice Division, Department of Agricultural Research	Myanmar
CAG	Martinez, Cesar P.	CIAT	Colombia
CAG	Salaices, Luis	Oficina Española De Variedades Vegetales	SPAIN
CAG	Shobha Rani, N.	Directorate of Rice Research	India
CAG	Tang, Shengxiang	China National Rice Research Institute	China
Reviewer	Almazan, Ma. Socorro R.	IRRI	Philippines
Reviewer	Anishetty, Murthi		India
Reviewer	Catibog, Noel A.	PCARRD	Philippines
Reviewer	Faberova, Iva	Crop Research Institute Prague	Czech Republic
Reviewer	Haque, Enamul A K G Md.	Bangladesh Rice Research Institute	Bangladesh
Reviewer	Lang, Nguyen Thi	Cuulong delta rice research Insitute	Vietnam
Reviewer	Dr Lewin, Laurie	NSW Department of Primary Industries	Australia
Reviewer	Myung Chul Lee	National Agrodiversity Center	Republic of Korea
Reviewer	Nafisah, Afif	Indonesian Centre for Rice Research	Indonesia
Reviewer	Natarajan, Sivaraj	NBPGR	India
Reviewer	Padolina, Thelma F.	PhilRice	Philippines
Reviewer	Pandey, Manish Kumar	Directorate of Rice Research	India
Reviewer	Pandravada, S.R.	NBPGR Regional Station, Rajendranagar, Hyderabad-500 030, Andhra Pradesh.	India
Reviewer	Ramanantsoanirina, Alain	FOFIFA/CENRADERU	Madagascar
Reviewer	Rana, J C	National Bureau of Plant Genetic Resources Regional Station	India
Reviewer	Reaño, Renato A.	TTC-GRC IRRI	Philippines
Reviewer	Romanova, Olga	VIR	Russia
Reviewer	Site Noorzuraini Binti Abd Rahman	MARDI	Malaysia
Reviewer	Susanto, Untung	Indonesian Center for Rice Research	Indonesia
Reviewer	Watanesk, Orapin	Bureau of Rice Research and Development	Thailand
Reviewer	Yang, Sae-Jun	Natl' Institute of Crop Science, RDA	Republic of Korea
Reviewer	Zain, Abdullah Md	University Malaysia Terengganu	Malaysia

Annex VI - Survey results ranked by rating average and sent to Dr Redoña for validation

Answer Options	Rating Average	Dr. Redoña's selection
Leaf blast (*Magnaporthe grisea*) (10.1.1)	4.35	
Endosperm amylose content [%] (8.1.3)	4.33	
Brown planthopper (*Nilaparvata lugens*) (10.3.1)	4.33	
Drought (9.3)	4.19	
Flood or submergence (9.8)	4.07	
Sheath blight (*Rhizoctonia solani*) (*Thanatephorus cucumeris*) (10.2.6)	4.04	
Phenotypic acceptability	3.81	
Plant height [cm]	3.74	
Heat (9.2)	3.63	
Alkali injury and salt injury (9.4)	3.54	
Rice tungro bacilliform virus	3.52	
Bacterial leaf streak (*Xanthomonas oryzae* pv. *oryzicola*) (10.1.5)	3.50	
Stem borers (10.3.5)	3.48	
Cold (9.1)	3.41	
Gall midge (*Orseolia oryzae*) (10.3.7)	3.00	
Brown spot (*Cochliobolus miyabeanus*) (10.1.3)	2.77	
Rice Yellow Mottle Virus (10.2.4)	2.36	

Annex VII - Additional descriptors proposed in the open-ended responds section of the survey

Additional descriptors	N. of times proposed	Shobha Rani	Pandravada	Watanesk	Martinez	Romanova	Ramanantsoanirina	Than Nwe	Tang	Laurie Lewin	Reaño	Nafisah	Padolina	Susanto	Anishetty	Rana
Plant stature, considering yield potential	1													X		
Growth duration, considering crop index	1													X		
Basal leaf sheath colour	1	X														
Panicle exertion	3	X					X	X								
Leaf pubescence of blade surface	1	X														
Leaf anthocynin colouration of auricles	1	X														
Ligule shape and colour	1	X														
Awn colour	1	X														
Gelatinization temperature	1	X														
Gel consistency	1							X								
Grain chalkiness.	1	X														
Degree of germination of grains on standing	1		X													
Performance under aerobic conditions	1		X													
Glume and glume tip colour	1		X													
Presence of ornamentation/ striations/ lines on glumes	1		X													
Rice leaffolder	1			X												
Bacterial leaf blight	3			X				X				X				
Ragged stunt	1			X												
Seedling **rot**	1			X												

Additional descriptors	N. of times proposed	Shobha Rani	Pandravada	Watanesk	Martinez	Romanova	Ramanantsoanirina	Than Nwe	Tang	Laurie Lewin	Reaño	Nafisah	Padolina	Susanto	Anishetty	Rana
Grain quality in terms of high milling recovery and endosperm translucency is very important for rice trade	**1**				**X**											
Grain aroma	**2**			**X**												**X**
Grain shape	**4**				**X**			**X**						**X**		**X**
Grain size	**1**				**X**											
Grain appearance	**1**				**X**											
Kernel length								**X**								
Sead coat colour (Kernel colour)	**1**														**X**	
Neck and leaf blast resistance is very important	**1**				**X**											
***Pyricularia oryzae* Cav.** (this is known as leaf and neck blast)	**1**					**X**										
Lodging (function of soil fertility for tall plant) but related to yield threshability or shatering	**3**						**X**				**X**		**X**			
Threshability	**1**														**X**	
Initial heading	**1**							**X**								
Main heading	**1**							**X**								
1000 grain weight	**2**							**X**			**X**					

Additional descriptors	N. of times proposed	Shobha Rani	Pandravada	Watanesk	Martinez	Romanova	Ramanantsoanirina	Than Nwe	Tang	Laurie Lewin	Reaño	Nafisah	Padolina	Susanto	Anishetty	Rana
Photoperiod sensitive (strong,weak, non), which is very important character especially for temperate zone rice area	**1**								**X**							
Number of spikelets per panicle	**1**										**X**					
Number of panicles per hill.	**1**										**X**					
Viviparity	**1**												**X**			

Annex VIII - Comments on survey results received from Dr Redoña on 2nd September 2009

Answer Options	Rating Average	Dr. Redoña's selection
Leaf blast (*Magnaporthe grisea*) (10.1.1)	4.35	OK
Endosperm amylose content [%] (8.1.3)	4.33	OK
Brown planthopper (*Nilaparvata lugens*) (10.3.1)	4.33	OK
Drought (9.3)	4.19	OK
Flood or submergence (9.8)	4.07	OK
Sheath blight (*Rhizoctonia solani*) (*Thanatephorus cucumeris*) (10.2.6)	4.04	OK but no strong source or resistance to this disease so most would be susceptible
Phenotypic acceptability	3.81	OK
Plant height [cm]	3.74	OK
Heat (9.2)	3.63	OK
Alkali injury and salt injury (9.4)	3.54	OK
Rice tungro bacilliform virus	3.52	OK
Bacterial leaf streak (*Xanthomonas oryzae* pv. *oryzicola*) (10.1.5)	3.50	OK
Stem borers (10.3.5)	3.48	OK
Cold (9.1)	3.41	OK
Gall midge (*Orseolia oryzae*) (10.3.7)	3.00	Limited in occurrence to South Asian countries only
Brown spot (*Cochliobolus miyabeanus*) (10.1.3)	2.77	OK; emerging disease
Rice Yellow Mottle Virus (10.2.4)	2.36	Limited in occurrence to Africa

Annex IX - First priority set of descriptors for rice resulting from the survey shared with the Core Advisory Group for final validation on 30th September 2009[i]

Endosperm amylose content [%]	(8.1.3)
Phenotypic acceptability [IS-10]	(8.1.a)
Cold [IS-75]	(9.1)
Heat [IS-76]	(9.2)
Drought [IS-80]	(9.3)
Alkali injury and salt injury [IS-70-71]	(9.4)
Flood or submergence [IS-86]	(9.8)
Leaf blast (*Magnaporthe grisea*) [IS-30]	(10.1.1)
Brown spot (*Cochliobolus miyabe*anus) [IS-32]	(10.1.3)
Bacterial leaf streak (*Xanthomonas oryzae* pv. *oryzicola*) [IS-33]	(10.1.5)
Bacterial blight (*Xanthomonas oryzae* pv. *oryzae*) [IS-35]	(10.1.7)
Rice tungro bacilliform virus (RTBV) [RTD]	(10.2.a)
Sheath blight (*Thanatephorus cucumeris*) [IS-37]	(10.2.6)
Brown planthopper (*Nilaparvata lugens*) [IS60]	(10.3.1)
Stem borers (*Chilo suppressalis*) [IS-63]	(10.3.5)

Annex X - Final list of characterization and evaluation descriptors for Rice including descriptor states and Contributors

PLANT DATA

Main heading (7.2.3)

Date on which 80% of the plants are heading. It is specified either as the number of days from effective seeding date to main heading date or as effective seeding date and main heading date

Auricle: colour (7.3.11)

Stage: late vegetative

	(IRRI)	
0	0	Absent (no auricles)
1	011	Whitish
2	062	Yellowish green
3	080	Purple
4	081	Light purple
5	084	Purple lines

Flag leaf: attitude (early observation) (7.3.22)

Measured near the collar. Angle of attachment between the flag leaf blade and the main panicle axis. Record the average of five samples.

Stage: cultivated species at anthesis; wild species seven days after anthesis

1 Erect
3 Semi-erect (intermediate)
5 Horizontal
7 Descending

Plant: height [cm] [IS-5] **(**7.3.25a)

Use actual measurement in cm from soil surface to the tip of the tallest panicle (awns excluded). For height measurements at other growth stages, specify the stage. Record in whole numbers (do not use decimals).

Stage: after flowering to maturity.

Alternatively, they can be coded as follows:

1 Semidwarf (lowland: less than 110 cm; upland: less than 90 cm)
5 Intermediate (lowland: 110–130 cm; upland: 90–125 cm)
9 Tall (lowland: more than 130 cm; upland: more than 125 cm)

Culm: length [cm] (7.3.25)

Measured from ground level to the base of the panicle. Record the average of five actual measurements, to the nearest cm.

Stage: cultivated species after flowering to maturity; wild species seven days after anthesis.

Alternatively, cultivated species can be coded as follows:

1	Very short	(<50 cm)
2	Very short to short	(51–70 cm)
3	Short	(71–90 cm)
4	Short to intermediate	(91–105 cm)
5	Intermediate	(106–120 cm)
6	Intermediate to long	(121–140 cm)
7	Long	(141–155 cm)
8	Long to very long	(156–180 cm)
9	Very long	(>180 cm)

Culm: anthocyanin colouration on nodes (7.3.28)

The presence and distribution of purple colour from anthocyanin, observed on the outer surface of the nodes on the culm.

Stage: after flowering to near maturity

	(IRRI)	
0	0	Absent
1	080	Purple
2	081	Light purple
3	084	Purple lines

Culm: underlying node colour (7.3.29)

The underlying colour of the outer surface of the nodes on the culm, ignoring any anthocyanin colouration.

Stage: after flowering to near maturity

	(IRRI)	
0	0	No underlying colour visible due to anthocyanin
1	041	Light gold
2	060	Green

Flag leaf: attitude (late observation) (7.3.34)

(Cultivated species) Observed near the collar. Angle of attachment between the flag leaf blade and the main panicle axis. Record the average of five samples.

Stage: maturity

1	Erect
3	Semi-erect
5	Horizontal
7	Descending

Stigma: colour (7.4.2)

Observed at anthesis (between 0900 and 1400) using a hand lens

	(IRRI)	
1	010	White
2	061	Light green
3	030	Yellow
4	081	Light purple
5	080	Purple

Lemma: colour of apiculus (early observation) (7.4.6)

Stage: cultivated species after anthesis to hard dough stage (pre-ripening stage); wild species at anthesis

	(IRRI)	
1	010	White
2	020	Straw
3	052	Brown (tawny)
4	060	Green
5	070	Red
6	071	Red apex
7	080	Purple
8	087	Purple apex
9	100	Black

Awns: distribution (7.4.9)

(Cultivated species) The presence and distribution of awns along the panicle.
Stage: flowering to maturity

0 None (awnless)
1 Tip only
2 Upper quarter only
3 Upper half only
4 Upper three-quarters only
5 Whole length

Panicle: length [cm] (7.4.18)

(Wild species) Length of main axis of panicle measured from the panicle base to the tip. Record the average of five representative plants.
Stage: seven days after anthesis or upon full panicle exsertion

Panicle: attitude of main axis (7.4.19)

Stage: near maturity

1 Upright
2 Semi-upright
3 Slightly drooping
4 Strongly drooping

Panicle: attitude of branches (7.4.20)

The compactness of the panicle, classified according to its mode of branching, angle of primary branches, and spikelet density.
Stage: cultivated species near maturity; wild species seven days after anthesis

1 Erect (compact panicle)
3 Semi-erect (semi-compact panicle)
5 Spreading (open panicle)
7 Horizontal
9 Drooping

Panicle: exsertion (7.4.22)

Extent to which the panicle is exserted above the flag leaf sheath.
Stage: near maturity

1 Enclosed (panicle is partly or entirely enclosed within the leaf sheath of the flag leaf blade)
3 Partly exserted (panicle base is slightly beneath the collar of the flag leaf blade)
5 Just exserted (panicle base coincides with the collar of the flag leaf blade)
7 Moderately well exserted (panicle base is above the collar of the flag leaf blade)
9 Well exserted (panicle base appears well above the collar of the flag leaf blade)

Lemma and palea: pubescence (7.5.4)

Visual assessment of the presence and distribution of mature grains using a hand lens

1 Glabrous
2 Hairs on lemma keel
3 Hairs on upper portion
4 Short hairs
5 Long hairs (velvety)

Sterile lemma: length [mm] (7.5.10)

Record the average length of five spikelets. For spikelets with symmetrical sterile lemmas (i.e. sterile length the same on both sides), record the length here. For spikelets with asymmetrical sterile lemmas (i.e. sterile lemma on one side longer than that on the other), record here only the length of the shorter sterile lemma (see **7.5.11** for the longer sterile lemma).

May be coded as:

3 Short
5 Medium
7 Long
9 Extra long

Longer sterile lemma: length [mm] (7.5.11)

(Only for spikelets with asymmetrical sterile lemmas) Record the average length of the longer sterile lemma on five spikelets.

May be coded as:

3 Short
5 Medium
7 Long
9 Extra long

Sterile lemma: colour (7.5.13)

Observe five representative plants

	(IRRI)	
1	020	Straw
2	040	Gold
3	070	Red
4	080	Purple

Caryopsis: length [mm] (7.5.20)

Caryopsis: shape (7.5.22)

1 Round
2 Semi-round
3 Half spindle-shaped
4 Spindle-shaped
5 Long spindle-shaped

Caryopsis: pericarp colour (7.5.23)

	(IRRI)	
1	010	White
2	051	Light brown
3	055	Speckled brown
4	050	Brown
5	070	Red
6	088	Variable purple
7	080	Purple

Caryopsis: scent (8.1.2)

From cooked kernel. Use freshly harvested grain. A molecular marker for fragrance is described in Section **12.3, Fragrance** of 'Descriptors for wild and cultivated Rice (*Oryza* spp.)'

0 Non-scented
1 Lightly scented
2 Scented

Endosperm amylose content [%] (8.1.3)

Amylose content of all cultivars of low amylose and many of intermediate amylose is sensitive to high temperatures during grain-filling. Molecular markers for classifying amylose are listed in Section **12.1, Amylose content** of 'Descriptors for wild and cultivated Rice (*Oryza* spp.)'

0	Waxy-glutinous	(<3)
1	Very low	(~9)
3	Low	(~17)
5	Intermediate	(~20)
7	High	(~23)
9	Very high	(>25)

Phenotypic acceptability [IS-10] (8.1.a)

Breeding objectives for each location vary. The score should reflect the overall acceptability of the variety in the location where it is being grown.

Stage: maturity

1 Excellent
3 Good
5 Fair
7 Poor
9 Unacceptable

ABIOTIC STRESSES

Cold [IS-75] (9.1)

Heat [IS-76] (9.2)

Drought [IS-80] (9.3)

Alkali injury and salt injury [IS-70-71] (9.4)

Flood or submergence [IS-86] (9.8)

BIOTIC STRESSES

Leaf blast (*Magnaporthe grisea*) [IS-30] (10.1.1)

Brown spot (*Cochliobolus miyabeanus*) [IS-32] (10.1.3)

Bacterial leaf streak (*Xanthomonas oryzae* pv. *oryzicola*) [IS-33] (10.1.5)

Bacterial blight (*Xanthomonas oryzae* pv. oryzae) [IS-35] (10.1.7)

Sheath blight (*Thanatephorus cucumeris*) [IS-37] (10.2.6)

Rice tungro bacilliform virus (RTBV) [IS-36] (10.2.a)

Brown planthopper (*Nilaparvata lugens*) [IS-60] (10.3.1)

Stem borer (*Chilo suppressalis*) [IS-63] (10.3.5)

CONTRIBUTORS

CORE ADVISORY GROUP

Edilberto D. Redoña, International Rice Research Institute (IRRI), Philippines
Teresita H. Borromeo, University of the Philippines Los Baños, Philippines
Cesar P. Martinez, Centro Internacional de Agricultura Tropical (CIAT), Colombia
Khin Than Nwe, Department of Agricultural Research, Myanmar
Luis Salaices, Oficina Española de Variedades Vegetales, Spain
N. Shobha Rani, Directorate of Rice Research, India
Shengxiang Tang, China National Rice Research Institute, China

REVIEWERS

Australia
Laurie Lewin, NSW Department of Primary Industries

Bangladesh
A. K. G. Md. Enamul Haque, Bangladesh Rice Research Institute

Czech Republic
Iva Faberova, Crop Research Institute, Prague

India
Narasimha Murthi Anishetty
Manish Kumar Pandey, Directorate of Rice Research
S. R. Pandravada, National Bureau of Plant Genetic Resources (NBPGR)
J. C. Rana, National Bureau of Plant Genetic Resources (NBPGR)
Natarajan Sivaraj, National Bureau of Plant Genetic Resources (NBPGR)

Indonesia
Afif Nafisah, Indonesian Center for Rice Research
Untung Susanto, Indonesian Center for Rice Research

Madagascar
Alain Ramanantsoanirina, Centre National de la Recherche Applique au Développement Rurale (FOFIFA/CENRADERU)

Malaysia
Site Noorzuraini Binti Abd Rahman, Malaysian Agricultural Research and Development Institute (MARDI)
Abdullah Md Zain, University Malaysia Terengganu

Philippines
Ma. Socorro R. Almazan, International Rice Research Institute (IRRI)
Noel A. Catibog, Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD)
Thelma F. Padolina, Philippine Rice Research Institute (PhilRice)
Renato A. Reaño, Genetic Resources Center, International Rice Research Institute (TTC-GRC, IRRI)

Republic of Korea
Myung Chul Lee, National Agrodiversity Center
Sae-Jun Yang, National Institute of Crop Science (RDA)

Russia
Olga Romanova, N. I. Vavilov Institute of Plant Industry (VIR)

Thailand
Orapin Watanesk, Bureau of Rice Research and Development

Vietnam
Nguyen Thi Lang, Cuulong Delta Rice Research Institute

Methodology for the definition of a key set of characterization and evaluation descriptors for sorghum [*Sorghum bicolor* (L.) Moench]

Information collection and preparation of the Minimum Descriptor List (MDL)

Information for the definition of a Minimum Descriptor List for sorghum [*Sorghum bicolor* (L.) Moench] was drawn from the publication 'Descriptors for Sorghum [*Sorghum bicolor* (L.) Moench]' (IBPGR and ICRISAT, 1993). The list was compared with descriptors highlighted as most important in the SGRP Global Public Goods, Phase 2 (GPG2) activity 4.2.1.1. A summary report on SGRP GPG2 data received can be found in Annex I. Results were subsequently integrated and harmonized with descriptors suggested in the 'Guidelines for the Conduct of Tests for Distinctness, Homogeneity and Stability' on *Sorghum bicolor* (L.) (International Union for the Protection of new Varieties of Plants, UPOV, 1989); the list of Descriptors for SORGHUM (USDA, ARS, GRIN); 'Characterization of ICRISAT-bred Sorghum Hybrid Parents' (Set I) (International Sorghum and Millets Newsletter, No. 47, Special issue, ICRISAT 2006). The list was then weighed against the 'Revised Descriptors for Sorghum [*Sorghum bicolor* (L.) Moench]' (IPGRI and ICRISAT, 2007), that was developed by a Committee formed at the Expert Consultation Meeting for Developing a Strategy for the Global Conservation of Sorghum Genetic Resources, held at ICRISAT, Patancheru, India March 2007, supported by the Global Crop Diversity Trust and ICRISAT. The comparison table obtained from all of the above documents and publications was further discussed during a crop-specific meeting held at the National Bureau of Plant Genetic Resources (NBPGR), in India in June 2009. During this meeting, a minimum and a long list were selected, the latter serving as a basis for the revision of the conventional list of sorghum descriptors. The resulting list of descriptors was also compared with the list of traits provided by the National Institute of Agrobiological Sciences (NIAS) (see Annex II).

Preparation of the List of Experts

Experts included in the list were some of the participants in crop-specific consultations for the definition of the 'Strategy for the Global *Ex Situ* Conservation of Sorghum Genetic Diversity (the Trust, 2007), representatives of the world's major sorghum collections, plant pathologists and breeders, besides experts that took part in the crop-specific consultation held in NBPGR, India. Overall, 74 experts were identified, coming from 24 countries and 45 different organizations (see Annex III). Out of these, Dr Jeff Dahlberg (United Sorghum Checkoff Program, USA) was identified as Crop Leader and a Core Advisory Group (CAG) consisting of 12 experts was selected to assist in the definition of a minimum set of descriptors, which was subsequently circulated for validation among a wider group of experts.

Survey preparation and distribution

The comparison table was submitted to members of the Core Advisory Group to assist them in the selection of a preliminary reduced set of traits. Dr Jeff Dahlberg, Crop Leader, selected traits to be included in the conventional long list and identified the key traits for the minimum set, while the selection of Dr Robert Henzell (Department of Primary Industries & Fisheries, Australia), a member of the CAG, focused only on the importance of traits for breeders. Feedback from NBPGR was also taken into consideration while harmonizing the list to be included in the survey. The aim of the survey was twofold: (i) to define a key set of descriptors for the utilization of sorghum genetic resources and (ii) to revise/validate the conventional list, as originally requested by Dr Dahlberg and Dr Henzell. In order to achieve this result, the survey was divided in two parts. The first part consisted of defining an 'Initial minimum key set of characterization and evaluation descriptors important for utilization' that focused mainly on the essential key traits. The second part included 'Other descriptors important for describing, discriminating and utilizing sorghum genetic resources' which would be included in the revised version of the updated conventional list, but not preventing the inclusion of some of them in the high priority list, provided they were well rated.

A list of descriptors, drawn from the comparison table to be included in the survey was submitted to the experts and subsequently endorsed by them (see Annex IV).

A draft survey on sorghum was prepared listing the descriptors validated by the experts. Once approved, the final draft of the survey was uploaded into the SurveyMonkey application (see Annex V) on the internet and sent out to the list of identified experts on 21 September 2009. The survey deadline was set at 23 October 2009. A first reminder was sent out on the 6 October 2009 and a second one on 19 October 2009 to ensure that the greatest possible feedback was obtained.

Survey analysis and refinement of the Minimum List

Out of the 74 experts who were identified and involved in the exercise, 39 from 15 countries and 26 organizations participated in this exercise (see Annex VI). Of the 39 respondents, 36 recorded their comments using the online survey whilst three additional experts participated during the second phase providing their advice on the survey outcomes.

Results from the consultation were analyzed and descriptors were ranked by rating average and percentage of importance (see Annex VII). Descriptors having a wide consensus amongst experts were highlighted in yellow. These summary results of the survey were sent to the Core Advisory Group inviting experts to select descriptors that should be included in the key set by indicating them with an 'X' in the relevant column. Other descriptors, such as 'Race (1.5.5)' and 'Group name (1.5.6)' that belong to Passport data, had been added to the key set because considered extremely important for understanding the type of material and making relevant selections.

After lengthy discussions concerning the definition of descriptors' names, methods and states chosen for the minimum priority set for sorghum, a first draft was compiled and shared with the Core Advisory Group for their approval on 11 March 2010 (see Annex VIII). The list resulting from these consultations was shared with all of the scientists (see Annex IX). They were asked to validate the key set, making them aware about the need to select traits and characteristics of a cosmopolitan nature and wide geographical coverage. Further comments received from ICRISAT were included and harmonized wherever possible with the final version. Dr Hari D. Upadhyaya (ICRISAT, India) was added as Crop Leader due to the substantial scientific advice provided.

Unfortunately, advice provided by Dr M. Elangovan of the Directorate of Sorghum Research (formerly National Research Centre for Sorghum), India could not be implemented during this first phase because consultations were already closed, but they will be included in a second round. Before implementing any change/addition/deletion to the agreed list (i.e. including new sizes, new colours, etc.), the list should be shared with the whole community, led by the Crop Leaders, to reach the right consensus amongst countries in order to obtain 'international' status. This exercise is therefore just the first step of an evolving process, so there will be opportunities in the near future to implement further additions, after they have been widely agreed.

Definition of a final key set of descriptors for sorghum

The final document approved by the whole group of experts, including all the descriptor states and contributors (see Annex X), was edited and proofread by an external editor and afterwards laid out and sent to the Bioversity Publications Unit for on-line publication processes. Additionally, the publication was shared with ECPGR; the Generation Challenge Programme (GCP) Ontology and the SGRP Crop Genebank Knowledge Base partners. Furthermore, data were converted into Excel files for uploading into the GRIN-Global genebank data-management system being developed by USDA, and into the global accession level information portal (GENESYS), linking national, regional and international genebank databases in support of the conservation and use of plant genetic resources for food and agriculture (PGRFA). The Excel files were also provided to the System-wide Information Network for Genetic Resources (SINGER) and to EURISCO.

Acknowledgement

Bioversity is grateful to all the scientists and researchers who have contributed to the development of the strategic set of 'Key access and utilization descriptors for sorghum genetic resources', and to the Global Crop Diversity Trust for their financial support. Particular recognition goes to Drs Jeff Dahlberg, Bob Henzell and Hari D. Upadhyaya for providing valuable scientific direction.

Annex I – Summary report on sorghum data from the SGRP Global Public Goods, Phase 2 (GPG2) exercise 4.2.1.1

Within the framework of Component 1 of the GIGA Project ('Development of characterization and evaluation data standards for 22 target crops'), data provided by Hari D. Upadhyaya (ICRISAT, India) on sorghum, resulting from the GPG2 4.2.1.1 exercise, was analyzed to identify a key set of descriptors for this crop.

The following factors will be considered when selecting key traits:

1. Global impact
2. Initial strategic set
3. Importance for germplasm utilization
4. Data availability
5. True economic damage
6. Wide geographical occurrence

Data received from ICRISAT were compared to the descriptors list for sorghum, drawn from 'Descriptors for Sorghum [*Sorghum bicolor* (L.) Moench.]' (IBPGR/ICRISAT, 1993). Unfortunately, no important descriptors were mentioned in the 'Strategy for the global *Ex-situ* conservation of Sorghum genetic diversity' (the Trust, 2007), to be able to perform a comparison.

The list was ultimately composed of the descriptors highlighted as most important on a 1-5 scale by ICRISAT (where 1 = most important). Diagnostic traits (1), breeding traits (3) and diagnostic/breeding traits (5) were included.

Numbers in parentheses on the right hand side are the original descriptor numbers drawn from the publication 'Descriptors for Sorghum' (IBPGR/ICRISAT, 1993).

1.	Plant height (5)	(4.1.1)
2.	Plant colour (1)	(4.1.2)
3.	Waxy bloom (1)	(4.1.6)
4.	Days to flowering (5)	(4.2.1)
5.	Inflorescence compactness and shape (5)	(4.2.2)
6.	Grain covering (1)	(4.2.4)
7.	Seed colour (5)	(4.3.1)
8.	Grain lustre (5)	(4.3.2)
9.	100-seed weight (5)	(4.3.3)
10.	Grain number per panicle (5)	(4.3.4)
11.	Grain sub-coat (1)	(4.3.5)
12.	Endosperm texture (1)	(4.3.8)
13.	Inflorescence exsertion (5)	(6.2.4)
14.	Inflorescence length [cm] (5)	(6.2.5)
15.	Inflorescence width [cm] (5)	(6.2.6)
16.	Seed threshability [%] (3)	(6.3.2)
17.	Sorghum shoot fly (3)	(8.1.1)
18.	Spotted stem borer (3)	(8.1.2)
19.	Sorghum midge (3)	(8.1.5)
20.	Earhead bug (3)	(8.1.6)
21.	Sugarcane aphid (3)	(8.1.13)

22. Anthracnose (8.2.3)
23. Grain moulds (3) (8.2.4)
24. Leaf blight (3) (8.2.5)
25. Downy mildew (3) (8.2.11)
26. Rust (3) (8.2.13)
27. Ergot (3) (8.2.15)
28. Striga (3) (8.5.1)

Remarks:

From the documents received:

1. Some descriptors are not rated (e.g. stalk juiciness, juice flavour, awns, shattering, quality traits and abiotic stresses).
2. No reply was received to questions 3a and 3b respectively "Are the above (1-28) descriptors adequate?"; "If not, list the additional descriptors for characterization".
3. No answer was provided to question 4 "List the 15 most important descriptors for characterization and evaluation (based on their value in research and breeding), in order of preference, which includes existing descriptors along with suggested new descriptors. (If you wish list can be shorter or exceed 15)".
4. No answer was received to question 5 "What are the specific breeding traits (grain quality, agronomic, biotic and abiotic traits) for which evaluation was done and to how many accessions?".
5. There is no indication on whether data are available for these traits.

Annex II – Comparison table weighing up important descriptors for sorghum drawn from different sources[1] [2]

Descr. no.	Descriptor name	IBPGR/ ICRISAT 1993 (a)	UPOV (1989) (b)	ARS_U SDA (c)	GPG2 (most imp =1) (d)	ICRISAT DUS 2006 (e)	Breeding traits (GPG2) (d)	NBPGR (f)	Dahlberg	Henzell	NIAS Genebank (g)
4.1.1	Plant height [cm]	*	*	*	*	*		B	B	B	
4.1.2	Plant colour	*		*	*			L	B	B	
4.1.3	Stalk juiciness	*		*				B	L	B	
4.1.4	Juice flavour	*						B	L		
4.1.5	Leaf midrib colour	*	*	*		*		B	B	B	
4.1.6	Waxy bloom	*		*	*			L	B		
4.2.1	Days to 50% flowering	*		*	*			B	B	B	*
4.2.2	Inflorescence compactness and shape	*	*	*	*	*		B	B	B	*
4.2.3	Glume colour	*	*	*		*		B	B	B	
4.2.4	Grain covering	*		*	*			B	B	B	*
4.2.5	Awns	*		*				L	B		
4.2.6	Shattering	*		*				L	B	B	
4.3.1	Grain colour	*	*	*	*	*		B	B	B	*
4.3.2	Grain lustre	*			*			L	L		
4.3.3	1000-seed weight [g]	*			*			B	L	B	
4.3.5	Pigmented testa (Grain sub-coat)	*			*			EXCL	B		
4.3.6	Grain plumpness	*		*				L	L	B	
4.3.7	Grain form	*		*				L	B	B	
4.3.8	Endosperm texture	*		*	*			L	B	B	
4.3.9	Endosperm colour	*		*				L	B	B	

4.3.10	Endosperm type	*		*				**L**	**B**	**B**	
6.1.1	Seedling vigour	*		*				**L**	**L**		
6.1.2	Lodging susceptibility	*		*				**Exclude: not a genetic trait**	**B**	**B**	
6.1.3	Senescence rating	*						**B**	**L**	**B**-This is a very important trait - make sure it is clear that this is a post-anthesis drought resistance trait see 6.1.5 in Jeff's descriptor table RGH	
6.2.1	Photosensitivity	*		*				**L**	**L**	**B**	
6.2.2	Number of flowering stems per plant	*						**EXCL**	**L**		
6.2.3	Synchrony of flowering	*						**EXCL**	**L**	**L**	
6.2.4	Inflorescence exsertion	*		*	*			**L**	**B**	**B**	
6.2.5	Inflorescence length [cm]	*		*	*			**B**	**B**	**B**	*
6.2.6	Inflorescence width (head) [cm]	*			*			**B**	**L**	**B**	
6.2.7	Restoration response (Milo source)	*						**L**	**L**	**B**	
6.2.8	Male sterile cytoplasm system	*						**L**	**L**		
6.3.1	Grain hardness [kg]	*						**EXCL**	**L**		
6.3.2	Threshability [%]	*			*			**L**	**L**	**B**	
6.3.3	Grain weathering susceptibility	*		*				**??**	**L**	Low heritability	
7.1	Reaction to low temperature	*					*	**L**	**L**	**B**	

7.2	Reaction to high temperature	*					*	**L**	**L**	**B**	
7.3	Reaction to drought	*					*	**B**	**L**	**B**	
7.4	Reaction to high soil moisture	*						**L**	**L**		
7.5	Reaction to salinity	*					*	**L**	**L**	**B**	
7.6	Reaction to soil acidity	*					*	**L**	**L**	**B**	
8.1.1	Sorghum shoot fly (*Atherigona soccata)*	*			*		*	**B**	**L**	**B**	
8.1.2	Spotted stem borer (*Chilo partellus)*	*			*		*	**B**	**L**	**B**	
8.1.3	Maize stalk borer (*Busseola fusca*)	*						**B**	**L**	**L**	
	Pink Stem Borer (*Sesamia inferens*)	*						**L**	**L**	**L**	
	Pink Borer (Africa) (*Sesamia calamistis*)	*						**L**	**L**	**L**	
8.1.4	Sugarcane borer, Stem borer (*Diatraea saccharalis)*	*						**L**	**L**	**L**	
	Lesser Cornstalk Borer (*Elasmopalpus lignosellus*)							**L**	**L**		
8.1.5	Sorghum midge (*Stenodiplosis sorghicola)*	*			*		*	**B**	**L**	**B**	
8.1.6	Earhead bug (*Calocoris angustatus; Eurystylus immaculatus)*	*			*			**L**	**L**		
8.1.7	Corn earworm *(Heliothis zea)*	*						**EXCLUDE**	**L**		
8.1.8	African bollworm (*Helicoverpa armigera*)	*						**EXCLUDE**	**L**		
8.1.9	Armyworms *(Spodoptera* spp.)	*		* (FAW)				**?**	**L**		
8.1.10	Oriental armyworms *(Mythimna separata)*	*						**?**	**L**		
8.1.11	Greenbug (*Schizaphis graminum*)	*		*				**?**	**L**	**B**	
	Shoot Bug (*Peregrinus maidis*) (Ashmead)							**L**	**L**		

	Spittel Bug (*Poophilus costalis*)							**L**	**L**		
	Sap-sucking Bug (*Dolycoris indicus*)							**L**	**L**		
8.1.12	Corn leaf aphid (*Rhopalosiphum maidis)*	*						**EXCLUDE**	**L**		
8.1.13	White sugarcane aphid (*Melanaphis sacchari)*	*			*		*	**L**	**L**		
8.1.14	Chinch bug (*Blissus leucopterus)*	*						**L**	**L**		
8.1.15	White grubs *(Phyllophaga crinita; Schizonycha* spp., *Holotrichia* spp.*)*	*						**EXCL**	**L**		
8.1.16	Sorghum web worm (*Nola sorghella*)	*						**L**	**L**		
	Earhead web worm (*Nola analis; Cryptoblabes gnidiella*)							**L**	**L**		
8.1.17	Web worm *(Stenachroia elongella*; *Eublemma* spp.)	*						**EXCL**	**L**		
8.1.18	Sorghum mite *(Oligonychus indicus)*	*						**EXCL**	**L**		
8.1.19	Banks grass mite (*Oligonychus pratensis*)	*						**L**	**L**		
8.1.20	Grasshopper (*Oedaleus senegalensis*)	*						**EXCL**	**L**		
8.1.21	Locusts (*Locusta migratoria*)	*						**EXCL**	**L**		
8.1.22	Birds	*						**EXCL**	**L**		
	Cutworms							**L**	**L**		
	Wireworms							**L**	**L**		
	Southern corn rootworm (*Diabrotica undecimpuncta*)							**L**	**L**		
8.2.1	Rough leaf spot (*Ascochyta sorghi)*	*						**L**	**L**		
8.2.2	Grey leaf spot *(Cercospora sorghi*)	*		*				**L**	**L**	**B**	

	Ladder leaf spot (*Cercospora fusimaculans*)							**B**	**L**	**B**	
8.2.3	Anthracnose *(Colletotrichum graminicola)*	*		*	*		*	**B**	**L**	**B**	
8.2.4	Grain moulds (*Curvularia lunata*; *Fusarium* spp.)	*			*		*	**B**	**L**	**B**	
8.2.5	Leaf blight *(Exserohilum turcicum; Setosphaeria turcica; Helminthosporium turcicum)*	*		*	*			**B**	**L**	**B**	
8.2.6	Target leaf spot *(Bipolaris sorghicola)*	*						**EXCL**	**L**		
8.2.7	Oval leaf spot *(Ramulispora sorghicola)*	*						**EXCL**	**L**		
8.2.8	Tar spot *(Phyllachora sacchari)*	*						**EXCL**	**L**		
8.2.9	Zonate leaf spot *(Gloeocercospora sorghi)*	*		*				**L**	**L**	**B**	
8.2.10	Charcoal rot *(Macrophomina phaseolina)*	*					*	**B**	**L**	**B**	
	Fusarium root and stalk rot, Head blight *(Fusarium* spp.)							**L**	**L**	**B**	
8.2.11	Downy mildew *(Peronosclerospora sorghi)*	*		*	*		*	**B**	**L**	**B**	
8.2.12	Black dot grain mould (*Phoma insidiosa*)	*						**EXCL**	**L**		
8.2.13	Rust *(Puccinia purpurea)*	*		*	*			**L**	**L**	**B**	
8.2.14	Sooty stripe *(Ramulispora sorghi)*	*						**EXCL**	**L**		
8.2.15	Ergot *(Sphacelia sorghi, Claviceps africana)*	*		*	*			**L**	**L**	**B**	
8.2.16	Smut (*Sphacelotheca* spp.)	*						**L**	**L**		

8.2.19	Long smut *(Tolyposporium ehrenbergii, Sporisorium cruentum)*	*						**L**	**L**		
8.3.1	Bacterial leaf stripe *(Pseudomonas andropogoni)* (E.F.Sm.) Stapp.	*						**L**	**L**	**B**	
8.3.2	Bacterial leaf spot *(Pseudomonas syringae)*	*						**L**	**L**	**B**	
8.3.3	Bacterial leaf streak *(Xanthomonas campestris)*	*						**L**	**L**	**B**	
8.4.1	Maize dwarf mosaic virus (MDMV)	*						**EXCL**	**L**		
8.4.2	Sugarcane mosaic virus (SCMV)	*		*				**EXCL**	**L**		
8.4.3	Johnsongrass mosaic virus (JsGMV)	*						**EXCL**	**L**		
8.4.4	Maize stripe virus (MStV)	*						**EXCL**	**L**		
8.4.5	Maize mosaic virus (MMV)	*						**EXCL**	**L**		
8.5.1	Witchweed *(Striga asiatica; Striga densiflora; Striga hermonthica)*	*			*		*	Imp x Africa	**L**		
	Sorghum yellow banding virus (SYBV)			*				**EXCL**	**L**		
	Number of basal tillers per plant			*				**EXCL**	**B**		*
	Glume pubescence			*				**L**	**B**		
	Grain shape			*				**B**	**L**	**B**	
	Mesocarp thickness			*				**EXCL**	**B**		
	Nodal tiller			*				**EXCL**	**L**		
	Pericarp colour (red, white and lemon yellow)			*					**B**		
	Spreader			*				**EXCL**	**B**		
	Maturity group (early, medium, late)			*				**EXCL**	**L**		

	Grain yield potential			*			* (grain yeild)	**EXCL**	**B**	**B**	
	Grain nutrient content (fat, phosphorous, starch, sucrose, dry matter)			*				**EXCL**	**L**		
	Aluminum toxicity			*				**EXCL**	**L**		
	Manganese toxicity			*				**EXCL**	**L**		
	Fodder yield						*	**L**	**L**		
	Desirability Rating							**EXCL**	**B**	**B**	
	Intensifier gene							**EXCL**	**L**		
	Coleoptile color							**EXCL**	**L**		
	Peduncle breakage							**EXCL**	**L**		
	Pollen shed							**EXCL**	**L**	**B**	
	Red-headed Hairy Caterpillar (*Amsacta albistriga)*							**L**	**L**		
	Flea Beetle (Several species, *Chrysomelidae*)							**L**	**L**		
	Grey Leaf Weevil (*Myllocerus subfasciatus)*							**L**	**L**		
	Sugarcane Rootstock Weevil *(Anacentrinus deplanatus)*							**L**	**L**		
	Blister Beetle (*Calocoris angustatus*)							**L**	**L**		
	Bacterial Leaf Blight (*Acidovorax avenae)*							**L**	**L**		
	Bacterial top and Stalk rot (*Erwinia chrysanthemi*)							**L**	**L**		
	Yellow Leaf Blotch *(Pseudomonas* sp.)							**L**	**L**		

	Seedling Diseases (Various genus: *Pythium* spp., *Fusarium* spp., *Aspergillus* spp., *Rhizoctonia* spp., *Phoma* spp.)							**L**	**L**		
	Crazy Top (*Sclerophthora macrospora*)							**L**	**L**		
	Pokkah Boeng (*Gibberella intermedia*)							**L**	**L**		
	Milo Disease (*Periconia circinata*) (L. Mangin) Sacc.							**L**	**L**		
	Pythium Root Rot *(Pythium* spp.)							**L**	**L**		
	Acremonium Wilt (*Acremonium strictum*)							**L**	**L**		
	Banded Leaf and Sheath Blight (*Rhizoctonia solani*) Kühn							**L**	**L**		
	Southern Sclerotial Rot (*Sclerotium rolfsii*) Sacc.							**L**	**L**		
	Storage moulds (Several Genus: *Aspergillus* spp., *Penicillium* spp., *Alternaria* spp., *Fusarium* spp.)							**L**	**L**		
	Maize chlorotic dwarf virus (MCDV)							**L**	**L**		
	Sorghum chlorotic spot virus (SgCSV)							**L**	**L**		
	Peanut clump virus (PCV)							**L**	**L**		
	Sorghum stunt mosaic virus (SSMV)							**L**	**L**		
	Maize rough dwarf virus (MRDV)							**L**	**L**		
	Mal de Rio Cuarto virus (MRCV)							**L**	**L**		

	Fiji disease virus (FDV)							L	L		
	Maize streak virus (MSV)							L	L		
	Yellow Sorghum Stunt (YSS)							L	L		
	Stunt Nematodes *(Tylenchorhynchus* spp.)							L	L		
	Root-Lesion Nematodes (*Pratylenchus* spp.)							L	L		
	Root-Knot Nematodes *(Meloidogyne* spp.)							L	L		
	Culm length										*
	Grain weight per panicle										*
	Panicle type										*
	Date of maturity										*
	Diameter of culm										*
	Leaf length										*
	Leaf width										*

[1] (a) 'Descriptors for Sorghum [*Sorghum bicolor* (L.) Moench]' (IBPGR and ICRISAT, 1993);
(b) 'Guidelines for the Conduct of Tests for Distinctness, Homogeneity and Stability' on *Sorghum bicolor* (L.) (International Union for the Protection of New Varieties of Plants, UPOV, 1989);
(c) 'Descriptors for SORGHUM' (USDA-ARS-GRIN);
(d) Descriptors highlighted as most important in the GPG2 4.2.1.1 exercise and breeding traits;
(e) 'Characterization of ICRISAT-bred Sorghum Hybrid Parents' (Set I) (International Sorghum and Millets Newsletter, No. 47, Special issue, ICRISAT 2006);
(f) A minimum and a long list selected during a crop specific meeting held at the National Bureau of Plant Genetic Resources (NBPGR), in India in June 2009;
(g) Traits provided by the National Institute of Agrobiological Sciences (NIAS), Japan.

[2] L = Long list; B= Both lists (Minimum and Long); and EXCL = exclude from both lists.

Annex III - List of experts identified to participate in the survey for the definition of a minimum set of descriptors for sorghum

Role	***Name***	***Organization***	***Country***
Crop Leader (Crop Strategy Expert)	**Dahlberg, Jeff**	United Sorghum Checkoff Program (USCP)	USA
CAG (Crop Strategy Expert)	Chantereau, Jacques	CIRAD	France
CAG (UPOV)	Guiard, Joël	GEVES	France
CAG (Suggested at ontology workshop)	Hash, C. Tom	ICRISAT	India
CAG (Crop Strategy Expert)	Henzell, R.G.	Department of Primary Industries & Fisheries	Australia
CAG	Khairwal, I.S.	AICPMIP	India
CAG (Bioversity)	Mathur, Prem	Bioversity International, Office for South Asia	India
CAG (Suggested by Jeff ahlberg/Added later)	Miller, Fred	MMR Genetics	USA
CAG (Crop Strategy Expert)	Pederson, Gary A.	ARS/USDA	USA
CAG/NBPGR	Prandavada S.R.	NBPGR	India
CAG (Crop Strategy Expert)	Seetharam, A.	Emeritus Scientist, AICRP on Small millets, Bangalore	India
CAG (Crop Strategy Expert)	Seetharama, N.	Directorate of Sorghum Research (formerly National Research Centre for Sorghum)	India
CAG (Crop Strategy Expert)	Updadhyaya, Hari D.	ICRISAT	India
Syngenta Foundation, Sorghum Breeder	Aboubacar, Touré	Institut d'Economie Rurale (IER) Bamako	Mali
Major collections	Aragón Cuevas, Flavio	INIFAP - Banco de Germoplasma de Oaxaca	Mexico
New	Aruna, C.	National Research Centre for Sorghum (NRCS)	India
Syngenta Foundation finger millet survey	Adugna, Asfaw	Ethiopian Institute of Agricultural Research (EIAR)	Ethiopia

NBPGR meeting	Ashok, Kumar	NBPGR	India
Crop Strategy Expert	Atoyebi, J.	National Centre for Genetic Resources and Biotechnology	Nigeria
Syngenta Foundation	Bandyopadhyay, Ranajit	IITA	Nigeria
Crop Strategy Expert	Beyene, M.	Institute of Biodiversity Conservation	Ethiopia
Crop Strategy Expert	Borikar, S.T.	Marathwada Agricultural University	India
Syngenta Foundation	Borrell, Andrew	Department of Primary Industries & Fisheries	Australia
Sorghum breeding Intsormil	Coulibaly, S.B.	Institut d'Economie Rurale (IER)	Mali
Syngenta Foundation	Ebiyau, Johnie	SAARI	Uganda
Crop Strategy Expert/Forwarded to Awdelkarim	El Tahir, I.M.	Agricultural Research Corporation	Sudan
Plant pathologist (specialized in sorghum)	Erpelding, John E.	ARS/USDA	USA
Major collections	Franzone, Pascual	INTA	Argentina
Syngenta Foundation	Glaszmann, Jean-Christophe	CIRAD	France
Crop Strategy Expert	Gowda, C.L.L.	ICRISAT	India
Revised descriptors	Grenier, Cecile	Purdue University	USA
Syngenta Foundation finger millet survey	Habindavyi, Espérance	Institut des Sciences Agronomiques du Burundi	Burundi
Syngenta Foundation	Hamid, Adam M. Ali	Sudan Ag Res & Tech Corp	Sudan
Syngenta Foundation	Jordan, David	DPI&F	Australia
NBPGR meeting	Jyoti, Kaul	Directorate of Maize Research	India
Crop Strategy Expert	Kamatar, M.Y.	Sorghum Improvement Project - University of Agricultural Sciences	India

McKnight Foundation Collaborative Crop Research Program	Kapran, Issoufou	INRAN	Niger
Major collections	Kawase, Makoto	National Institute of Agrobiological Sciences	Japan
NIAS website	Kazutoshi Okuno	NIAS genebanK	Japan
Syngenta Foundation	Kwame Offei, Sam	University of Ghana	Ghana
Syngenta Foundation	Li, Yu	Institute of Crop Sciences (CAAS)	China
Suggested by Marilia Burle/Added later	Lira, Mário de Andrade	Instituto Agronômico de Pernambuco (IPA)	Brazil
Syngenta Foundation	Magalhaes, Jurandir	EMBRAPA	Brazil
Suggested by Marilia Burle/Added later	Martins Netto, Déa Alécia	EMBRAPA	Brazil
NBPGR meeting	Mishra, S.K.	NBPGR	India
Major collections/ Forwarded to Romanova	Mitrofanova, Olga P.	N.I. Vavilov Research Institute of Plant Industry (VIR)	Russian Federation
Syngenta Foundation	Muller, Neil	Pacific Seeds, Advanta Seeds	Australia
Reviewer	Muthamia, Zachary K.	National Genebank of Kenya (KARI)	Kenya
Syngenta Foundation	Muuka, Ferdinand	Zambia ARS	Zambia
Syngenta Foundation	Ochanda, James	BECA, ILRI	Kenya
Syngenta Foundation Senior Scientist, pearl millet survey	Parzies, Heiko K.	University of Hohenheim, Inst. of Plant Breeding	Germany
Sorghum & Millet Crop Germplams Committee	Pedersen, Jeff	ARS/USDA	USA
Crop Strategy Expert	Ping, Lu	Institute of Crop Sciences (CAAS)	China
Major collections	Ramirez, Dolores, A.	Institute of Plant Breeding/ULPB	Philippines

SRG	Rao, Kameswara	International Center for Biosaline Agriculture (ICBA)	India
Syngenta Foundation Collaborative Crop Research programme (website)	Rattunde, Fred	ICRISAT	Mali
Crop Strategy Expert	Reddy, Belum	ICRISAT	India
Crop Strategy Expert	Reddy, M. Thimma	ICRISAT	India
Crop Strategy Expert	Rosenow, Darrell	Texas Agricultural Experiment Station	USA
NBPGR meeting	Sain, Dass	Directorate of Maize Research	India
Syngenta Foundation	Schaffert, Robert	EMBRAPA	Brazil
Suggested by H. Knüpffer	Schmidt, Barbel	IPK, Gatersleben - Genebank Dept	Germany
Crop Strategy Expert	Sharma, H.C.	ICRISAT	India
Crop Strategy Expert	Sharma, S.K.	NBPGR	India
EVIGEZ Information system	Stehno, Zdenek	Crop Research Institute (CRI) Dept Gene Bank	Czech Republic
Syngenta Foundation Sorghum and Millet research coordinator, finger millet survey	Tadesse, Taye	Ethiopian Institute of Agricultural Research	Ethiopia
Reviewer (NBPGR meeting)	Tara Satyavathi, C.	Indian Agricultural Research Institute	India
Crop Strategy Expert	Thakur, R.P.	ICRISAT	India
Reviewer (NBPGR meeting)	Unnikrishnan, K.V.	Indian Agricultural Research Institute	India
Crop Strategy Expert	Vadez, V.	ICRISAT	India
Crop Strategy Expert	Wang, Shumin	Institute of Crop Sciences (CAAS)	China

Syngenta Foundation	Wanyera, Nelson	SAARI	Uganda
Crop Strategy Expert	Weltzien, Eva	ICRISAT	India
Syngenta Foundation Program Director CRSP	Yohe, John M.	Int Sorghum/millet program	USA

Annex IV – List of descriptors, drawn from the comparison table, to be included in the survey, approved by the experts after consultations

(bold face= to be included in the first section; normal face= to be included in the second section)

1.	**Plant height [cm]**	**4.1.1**
2.	**Plant colour**	**4.1.2**
3.	Stalk juiciness	4.1.3
4.	Juice flavour	4.1.4
5.	**Leaf midrib colour**	**4.1.5**
6.	Waxy bloom	4.1.6
7.	Number of basal tillers per plant	
8.	Nodal tillering	
9.	**Grain yield**	
10.	Fodder yield	
11.	Desirability rating (total plant)	
12.	**Days to 50% flowering**	**4.2.1**
13.	**Inflorescence compactness and shape**	**4.2.2**
14.	**Glume colour**	**4.2.3**
15.	**Grain covering**	**4.2.4**
16.	Awns	4.2.5
17.	Glume pubescence	
18.	**Shattering**	**4.2.6**
19.	**Grain colour**	**4.3.1**
20.	Grain luster	4.3.2
21.	Seed shape	
22.	**100-seed weight [g]**	**4.3.3**
23.	Genotypic pericarp colour	
24.	Pigmented testa (Grain sub-coat)	4.3.5
25.	Grain plumpness	4.3.6
26.	Intensifier gene	
27.	Grain form	4.3.7
28.	Mesocarp thickness	
29.	**Endosperm texture**	**4.3.8**
30.	Endosperm colour	4.3.9
31.	Absence/presence of spreader gene	
32.	Endosperm type	4.3.10
33.	Coleoptile color	
34.	Seedling vigour	6.1.1
35.	**Lodging susceptibility**	**6.1.2**
36.	Senescence rating	6.1.3
37.	Peduncle breakage	
38.	Photosensitivity	6.2.1
39.	Number of flowering stems per plant	6.2.2
40.	Pollen shed	
41.	Synchrony of flowering	6.2.3
42.	**Inflorescence exsertion**	**6.2.4**
43.	**Inflorescence length [cm]**	**6.2.5**
44.	Inflorescence width (head) [cm]	6.2.6
45.	Restoration response (Milo source)	6.2.7
46.	Male sterile cytoplasm system	6.2.8
47.	Grain hardness [kg]	6.3.1
48.	Threshability [%]	6.3.2
49.	Grain weathering susceptibility	6.3.3
50.	Grain Nutrient content (fat, phosphorous, starch, sucrose, dry matter)	
51.	Mineral toxicity (Aluminium, Manganese)	

52.	Reaction to low temperature	7.1
53.	Reaction to high temperature	7.2
54.	**Reaction to drought**	**7.3**
55.	Reaction to high soil moisture	7.4
56.	Reaction to salinity	7.5
57.	Reaction to soil acidity	7.6
58.	**Sorghum shoot fly (*Atherigona soccata)***	**8.1.1**
59.	**Spotted stem borer (*Chilo partellus)***	**8.1.2**
60.	Maize stalk borer (*Busseola fusca*)	8.1.3
61.	Pink Stem Borer *(Sesamia inferens*)	
62.	Pink Borer (Africa) (*Sesamia calamistis*)	
63.	Sugarcane borer, Stem borer (*Diatraea saccharalis)*	8.1.4
64.	Lesser Cornstalk Borer (*Elasmopalpus lignosellus*)	
65.	**Sorghum midge *(Stenodiplosis sorghicola)***	**8.1.5**
66.	Earhead bug (*Calocoris angustatus)*	8.1.6
67.	African head bug *Eurystylus immaculatus)*	
68.	Corn earworm *(Heliothis zea)*	8.1.7
69.	African bollworm (*Helicoverpa armigera*)	8.1.8
70.	Armyworms *(Spodoptera* spp.)	8.1.9
71.	Oriental armyworms *(Mythimna separata)*	8.1.10
72.	Greenbug (*Schizaphis graminum*)	8.1.11
73.	Shoot Bug (*Peregrinus maidis*)	
74.	Spittel Bug (*Poophilus costalis*)	
75.	Sap-sucking Bug (*Dolycoris indicus*)	
76.	Corn leaf aphid (*Rhopalosiphum maidis)*	8.1.12
77.	White sugarcane aphid (*Melanaphis sacchari)*	8.1.13
78.	Chinch bug (*Blissus leucopterus)*	8.1.14
79.	White grubs *(Phyllophaga crinita; Schizonycha* spp., *Holotrichia* spp.*)*	8.1.15
80.	Sorghum web worm (*Nola sorghella*)	8.1.16
81.	Earhead web worm (*Nola analis; Cryptoblabes gnidiella*)	
82.	Web worm *(Stenachroia elongella*; *Eublemma* spp.)	8.1.17
83.	Sorghum mite *(Oligonychus indicus)*	8.1.18
84.	Banks grass mite (*Oligonychus pratensis*)	8.1.19
85.	Grasshopper (*Oedaleus senegalensis*)	8.1.20
86.	Locusts (*Locusta migratoria*)	8.1.21
87.	Birds	8.1.22
88.	Red-headed Hairy Caterpillar (*Amsacta albistriga)*	
89.	Flea Beetle	
90.	Grey Leaf Weevil (*Myllocerus subfasciatus)*	
91.	Sugarcane Rootstock Weevil (*Anacentrinus deplanatus*)	
92.	Cutworms	
93.	Wireworms	
94.	Southern corn rootworm (*Diabrotica undecimpuncta*)	
95.	Rough leaf spot (*Ascochyta sorghi)*	8.2.1
96.	Grey leaf spot *(Cercospora sorghi*)	8.2.2
97.	Ladder leaf spot (*Cercospora fusimaculans*)	
98.	**Anthracnose *(Colletotrichum graminicola)***	**8.2.3**
99.	**Grain molds (*Curvularia lunata*; *Fusarium* spp.)**	**8.2.4**
100.	Leaf blight *(Exserohilum turcicum; Setosphaeria turcica; Helminthosporium turcicum)*	8.2.5
101.	Target leaf spot *(Bipolaris sorghicola)*	8.2.6
102.	Oval leaf spot *(Ramulispora sorghicola)*	8.2.7
103.	Tar spot *(Phyllachora sacchari)*	8.2.8
104.	Zonate leaf spot *(Gloeocercospora sorghi)*	8.2.9

105.	**Charcoal rot *(Macrophomina phaseolina)***	**8.2.10**
106.	Fusarium root and stalk rot; Head blight *(Fusarium* spp.)	
107.	Pokkah Boeng (*Gibberella intermedia*)	
108.	**Downy mildew *(Peronosclerospora sorghi)***	**8.2.11**
109.	Crazy Top (*Sclerophthora macrospora*)	
110.	Black dot grain mold (*Phoma insidiosa*)	8.2.12
111.	Rust *(Puccinia purpurea)*	8.2.13
112.	Sooty stripe *(Ramulispora sorghi)*	8.2.14
113.	Ergot *(Sphacelia sorghi, Claviceps africana)*	8.2.15
114.	Smut *(Sphacelotheca* spp*.)*	8.2.16
115.	Long smut *(Tolyposporium ehrenbergii, Sporisorium cruentum)*	8.2.19
116.	Pythium Root rot *(Pythium* spp.)	
117.	Southern sclerotial rot (*Sclerotium rolfsii*)	
118.	Banded Leaf and Sheath Blight (*Rhizoctonia solani*)	
119.	Acremonium Wilt (*Acremonium strictum*)	
120.	Milo Disease (*Periconia circinata*)	

121.	Bacterial leaf stripe *(Pseudomonas andropogoni)*	8.3.1
122.	Bacterial leaf spot *(Pseudomonas syringae)*	8.3.2
123.	Yellow leaf blotch *(Pseudomonas* sp.)	
124.	Bacterial leaf streak *(Xanthomonas campestris)*	8.3.3
125.	Bacterial leaf blight (*Acidovorax avenae)*	
126.	Bacterial top and stalk rot (*Erwinia chrysanthemi*)	

127.	Maize dwarf mosaic virus (MDMV)	8.4.1
128.	Sugarcane mosaic virus (SCMV)	8.4.2
129.	Johnsongrass mosaic virus (JsGMV)	8.4.3
130.	Maize stripe virus (MStV)	8.4.4
131.	Maize mosaic virus (MMV)	8.4.5
132.	Maize rough dwarf virus (MRDV)	
133.	Maize chlorotic dwarf virus (MCDV)	
134.	Maize streak virus (MSV)	
135.	Sorghum chlorotic spot virus (SgCSV)	
136.	Peanut clump virus (PCV)	
137.	Sorghum stunt mosaic virus (SSMV)	
138.	Mal de Rio Cuarto virus (MRCV)	
139.	Fiji disease virus (FDV)	
140.	Yellow Sorghum Stunt (YSS)	
141.	Sorghum yellow banding virus (SYBV)	

142.	Witchweed *(Striga asiatica; Striga densiflora; Striga hermonthica)*	8.5.1

143.	Stunt nematode *(Tylenchorhynchus* spp.)	
144.	Root-lesion nematode (*Pratylenchus* spp.)	
145.	Root-knot nematode *(Meloidogyne* spp.)	

Annex V – Survey to choose a key set of descriptors for sorghum utilization

WELCOME

Welcome to the survey for the selection of a minimum set of characterization and evaluation descriptors for sorghum to support an international information system to enhance the utilization of germplasm held in genebanks.

Your knowledge and experience are being sought to select this initial minimum 'key set of descriptors' to identify traits important to crop production and to facilitate their use by researchers. This set will be made available through a global portal for identifying sets of accessions for evaluation and use.

Your participation in it is highly appreciated. The deadline for this survey is **23 October 2009**.

This initial minimum list of descriptors should be relevant to describing, and especially utilizing germplasm.

It is hoped that a priority set of data, available for most ex situ conserved material, will allow a better comparability between genebanks which should facilitate the identification of interesting material and an increased use of conserved material.

This survey also allows you to indicate other descriptors considered important for describing and discriminating between accessions.

This survey consists of two parts:

- **PART I: Initial minimum key set of characterization and evaluation descriptors important for sorghum utilization**
- **PART II: Other traits important for describing, discriminating and utilizing sorghum genetic resources**

We thank you in advance for investing your time and expertise in selecting the set of descriptors.

*** Please allow us to acknowledge your contribution by completing your full contact details below:**

Name:

Position:

Organization:

Country:

Email:

PART I: Initial minimum key set of C&E descriptors important for sorghum utilization

This initial key set has been defined following advice from NBPGR scientists and further refined by Jeff Dhalberg and Bob Henzell.

Please select these traits in order of importance bearing in mind the following factors:

- Importance for germplasm utilization
- Initial strategic set
- Global impact
- Data availability
- For abiotic and biotic stresses, true economic damage and wide geographical occurrence

*Numbers in parentheses on the right-hand side are the corresponding descriptors numbers as published in the IBPGR/ICRISAT publication 'Descriptors for Sorghum' [*Sorghum bicolor* (L.) Moench], 1993.

	Very important	Important	Not important
Plant height [cm] (4.1.1)	○	○	○
Plant colour (4.1.2)	○	○	○
Leaf midrib colour (4.1.5)	○	○	○
Grain yield	○	○	○
Days to 50% flowering (4.2.1)	○	○	○
Inflorescence compactness and shape (4.2.2)	○	○	○
Glume colour (4.2.3)	○	○	○
Grain covering (4.2.4)	○	○	○
Shattering (4.2.6)	○	○	○
Grain colour (4.3.1)	○	○	○
100-seed weight [g] (4.3.3)	○	○	○
Endosperm texture (4.3.8)	○	○	○
Lodging susceptibility (6.1.2)	○	○	○
Inflorescence exsertion (6.2.4)	○	○	○
Inflorescence length [cm] (6.2.5)	○	○	○
Reaction to drought (7.3)	○	○	○
Sorghum shoot fly (*Atherigona soccata*) (8.1.1)	○	○	○
Spotted stem borer (*Chilo partellus*) (8.1.2)	○	○	○
Sorghum midge (*Stenodiplosis sorghicola*) (8.1.5)	○	○	○
White sugarcane aphid (*Melanaphis sacchari*) (8.1.13)	○	○	○
Anthracnose (*Colletotrichum graminicola*) (8.2.3)	○	○	○
Grain molds (*Curvularia lunata*; *Fusarium* spp.) (8.2.4)	○	○	○
Charcoal rot (*Macrophomina phaseolina*) (8.2.10)	○	○	○
Downy mildew (*Peronosclerospora sorghi*) (8.2.11)	○	○	○

PART II: Other traits important for describing, discriminating and utilizing sorghum genetic resources

Please rate these characteristics and traits in order of importance in describing, discriminating and utilizing sorghum accessions.

By selecting descriptors here you are contributing to the next revision of the Characterization and Evaluation categories of the conventional sorghum list of descriptors.

	Very important	Important	Not Important
Stalk juiciness (4.1.3)	○	○	○
Juice flavour (4.1.4)	○	○	○
Waxy bloom (4.1.6)	○	○	○
Number of basal tillers per plant	○	○	○
Nodal tillering	○	○	○
Fodder yield	○	○	○
Desirability rating (total plant)	○	○	○
Awns (4.2.5)	○	○	○
Glume pubescence	○	○	○
Grain lustre (4.3.2)	○	○	○
Seed shape	○	○	○
Genotypic pericarp colour	○	○	○
Pigmented testa (Grain sub-coat) (4.3.5)	○	○	○
Grain plumpness (4.3.6)	○	○	○
Intensifier gene	○	○	○
Grain form (4.3.7)	○	○	○
Mesocarp thickness	○	○	○
Endosperm colour (4.3.9)	○	○	○
Absence/presence of spreader gene	○	○	○
Endosperm type (4.3.10)	○	○	○
Coleoptile color	○	○	○
Seedling vigour (6.1.1)	○	○	○
Senescence rating (6.1.3)	○	○	○
Peduncle breakage	○	○	○
Photosensitivity (6.2.1)	○	○	○
Number of flowering stems per plant (6.2.2)	○	○	○
Pollen shed	○	○	○
Synchrony of flowering (6.2.3)	○	○	○
Inflorescence width (head) [cm] (6.2.6)	○	○	○
Restoration response (Milo source) (6.2.7)	○	○	○
Male sterile cytoplasm system (6.2.8)	○	○	○

Grain hardness [kg] (6.3.1)			
Threshability [%] (6.3.2)			
Grain weathering susceptibility (6.3.3)			
Grain Nutrient content (fat, phosphorous, starch, sucrose, dry matter)			
Mineral toxicity (Aluminium, Manganese)			
Reaction to low temperature (7.1)			
Reaction to high temperature (7.2)			
Reaction to high soil moisture (7.4)			
Reaction to salinity (7.5)			
Reaction to soil acidity (7.6)			
Maize stalk borer (*Busseola fusca*) (8.1.3)			
Pink stem borer (*Sesamia inferens*)			
Pink borer (Africa) (*Sesamia calamistis*)			
Sugarcane borer, Stem borer (*Diatraea saccharalis*) (8.1.4)			
Lesser cornstalk borer (*Elasmopalpus lignosellus*)			
Earhead bug (*Calocoris angustatus*) (8.1.6)			
African head bug (*Eurystylus immaculatus*)			
Corn earworm (*Heliothis zea*) (8.1.7)			
African bollworm (*Helicoverpa armigera*) (8.1.8)			
Armyworms (*Spodoptera* spp.) (8.1.9)			
Oriental armyworms (*Mythimna separata*) (8.1.10)			
Greenbug (*Schizaphis graminum*) (8.1.11)			
Shoot bug (*Peregrinus maidis*)			
Spittel bug (*Poophilus costalis*)			
Sap-sucking bug (*Dolycoris indicus*)			
Corn leaf aphid (*Rhopalosiphum maidis*) (8.1.12)			
Chinch bug (*Blissus leucopterus*) (8.1.14)			
White grubs (*Phyllophaga crinita*; *Schizonycha* spp., *Holotrichia* spp.) (8.1.15)			
Sorghum web worm (*Nola sorghella*) (8.1.16)			
Earhead web worm (*Nola analis*; *Cryptoblabes gnidiella*)			
Web worm (*Stenachroia elongella*; Eublemma spp.) (8.1.17)			
Sorghum mite (*Oligonychus indicus*) (8.1.18)			
Banks' grass mite (*Oligonychus pratensis*) (8.1.19)			
Grasshopper (*Oedaleus senegalensis*) (8.1.20)			
Locusts (*Locusta migratoria*) (8.1.21)			
Birds (8.1.22)			
Red-headed hairy caterpillar (*Amsacta albistriga*)			
Flea beetle			
Grey leaf weevil (*Myllocerus subfasciatus*)			

Sugarcane rootstock weevil (*Anacentrinus deplanatus*)			
Cutworms			
Wireworms			
Southern corn rootworm (*Diabrotica undecimpuncta*)			
Rough leaf spot (*Ascochyta sorghi*) (8.2.1)			
Grey leaf spot (*Cercospora sorghi*) (8.2.2)			
Ladder leaf spot (*Cercospora fusimaculans*)			
Leaf blight (*Exserohilum turcicum*; *Setosphaeria turcica*; *Helminthosporium turcicum*) (8.2.5)			
Target leaf spot (*Bipolaris sorghicola*) (8.2.6)			
Oval leaf spot (*Ramulispora sorghicola*) (8.2.7)			
Tar spot (*Phyllachora sacchari*) (8.2.8)			
Zonate leaf spot (*Gloeocercospora sorghi*) (8.2.9)			
Fusarium root and stalk rot; Head blight (*Fusarium* spp.)			
Pokkah boeng (*Gibberella intermedia*)			
Crazy top (*Sclerophthora macrospora*)			
Black dot grain mold (*Phoma insidiosa*) (8.2.12)			
Rust (*Puccinia purpurea*) (8.2.13)			
Sooty stripe (*Ramulispora sorghi*) (8.2.14)			
Ergot (*Sphacelia sorghi*, *Claviceps africana*) (8.2.15)			
Smut (*Sphacelotheca* spp.) (8.2.16)			
Long smut (*Tolyposporium ehrenbergii*, *Sporisorium cruentum*) (8.2.19)			
Pythium root rot (*Pythium* spp.)			
Southern sclerotial rot (*Sclerotium rolfsii*)			
Banded leaf and sheath blight (*Rhizoctonia solani*)			
Acremonium wilt (*Acremonium strictum*)			
Milo disease (*Periconia circinata*)			
Bacterial leaf stripe (*Pseudomonas andropogoni*) (8.3.1)			
Bacterial leaf spot (*Pseudomonas syringae*) (8.3.2)			
Yellow leaf blotch (*Pseudomonas* sp.)			
Bacterial leaf streak (*Xanthomonas campestris*) (8.3.3)			
Bacterial leaf blight (*Acidovorax avenae*)			
Bacterial top and stalk rot (*Erwinia chrysanthemi*)			
Maize dwarf mosaic virus (MDMV) (8.4.1)			
Sugarcane mosaic virus (SCMV) (8.4.2)			
Johnsongrass mosaic virus (JsGMV) (8.4.3)			
Maize stripe virus (MStV) (8.4.4)			
Maize mosaic virus (MMV) (8.4.5)			
Maize rough dwarf virus (MRDV)			
Maize chlorotic dwarf virus (MCDV)			

Maize streak virus (MSV)	◯	◯	◯
Sorghum chlorotic spot virus (SgCSV)	◯	◯	◯
Peanut clump virus (PCV)	◯	◯	◯
Sorghum stunt mosaic virus (SSMV)	◯	◯	◯
Mal de Rio Cuarto virus (MRCV)	◯	◯	◯
Fiji disease virus (FDV)	◯	◯	◯
Yellow Sorghum stunt (YSS)	◯	◯	◯
Sorghum yellow banding virus (SYBV)	◯	◯	◯
Witchweed (*Striga asiatica*; *Striga densiflora*; *Striga hermonthica*) (8.5.1)	◯	◯	◯
Stunt nematode (*Tylenchorhynchus* spp.)	◯	◯	◯
Root-lesion nematode (*Pratylenchus* spp.)	◯	◯	◯
Root-knot nematode (*Meloidogyne* spp.)	◯	◯	◯

If you consider that an important characteristic for describing or discriminating among accessions is missing from this list, please indicate it here along with a substantiated justification.

THANK YOU VERY MUCH FOR YOUR PARTICIPATION.

If you consider that an essential trait important for crop improvement and production is missing from this list, or, if any of the descriptors listed is not clearly useful to promote utilization, please indicate it here along with a substantiated justification.

NOTE: Please remember, this list is the starting point and will grow over time, as required.

Annex VI – List of respondents to the survey

Role	***Name***	***Position***	***Organization***	***Country***
Crop Leader	**Dahlberg, Jeff**	Research Director	United Sorghum Checkoff Program	USA
Crop Leader	**Upadhyaya, Hari D.**		International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	India
CAG	Guiard, Joël	Directeur adjoint	Groupe d'Etude et de contrôle des Variétés et des Semences (GEVES)	France
CAG	Hash, C. Tom		International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	India
CAG	Henzell, R.G.	Sorghum plant breeder (retired)	Queensland Department of Primary Industries	Australia
CAG	Lira, Mario		Instituto Agronômico de Pernambuco (IPA)	Brazil
CAG	Mathur, Prem		Bioversity International	India
CAG	Miller, Frederick R.	Research Director/ Senior Breeder	MMR Genetics	USA
CAG	Pandravada, S.R.	Senior Scientist	National Bureau of Plant Genetic Resources (NBPGR), Regional Station, Hyderabad	India
CAG	Pederson, Gary A.	Research Leader	United States Department of Agriculture, Agricultural Research Service (USDA, ARS), Plant Genetic Resources Conservation Unit	USA
CAG	Seetharam, A.	Emeritus Scientist	Indian Council of Agricultural Research (ICAR)	India
CAG	Seetharama, N.	Director	Directorate of Sorghum Research (formerly National Research Centre for Sorghum)	India
Reviewer	Adugna, Asfaw	Researcher/plant breeder	Ethiopian Institute of Agricultural Research (EIAR)	Ethiopia
Reviewer	Ashok, Kumar	Principal Scientist	National Bureau of Plant Genetic Resources (NBPGR)	India
Reviewer	Awadelkarim, A. Ahmed	Researcher	Agricultural Research Cooperation	Sudan
Reviewer	Bandyopadhyay, Ranajit	Plant pathologist	International Institute of Tropical Agriculture (IITA)	Nigeria
Reviewer	Borikar, S.T.	Director of Research (Retd.)	Marathwada Agricultural University	India
Reviewer	Coulibaly, Sidi Bekaye	Sorghum breeder	Institut d'Economie Rurale	Mali

Reviewer	Elangovan, M.	Senior Scientist	Directorate of Sorghum Research (DSR)	India
Reviewer	Erpelding, John	Research Geneticist	United States Department of Agriculture, Agricultural Research Service (USDA, ARS)	USA
Reviewer	Habindavyi, Espérance	Researcher/Breeder	Institute of Agricultural Research - Burundi (ISABU)	Burundi
Reviewer	Jordan, David	Principal Plant Breeder	Queensland Primary Industries and Fisheries	Australia
Reviewer	Kawase, Makoto		National Institute of Agrobiological Sciences (NIAS)	Japan
Reviewer	Magalhaes, Jurandir		Embrapa Maize and Sorghum	Brazil
Reviewer	Okuizumi, Hisato	Chief researcher	National Institute of Agrobiological Sciences (NIAS)	Japan
Reviewer	Parzies, Heiko K.	Research Officer	University of Hohenheim, Stuttgart	Germany
Reviewer	Pedersen, Jeff	Research Geneticist	United States Department of Agriculture, Agricultural Research Service (USDA, ARS)	USA
Reviewer	Ping, Lu		Institute of Crop Science, Chinese Academy of Agricultural Sciences (CAAS)	China P.R.
Reviewer	Rao, N. Kameswara	Scientist	International Center for Biosaline Agriculture	UAE
Reviewer	Reddy, Belum V.S.	Principal Scientist	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	India
Reviewer	Reddy, Gopal, V.		International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	India
Reviewer	Satyavathi, Tara	Senior Scientist	Indian Agricultural Research Institute (IARI)	India
Reviewer	Sharma, H.C.		International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	India
Reviewer	Sharma, Shivali		International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	India
Reviewer	Schmidt, Baerbel	Curator for Vegetables	Leibniz Institute of Plant Genetics and Crop Plant Research (IPK), Gatersleben	Germany
Reviewer	Stehno, Zdenek	Head of genebank	Crop Research Institute	Czech Republic
Reviewer	Tadesse, Taye	National Sorghum Research Coordinator	Ethiopian Institute of Agricultural Research (EIAR)	Ethiopia

Reviewer	Thakur, R.P.	Principal Scientist (Cereals Path)	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	India
Reviewer	Vadez, Vincent	Principal Scientist	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	India

Annex VII – List of descriptors proposed in the survey ranked by rating average and percentage of importance, sent to the Core Advisory Group for their selection in order to choose an initial key set of sorghum descriptors[i]

Part 1. Key set descriptors for sorghum				Answered questions= 32	Skipped questions= 1	
Survey results	**Your selection**	**Rating Average**	**Very important**	**Important**	**Not important**	**Response Count**
Race (1.5.5)						
Group name (1.5.6)						
Days to 50% flowering (4.2.1)		5.63	87.5% (28)	12.5% (4)	0% (0)	32
Plant height [cm] (4.1.1)		5.44	81.3% (26)	18.8% (6)	0% (0)	32
Grain yield		5.32	77.4% (24)	22.6% (7)	0% (0)	31
Grain colour (4.3.1)		5.16	71.9% (23)	28.1% (9)	0% (0)	32
100-seed weight [g] (4.3.3)		5.03	67.7% (21)	32.3% (10)	0% (0)	31
Reaction to drought (7.3)		4.97	71.9% (23)	21.9% (7)	6.3% (2)	32
Inflorescence compactness and shape (4.2.2)		4.69	59.4% (19)	37.5% (12)	3.1% (1)	32
Shattering (4.2.6)		4.6	56.7% (17)	40.0% (12)	3.3% (1)	30
Inflorescence length [cm] (6.2.5)		4.45	51.6% (16)	45.2% (14)	3.2% (1)	31
Sorghum shoot fly (*Atherigona soccata*) (8.1.1)		4.35	51.6% (16)	41.9% (13)	6.5% (2)	31
Grain moulds (Curvularia lunata; *Fusarium* spp.) (8.2.4)		4.26	48.4% (15)	45.2% (14)	6.5% (2)	31
Lodging susceptibility (6.1.2)		4.16	45.2% (14)	48.4% (15)	6.5% (2)	31
Spotted stem borer (*Chilo partellus*) (8.1.2)		4.1	46.7% (14)	43.3% (13)	10.0% (3)	30
Anthracnose (*Colletotrichum graminicola*) (8.2.3)		4.06	45.2% (14)	45.2% (14)	9.7% (3)	31
Endosperm texture (4.3.8)		3.87	38.7% (12)	51.6% (16)	9.7% (3)	31
Inflorescence exsertion (6.2.4)		3.87	38.7% (12)	51.6% (16)	9.7% (3)	31
Grain covering (4.2.4)		3.77	38.7% (12)	48.4% (15)	12.9% (4)	31
Sorghum midge (*Stenodiplosis sorghicola*) (8.1.5)		3.77	32.3% (10)	61.3% (19)	6.5% (2)	31
Downy mildew (*Peronosclerospora sorghi*) (8.2.11)		3.58	25.8% (8)	67.7% (21)	6.5% (2)	31
Charcoal rot (*Macrophomina phaseolina*) (8.2.10)		3.3	20.0% (6)	70.0% (21)	10.0% (3)	30
Leaf midrib colour (4.1.5)		3.19	18.8% (6)	68.8% (22)	12.5% (4)	32
Glume colour (4.2.3)		3	21.9% (7)	56.3% (18)	21.9% (7)	32
White sugarcane aphid (*Melanaphis sacchari*) (8.1.13)		3	19.4% (6)	61.3% (19)	19.4% (6)	31
Plant colour (4.1.2)		2.63	9.4% (3)	68.8% (22)	21.9% (7)	32

Part 2. Other traits important for describing and utilizing sorghum				Answered question= 29		Skipped question= 4
Survey results	Your selection	Rating Average	Very important	Important	Not Important	Response Count
Photosensitivity (6.2.1)		5.35	82.1% (23)	14.3% (4)	3.6% (1)	28
Fodder yield		4.93	71.4% (20)	21.4% (6)	7.1% (2)	28
Stalk juiciness (4.1.3)		4.71	57.1% (16)	42.9% (12)	0% (0)	28
Male sterile cytoplasm system (6.2.8)		4.67	66.7% (18)	22.2% (6)	11.1% (3)	27
Synchrony of flowering (6.2.3)		4.50	57.7% (15)	34.6% (9)	7.7% (2)	26
Restoration response (Milo source) (6.2.7)		4.11	55.6% (15)	25.9% (7)	18.5% (5)	27
Desirability rating (total plant)		4.00	51.9% (14)	29.6% (8)	18.5% (5)	27
Threshability [%] (6.3.2)		4.00	40.7% (11)	51.9% (14)	7.4% (2)	27
Reaction to high temperature (7.2)		4.00	48.1% (13)	37.0% (10)	14.8% (4)	27
Endosperm type (4.3.10)		3.92	42.3% (11)	46.2% (12)	11.5% (3)	26
Seedling vigour (6.1.1)		3.92	53.8% (14)	23.1% (6)	23.1% (6)	26
Genotypic pericarp colour		3.86	42.9% (12)	42.9% (12)	14.3% (4)	28
Grain Nutrient content (fat, phosphorous, starch, sucrose, dry matter)		3.69	34.6% (9)	53.8% (14)	11.5% (3)	26
Reaction to low temperature (7.1)		3.69	46.2% (12)	30.8% (8)	23.1% (6)	26
Senescence rating (6.1.3)		3.67	40.7% (11)	40.7% (11)	18.5% (5)	27
Grain hardness [kg] (6.3.1)		3.67	37.0% (10)	48.1% (13)	14.8% (4)	27
Pigmented testa (Grain sub-coat) (4.3.5)		3.64	39.3% (11)	42.9% (12)	17.9% (5)	28
Grain weathering susceptibility (6.3.3)		3.58	34.6% (9)	50.0% (13)	15.4% (4)	26
Seed shape		3.54	28.6% (8)	60.7% (17)	10.7% (3)	28
Pollen shed		3.48	40.0% (10)	36.0% (9)	24.0% (6)	25
Grain form (4.3.7)		3.44	33.3% (9)	48.1% (13)	18.5% (5)	27
Endosperm colour (4.3.9)		3.44	40.7% (11)	33.3% (9)	25.9% (7)	27
Grain plumpness (4.3.6)		3.43	28.6% (8)	57.1% (16)	14.3% (4)	28
Mineral toxicity (Aluminium, Manganese)		3.43	32.1% (9)	50.0% (14)	18.5% (5)	28
Leaf blight (*Exserohilum turcicum*; *Setosphaeria turcica*; *Helminthosporium turcicum*) (8.2.5)		3.38	29.2% (7)	54.2% (13)	16.7% (4)	24
Ergot (*Sphacelia sorghi; Claviceps africana*) (8.2.15)		3.38	29.2% (7)	54.2% (13)	16.7% (4)	24
Birds (8.1.22)		3.36	44.0% (11)	24.0% (6)	32.0% (8)	25
Number of basal tillers per plant		3.32	32.1% (9)	46.4% (13)	21.4% (6)	28
Grain lustre (4.3.2)		3.32	25.0% (7)	60.7% (17)	14.3% (4)	28
Rust (*Puccinia purpurea*) (8.2.13)		3.26	30.4% (7)	47.8% (11)	21.7% (5)	23

Witchweed (*Striga asiatica*; *Striga densiflora*; *Striga hermonthica*) (8.5.1)		3.13	37.5% (9)	29.2% (7)	33.3% (8)	24
Reaction to salinity (7.5)		3.11	29.6% (8)	44.4% (12)	25.9% (7)	27
Number of flowering stems per plant (6.2.2)		3.00	24.0% (6)	52.0% (13)	24.0% (6)	25
Reaction to soil acidity (7.6)		3.00	25.9% (7)	48.1% (13)	25.9% (7)	27
Smut (*Sphacelotheca* spp.) (8.2.16)		3.00	25.0% (6)	50.0% (12)	25.0% (6)	24
Inflorescence width (head) [cm] (6.2.6)		2.88	26.9% (7)	12.3% (11)	30.8% (8)	26
Grey leaf spot (*Cercospora sorghi*) (8.2.2)		2.87	21.7% (5)	52.2% (12)	26.1% (6)	23
Awns (4.2.5)		2.79	27.6% (8)	37.9% (11)	34.5% (10)	29
Long smut (*Tolyposporium ehrenbergii*, *Sporisorium cruentum*) (8.2.19)		2.75	20.8% (5)	50.0% (12)	29.2% (7)	24
Corn leaf aphid (*Rhopalosiphum maidis*) (8.1.12)		2.74	26.1% (6)	39.1% (9)	34.8% (8)	23
Maize stripe virus (MStV) (8.4.4)		2.74	34.8% (8)	21.7% (5)	43.5% (10)	23
Intensifier gene		2.65	11.5% (3)	65.4% (17)	23.1% (6)	26
Fusarium root and stalk rot; Head blight (*Fusarium* spp.)		2.63	25.0% (6)	37.5% (9)	37.5% (9)	24
Greenbug (*Schizaphis graminum*) (8.1.11)		2.61	30.4% (7)	26.1% (6)	43.5% (10)	23
Peduncle breakage		2.54	15.4% (4)	53.8% (14)	30.8% (8)	26
Reaction to high soil moisture (7.4)		2.52	20.0% (5)	44.0% (11)	36.0% (9)	25
Zonate leaf spot (*Gloeocercospora sorghi*) (8.2.9)		2.48	17.4% (4)	47.8% (11)	34.8% (8)	23
Waxy bloom (4.1.6)		2.46	14.3% (4)	53.6% (15)	32.1% (9)	28
Mesocarp thickness		2.42	19.2% (5)	42.3% (11)	38.5% (10)	26
Absence/presence of spreader gene		2.42	15.4% (4)	50.0% (13)	34.6% (9)	26
Earhead bug (*Calocoris angustatus*) (8.1.6)		2.35	21.7% (5)	34.8% (8)	43.5% (10)	23
Maize dwarf mosaic virus (MDMV) (8.4.1)		2.35	17.4% (4)	43.5% (10)	39.1% (9)	23
Black dot grain mold (*Phoma insidiosa*) (8.2.12)		2.32	22.7% (5)	31.8% (7)	45.5% (10)	22
Shoot bug (*Peregrinus maidis*)		2.25	16.7% (4)	41.7% (10)	41.7% (10)	24
Sugarcane mosaic virus (SCMV) (8.4.2)		2.25	12.5% (3)	50.0% (12)	37.5% (9)	24
Sooty stripe (*Ramulispora sorghi*) (8.2.14)		2.22	17.4% (4)	39.1% (9)	43.5% (10)	23
Bacterial leaf stripe (*Pseudomonas andropogoni*) (8.3.1)		2.22	17.4% (4)	39.1% (9)	43.5% (10)	23
Maize stalk borer (*Busseola fusca*) (8.1.3)		2.19	15.4% (4)	42.3% (11)	42.3% (11)	26
Nodal tillering		2.14	14.3% (4)	42.9% (12)	42.9% (12)	28

Banded leaf and sheath blight (*Rhizoctonia solani*)		2.09	17.4% (4)	34.8% (8)	47.8% (11)	23
Maize mosaic virus (MMV) (8.4.5)		2.09	17.4% (4)	34.8% (8)	47.8% (11)	23
African head bug (*Eurystylus immaculatus*)		2.05	18.2% (4)	31.8% (7)	50.0% (11)	22
Glume pubescence		2.04	10.7% (3)	46.4% (13)	42.9% (12)	28
Sugarcane borer, Stem borer (*Diatraea saccharalis*) (8.1.4)		2.00	16.7% (4)	33.3% (8)	50.0% (12)	24
Armyworms (*Spodoptera* spp.) (8.1.9)		1.96	13.0% (3)	39.1% (9)	47.8% (11)	23
Bacterial leaf spot (*Pseudomonas syringae*) (8.3.2)		1.96	21.7% (5)	21.7% (5)	56.5% (13)	23
Pink borer (Africa) (*Sesamia calamistis*)		1.92	16.0% (4)	32.0% (8)	52.0% (13)	25
Coleoptile colour		1.88	12.5% (3)	37.5% (9)	50.0% (12)	24
Pink stem borer (*Sesamia inferens*)		1.88	12.5% (3)	37.5% (9)	50.0% (12)	24
African bollworm (*Helicoverpa armigera*) (8.1.7)		1.83	13.0% (3)	34.8% (8)	52.2% (12)	23
Sorghum mite (*Oligonychus indicus*) (8.1.18)		1.83	21.7% (5)	17.4% (4)	60.9% (14)	23
Rough leaf spot (*Ascochyta sorghi*) (8.2.1)		1.83	8.7% (2)	43.5% (10)	47.8% (11)	23
Pythium root rot (*Pythium* spp.)		1.83	8.7% (2)	43.5% (10)	47.8% (11)	23
Juice flavour (4.1.4)		1.82	10.7% (3)	39.3% (11)	50.0% (14)	28
Ladder leaf spot (*Cercospora fusimaculans*)		1.77	18.2% (4)	22.7% (5)	59.1% (13)	22
Bacterial leaf streak (*Xanthomonas campestris*) (8.3.3)		1.75	12.5% (3)	33.3% (8)	54.2% (13)	24
Bacterial leaf blight (*Acidovorax avenae*)		1.75	12.5% (3)	33.3% (8)	54.2% (13)	24
Corn earworm (*Heliothis zea*) (8.1.8)		1.70	8.7% (2)	39.1% (9)	52.2% (12)	23
Target leaf spot (*Bipolaris sorghicola*) (8.2.6)		1.70	8.7% (2)	39.1% (9)	52.2% (12)	23
Chinch bug (*Blissus leucopterus*) (8.1.14)		1.64	13.6% (3)	27.3% (6)	59.1% (13)	22
Locusts (*Locusta migratoria*) (8.1.21)		1.63	12.5% (3)	29.2% (7)	58.3% (14)	24
Web worm (*Stenachroia elongella*; *Eublemma* spp.) (8.1.17)		1.57	13.0% (3)	26.1% (6)	60.9% (14)	23
Acremonium wilt (*Acremonium strictum*)		1.57	8.7% (2)	34.8% (8)	56.5% (13)	23
Sorghum chlorotic spot virus (SgCSV)		1.57	17.4% (4)	17.4% (4)	65.2% (15)	23
Stunt nematode (*Tylenchorhynchus* spp.)		1.57	8.7% (2)	34.8% (8)	56.5% (13)	23

White grubs (*Phyllophaga crinita*; *Schizonycha* spp., *Holotrichia* spp.) (8.1.15)		1.50	9.1% (2)	31.8% (7)	59.1% (13)	22
Cutworms		1.50	12.5% (3)	25.0% (6)	62.5% (15)	24
Maize chlorotic dwarf virus (MCDV)		1.50	13.6% (3)	22.7% (5)	63.6% (14)	22
Sorghum stunt mosaic virus (SSMV)		1.50	13.6% (3)	22.7% (5)	63.6% (14)	22
Oriental armyworms (*Mythimna separata*) (8.1.10)		1.43	8.7% (2)	30.4% (7)	60.9% (14)	23
Sorghum web worm (*Nola sorghella*) (8.1.16)		1.43	8.7% (2)	30.4% (7)	60.9% (14)	23
Earhead web worm (*Nola analis*; *Cryptoblabes gnidiella*)		1.43	8.7% (2)	30.4% (7)	60.9% (14)	23
Oval leaf spot (*Ramulispora sorghicola*) (8.2.7)		1.43	8.7% (2)	30.4% (7)	60.9% (14)	23
Pokkah boeng (*Gibberella intermedia*)		1.43	4.3% (1)	39.1% (9)	56.5% (13)	23
Crazy top (*Sclerophthora macrospora*)		1.43	8.7% (2)	30.4% (7)	60.9% (14)	23
Southern sclerotial rot (*Sclerotium rolfsii*)		1.43	8.7% (2)	30.4% (7)	60.9% (14)	23
Milo disease (*Periconia circinata*)		1.43	8.7% (2)	30.4% (7)	60.9% (14)	23
Yellow leaf blotch (*Pseudomonas* sp.)		1.43	13.0% (3)	21.7% (5)	65.2% (15)	23
Johnsongrass mosaic virus (JsGMV) (8.4.3)		1.43	4.3% (1)	39.1% (9)	56.5% (13)	23
Root-lesion nematode (*Pratylenchus* spp.)		1.43	8.7% (2)	30.4% (7)	60.9% (14)	23
Root-knot nematode (*Meloidogyne* spp.)		1.43	8.7% (2)	30.4% (7)	60.9% (14)	23
Lesser cornstalk borer (*Elasmopalpus lignosellus*)		1.38	12.5% (3)	20.8% (5)	66.7% (16)	24
Flea beetle		1.36	9.1% (2)	27.3% (6)	63.6% (14)	22
Maize streak virus (MSV)		1.36	13.6% (3)	18.2% (4)	68.2% (15)	22
Sorghum yellow banding virus (SYBV)		1.36	9.1% (2)	27.3% (6)	63.6% (14)	22
Spittel bug (*Poophilus costalis*)		1.30	8.7% (2)	26.1% (6)	65.2% (15)	23
Sap-sucking bug (*Dolycoris indicus*)		1.30	13.0% (3)	17.4% (4)	69.6% (16)	23
Banks grass mite (*Oligonychus pratensis*) (8.1.19)		1.30	8.7% (2)	26.1% (6)	65.2% (15)	23
Grey leaf weevil (*Myllocerus subfasciatus*)		1.30	13.0% (3)	17.4% (4)	69.6% (16)	23
Sugarcane rootstock weevil (*Anacentrinus deplanatus*)		1.30	8.7% (2)	26.1% (6)	65.2% (15)	23
Wireworms		1.30	8.7% (2)	26.1% (6)	65.2% (15)	23
Red-headed hairy caterpillar (*Amsacta albistriga*)		1.25	8.3% (2)	25.0% (6)	66.7% (16)	24

Southern corn rootworm (*Diabrotica undecimpuncta*)		1.23	13.6% (3)	13.6% (3)	72.7% (16)	22
Grasshopper (*Oedaleus senegalensis*) (8.1.20)		1.17	8.7% (2)	21.7% (5)	69.6% (16)	23
Tar spot (*Phyllachora sacchari*) (8.2.8)		1.17	4.3% (1)	30.4% (7)	65.2% (15)	23
Bacterial top and stalk rot (*Erwinia chrysanthemi*)		1.17	8.7% (2)	21.7% (5)	69.6% (16)	23
Maize rough dwarf virus (MRDV)		1.17	8.7% (2)	21.7% (5)	69.6% (16)	23
Yellow sorghum stunt (YSS)		1.17	8.7% (2)	21.7% (5)	69.6% (16)	23
Peanut clump virus (PCV)		1.04	4.3% (1)	26.1% (6)	69.6% (16)	23
Fiji disease virus (FDV)		0.82	4.5% (1)	17.4% (4)	77.3% (17)	22
Mal de Rio Cuarto virus (MRCV)		0.78	4.3% (1)	18.2% (4)	78.3% (18)	23

---

[i] Descriptors highlighted in yellow are those that received a wide consensus amongst the experts.

Annex VIII – First draft for the minimum priority set of descriptors for sorghum submitted to the CAG

Key set of descriptors

PLANT DATA

Race	(1.5.5)
Group name	(1.5.6)
Plant height [cm]	(4.1.1)
Stalk juiciness	(4.1.3)
Days to 50% flowering	(4.2.1)
Planting date [YYYYMMDD]	
Flowering behaviour	
Inflorescence compactness and shape	(4.2.2)
Grain covering	(4.2.4)
Shattering	(4.2.6)
Grain yield	
Fodder yield	
Desirability rating (total plant)	
Grain colour	(4.3.1)
Genotypic pericarp colour	
100-seed weight [g]	(4.3.3)
Pigmented testa (Grain sub-coat)	(4.3.5)
Endosperm texture	(4.3.8)
Pollen shed	
Seedling vigour	(6.1.1)
Lodging susceptibility	(6.1.2)
Senescence rating	(6.1.3)
Photosensitivity	(6.2.1)
Inflorescence exertion	(6.2.4)
Inflorescence length [cm]	(6.2.5)
Restoration response (Milo source)	(6.2.7)
Male sterile cytoplasm system	(6.2.8)

ABIOTIC STRESSES

Reaction to low temperature	(7.1)
Pollen susceptibility	
Seedling susceptibility	
Reproductive susceptibility	
Reaction to drought	(7.3)
Pre-anthesis drought reaction	
Post-anthesis drought reaction (stay-green ability)	

BIOTIC STRESSES

Sorghum shoot fly (*Atherigona soccata*)	(8.1.1)
Spotted stem borer (*Chilo partellus*)	(8.1.2)
Sorghum midge (*Stenodiplosis sorghicola*)	(8.1.5)
Anthracnose (*Colletotrichum graminicola*)	(8.2.3)
Grain moulds (*Curvularia lunata*; *Fusarium* spp.)	(8.2.4)

Annex IX – First draft of the key access and utilization descriptors for sorghum

Key access and utilization descriptors for sorghum genetic resources

This list consists of an initial set of characterization and evaluation descriptors for sorghum genetic resources utilization. This strategic set of descriptors, together with passport data, will become the basis for the global accession level information portal being developed by Bioversity International with the financial support of the Global Crop Diversity Trust (the Trust). It will facilitate access to and utilization of sorghum accessions held in genebanks and does not preclude the addition of further descriptors, should data subsequently become available.

Based on the comprehensive list 'Descriptors for Sorghum [*Sorghum bicolor* (L.) Moench]' published by ICRISAT and IBPGR (now Bioversity International) in 1993, the list was subsequently compared with a number of sources such as 'UPOV technical guidelines for Sorghum (*Sorghum bicolor* L.)' (1989); 'Descriptors for SORGHUM' (USDA, ARS, GRIN); 'Characterization of ICRISAT-Bred Sorghum Hybrid Parents (Set I)'[1] (ICRISAT, 2006); as well as the list of traits provided by National Institute of Agrobiological Sciences (NIAS). The initial list also builds on the results of the SGRP Global Public Goods Activity 4.2.1.1 led by Dr Hari D. Upadhyaya (ICRISAT), particularly with regard to those descriptors highlighted as having the most important diagnostic and breeding traits and also to the Descriptors Draft for Sorghum, as revised by a Committee formed at the Expert Consultation Meeting for Developing a Strategy for the Global Conservation of Sorghum Genetic Resources held at ICRISAT in 2007. The initial list was further refined during a crop-specific consultation meeting held at the National Bureau of Plant Genetic Resources (NBPGR, India) in June 2009.

A worldwide distribution of experts was involved in an online survey to define a first priority set of descriptors to describe, to access and to utilize sorghum genetic resources. This key set was afterwards validated by a Core Advisory Group (see 'Contributors') led by Dr Jeff Dahlberg of the United Sorghum Checkoff Program, and included leading sorghum organizations such as ICRISAT, NBPGR, USDA and the Directorate of Sorghum Research (formerly National Research Centre for Sorghum), amongst others.

Biotic and abiotic stresses included in the list were chosen because of their wide geographic occurrence and significant economic impact at a global level.

Numbers in parentheses on the right-hand side are the corresponding descriptor numbers listed in the 1993 publication. Descriptors with numbers ending in 'letters' are either modified or are new descriptors that were added during the development of the list below.

[1] International Sorghum and Millets Newsletter, No. 47, Special issue

Race and Group name (1.5.5/6)

(As per Dahlberg, 2000)

1 Bicolor
- 10 Bicolor
- 11 Dochna
- 12 Nervosum
- 13 Nervosum-kaoliang
- 14 Nervosum-broomcorn
- 15 Sudanense

2 Guinea
- 20 Guineense
- 21 Conspicuum
- 22 Margaritiferum
- 23 Roxburghii

3 Caudatum
- 30 Caudatum
- 31 Caudatum-nigricans
- 32 Nigricans
- 33 Sumac
- 34 Nigricans-feterita
- 35 Dobbs
- 36 Caudatum-kaura
- 37 Zerazera

4 Kafir
- 40 Caffrorum

5 Durra
- 50 Durra
- 51 Nandyal
- 52 Cernuum

6 Guinea-bicolor
- 60 Guinea-bicolor
- 61 Dochna-honey
- 62 Dochna-roxburghii

7 Caudatum-bicolor
- 70 Caudatum-bicolor
- 71 Caudatum-dochna
- 72 Nigricans-bicolor
- 73 Dochna-nigricans

8 Kafir-bicolor
- 80 Bicolor-kafir
- 81 Caffrorum-bicolor
- 82 Dochna-kafir

9 Durra-bicolor
- 90 Durra-bicolor
- 91 Dochna-durra
- 92 Durra-dochna
- 93 Subglabrescens
- 94 Subglabrescens-milo
- 95 Milo-kaura

10 Guinea-caudatum
- 100 Caudatum-guineense
- 101 Nigricans-guineense

11 Guinea-kafir
- 110 Caffrorum-roxburghii
- 111 Roxburghii-shallu

12 Guinea-durra
- 120 Durra-roxburghii
- 121 Membraneceum
- 122 Durra-membranaceum

13 Kafir-caudatum
- 130 Caudatum-kafir
- 131 Caffrorum-birdproof
- 132 Caffrorum-darso
- 133 Caffrorum-feterita

14 Durra-caudatum
- 140 Caudatum-durra
- 141 Nigricans-durra
- 142 Durra-nigricans
- 143 Durra-feterita/Kaura

15 Kafir-durra
- 150 Durra-kafir
- 151 Caffrorum-durra

16 Perennial wild
- 160 S. halepense
- 161 S. propinquum

17 Annual wild
- 170 S. bicolor subsp. drummondii

18 S. bicolor subsp. verticilliforum
- 180 verticilliforum
- 181 arundinaceum
- 182 virgatum
- 183 aethiopicum

19 Unclassified

20 Breeding material
- 200 Unclassified

21 Mixed

Plant height [cm] (4.1.1)
From ground (base of plant) to tip of panicle at 50% flowering. Mean of 10 randomly selected plants

Stalk juiciness (4.1.3)
0 Not juicy
1 Slightly juicy
3 Juicy

Days to 50% flowering (4.2.1)
From planting date to when 50% of the plants have started flowering

Planting date [YYYYMMDD] (5.4)
When planting is done (if moisture is sufficient) or when irrigation is done after planting

Flowering behaviour
If grown under long days
0 Absent
3 Early
7 Late

Inflorescence compactness and shape (4.2.2)
1 Very lax panicle (typical of wild sorghums)
2 Very loose erect primary branches
3 Very loose drooping primary branches
4 Loose erect primary branches
5 Loose drooping primary branches
6 Semi-loose erect primary branches
7 Semi-loose drooping primary branches
8 Semi-compact elliptic
9 Semi-compact rectangular
10 Compact elliptic
11 Compact oval
12 Half broom corn
13 Broomcorn
99 Other (specify in the **Notes** descriptor)

Grain covering (4.2.4)
Amount of grain covered by glumes at maturity. Involuted grain is found when the grain has completely twisted inside of the glumes and is fully exposed, such as in the race Guinea
1 25% grain covered
2 50% grain covered
3 75% grain covered
4 Grain fully covered
5 Glumes longer than grain
6 Involuted

Shattering (4.2.6)
Observed at maturity
3 Low
5 Intermediate
7 High

Grain yield (6.3.b)

Overall estimation of the grain yield for the accession based upon the particular growing conditions that the accession was accessed in

3 Low
5 Medium
7 High

Fodder yield

3 Low
5 Medium
7 High

Desirability rating (6.1.4)

Overall agronomic desirability (use and yield potential) of the total plant as observed visually

3 Poor
5 Medium
7 Good

Grain colour (4.3.1)

Phenotypic colour of the grain

1 White
2 Chalky white
3 Grey
4 Red
5 Light red
6 Yellow
7 Bronze
8 Brown
9 Black
10 Purple
11 Variegated
12 Mixed

Genotypic pericarp colour

Genetically, there are three pericarp colours in sorghum

1 White (R-yy or rryy)
2 Lemon Yellow (rrY-)
3 Red (R-Y-)

100-seed weight [g] (4.3.3)

Measured at 12% moisture content

Pigmented testa (Grain sub-coat) (4.3.5)

Tannins are not present without the presence of a pigmented testa

0 Absent ($b_1b_1b_2b_2$ or B_1-b_2b_2 or $b_1b_1B_2$-)
1 Present (B_1-B_2-)

Endosperm texture (4.3.8)

1 Completely corneous
3 Mostly corneous
5 Intermediate-partly corneous
7 Mostly starchy (floury)
9 Completely starchy (floury)

Pollen shed

Visual score (early morning) when the panicle is lightly tapped. Observed at 50% flowering. Mean of five randomly selected plants

3 Low
5 Intermediate
7 High

Seedling vigour (6.1.1)

Observed 15 days after emergence

3 Low
5 Intermediate
7 High

Lodging susceptibility (6.1.2)

Indicate if root or stalk

3 Low
5 Intermediate
7 High

Senescence rating [%] (6.1.3)

Death of leaves and stalk at grain maturity

1 Very slightly senescent (10%)
3 Slightly senescent (25%)
5 Intermediate (about half of leaves dead) (50%)
7 Mostly senescent (75%)
9 Completely senescent (leaves and stalk dead)

Photosensitivity (6.2.1)

Recorded on the basis of rainy season (long days): post-rainy season (short days) ratios of plant height (4.1.1) and days to flowering (4.2.1) above

1 Insensitive
2 Partially sensitive
3 Very sensitive

Inflorescence exsertion (6.2.4)

1 Slightly exserted (<2 cm but ligule of flag leaf definitively below inflorescence base)
2 Exserted (2-10 cm between ligule and inflorescence base)
3 Well-exserted (>10 cm between ligule and inflorescence base)
4 Peduncle recurved (inflorescence below ligule and clearly exposed splitting the leaf sheath)

Inflorescence length [cm] (6.2.5)

From base of inflorescence (head) to tip. Mean of five randomly selected plants

Restoration response (Milo source) (6.2.7)

The reaction of the F_1 plant when a male sterile (A line) is pollinated with the accession

1 Maintainer
2 Partial maintainer/restorer
3 Restorer

Male sterile cytoplasm system (6.2.8)

There are four major distinct cytoplasmic-genetic systems

1 A_1
2 A_2
3 A_3
4 A_4
5 Other (specify in the Notes descriptor)

ABIOTIC STRESSES

Reaction to low temperature (7.1)

Pollen susceptibility (7.1.a)
Measured as reduction in pollen production at low temperatures (10ºC to 15ºC)

Seedling susceptibility (7.1.1)
Measured as reduction in seed germination at low temperatures (10ºC to 15ºC)

Reproductive susceptibility (7.1.2)
Measured as reduction in seed set at low temperatures (10ºC to 15ºC)

Reaction to drought (7.3)

Pre-anthesis drought reaction (7.3.a)
Measured as plants stressed prior to flowering. Plant symptoms include leaf rolling, leaf erectness, leaf bleaching, leaf firing, delayed flowering, poor panicle exsertion, saddle effect, panicle/floret blasting, and reduced panicle size. Ratings may be on individual symptoms or a combination of symptoms

Post-anthesis drought reaction (stay-green ability) (7.3.b)
Measured as plants stressed post-flowering. Plant symptoms include premature leaf and plant death, stalk collapse and lodging, charcoal rot (*Macrophomina phaseolina*) infestation, and reduced seed size

BIOTIC STRESSES

Sorghum shoot fly *(Atherigona soccata)* (8.1.1)

Spotted stem borer *(Chilo partellus)* (8.1.2)

Sorghum midge (Stenodiplosis sorghicola) (8.1.5)

Anthracnose *(Colletotrichum graminicola)* (8.2.3)

Grain moulds *(Curvularia lunata*; *Fusarium* spp.*)* (8.2.4)

NOTES

Any additional information may be specified here, particularly that referring to the category '99=Other' present in some of the descriptors above.

CONTRIBUTORS

Bioversity is grateful to all the scientists and researchers who have contributed to the development of this strategic set of 'Key access and utilization descriptors for sorghum genetic resources', and in particular to Dr Jeff Dahlberg (United Sorghum Checkoff Program, USA) for providing valuable scientific direction. Adriana Alercia (Bioversity International) provided technical expertise and guided the entire production process.

The valuable substantial scientific advice provided by ICRISAT scientists is gratefully acknowledged.

CORE ADVISORY GROUP

Jeff Dahlberg, United Sorghum Checkoff Program, USA
Joël Guiard, Groupe d'Etude et de contrôle des Variétés et des Semences (GEVES), France
C. Tom Hash, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India
R.G. Henzell, Queensland Department of Primary Industries, Australia
Mario A. Lira, Agricultural Research Institute of Pernambuco (IPA), Brazil
Prem Mathur, Bioversity International, India
Frederick R. Miller, MMR Genetics L.L.C., USA
S.R. Pandravada, National Bureau of Plant Genetic Resources (NBPGR), Regional Station, Hyderabad, India
Gary A. Pederson, United States Department of Agriculture, Agricultural Research Service (USDA, ARS), Plant Genetic Resources Conservation Unit, USA
A. Seetharam, Indian Council of Agricultural Research (ICAR), India
N. Seetharama, Directorate of Sorghum Research (formerly National Research Centre for Sorghum), India
Hari D. Upadhyaya, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India

REVIEWERS

Australia
David Jordan, Queensland Primary Industries and Fisheries

Brazil
Jurandir Magalhaes, Embrapa Maize and Sorghum

Burundi
Espérance Habindavyi, Institute of Agricultural Research - Burundi (ISABU)

China P. R.
Lu Ping, Institute of Crop Science, Chinese Academy of Agricultural Sciences (CAAS)

Czech Republic
Zdenek Stehno, Crop Research Institute

Ethiopia
Asfaw Adugna, Ethiopian Institute of Agricultural Research (EIAR)
Taye Tadesse, Ethiopian Institute of Agricultural Research (EIAR)

Germany
Heiko K. Parzies, University of Hohenheim, Stuttgart
Baerbel Schmidt, Leibniz Institute of Plant Genetics and Crop Plant Research (IPK), Gatersleben

India
Kumar Ashok, National Bureau of Plant Genetic Resources (NBPGR)
S.T. Borikar, Marathwada Agricultural University
M. Elangovan, Directorate of Sorghum Research (DSR)
Belum V.S. Reddy, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
M. Thimma Reddy, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
V. Gopal Reddy, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
H.C. Sharma, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India
Shivali Sharma, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India
Tara Satyavathi, Indian Agricultural Research Institute (IARI)
R.P. Thakur, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
Vincent Vadez, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)

Japan
Makoto Kawase, National Institute of Agrobiological Sciences (NIAS)
Hisato Okuizumi, National Institute of Agrobiological Sciences (NIAS)

Mali
Sidi Bekaye Coulibaly, Institut d'Economie Rurale

Nigeria
Ranajit Bandyopadhyay, International Institute of Tropical Agriculture (IITA)

Sudan
A. Ahmed Awadelkarim, Agricultural Research Cooperation

United Arab Emirates
N. Kameswara Rao, International Center for Biosaline Agriculture

USA
John Erpelding, United States Department of Agriculture, Agricultural Research Service (USDA, ARS)
Jeff Pedersen, United States Department of Agriculture, Agricultural Research Service (USDA, ARS)

Annex X – Final key set of descriptors for sorghum genetic resources obtained after validation

Key access and utilization descriptors for sorghum genetic resources

This list consists of an initial set of characterization and evaluation descriptors for sorghum [*Sorghum bicolor* (L.) Moench] genetic resources utilization. This strategic set of descriptors, together with passport data, will become the basis for the global accession level information portal being developed by Bioversity International with the financial support of the Global Crop Diversity Trust (the Trust). It will facilitate access to and utilization of sorghum accessions held in genebanks and does not preclude the addition of further descriptors, should data subsequently become available.

Based on the comprehensive list 'Descriptors for Sorghum [*Sorghum bicolor* (L.) Moench]' published by ICRISAT and IBPGR (now Bioversity International) in 1993, the list was subsequently compared with a number of sources such as 'UPOV technical guidelines for Sorghum (*Sorghum bicolor* L.)' (1989); 'Descriptors for SORGHUM' (USDA, ARS, GRIN); 'Characterization of ICRISAT-Bred Sorghum Hybrid Parents (Set I)'[1] (ICRISAT, 2006); as well as the list of traits provided by the National Institute of Agrobiological Sciences (NIAS). The initial list also builds on the results of the SGRP Global Public Goods Activity 4.2.1.1 led by Dr Hari D. Upadhyaya (ICRISAT), particularly with regard to those descriptors highlighted as having the most important diagnostic and breeding traits, and also to the Descriptors Draft for sorghum, which was revised by a Committee formed at the Expert Consultation Meeting for Developing a Strategy for the Global Conservation of Sorghum Genetic Resources held at ICRISAT in 2007. The initial list was further refined during a crop-specific consultation meeting held at the National Bureau of Plant Genetic Resources (NBPGR, India) in June 2009.

A worldwide distribution of experts was involved in an online survey to define a first priority set of descriptors to describe, to access and to utilize sorghum genetic resources. This key set was afterwards validated by a Core Advisory Group (see 'Contributors') led by Dr Jeff Dahlberg of the United Sorghum Checkoff Program and Dr Hari D. Upadhyaya of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), together with leading sorghum organizations such as NBPGR, USDA and the Directorate of Sorghum Research (formerly National Research Centre for Sorghum), amongst others.

Biotic and abiotic stresses included in the list were chosen because of their wide geographic occurrence and significant economic impact at a global level.

Numbers in parentheses on the right-hand side are the corresponding descriptor numbers listed in the 1993 publication. Descriptors with numbers ending in 'letters' are either modified or are new descriptors that were added during the development of the list below.

---

[1] International Sorghum and Millets Newsletter, No. 47, Special issue

Race and Group name (1.5.5/6)
(As per Dahlberg, 2000)

1 Bicolor
- 10 Bicolor
- 11 Dochna
- 12 Nervosum
- 13 Nervosum-kaoliang
- 14 Nervosum-broomcorn
- 15 Sudanense

2 Guinea
- 20 Guineense
- 21 Conspicuum
- 22 Margaritiferum
- 23 Roxburghii

3 Caudatum
- 30 Caudatum
- 31 Caudatum-nigricans
- 32 Nigricans
- 33 Sumac
- 34 Nigricans-feterita
- 35 Dobbs
- 36 Caudatum-kaura
- 37 Zerazera

4 Kafir
- 40 Caffrorum

5 Durra
- 50 Durra
- 51 Nandyal
- 52 Cernuum

6 Guinea-bicolor
- 60 Guinea-bicolor
- 61 Dochna-honey
- 62 Dochna-roxburghii

7 Caudatum-bicolor
- 70 Caudatum-bicolor
- 71 Caudatum-dochna
- 72 Nigricans-bicolor
- 73 Dochna-nigricans

8 Kafir-bicolor
- 80 Bicolor-kafir
- 81 Caffrorum-bicolor
- 82 Dochna-kafir

9 Durra-bicolor
- 90 Durra-bicolor
- 91 Dochna-durra
- 92 Durra-dochna
- 93 Subglabrescens
- 94 Subglabrescens-milo
- 95 Milo-kaura

10 Guinea-caudatum
- 100 Caudatum-guineense
- 101 Nigricans-guineense

11 Guinea-kafir
- 110 Caffrorum-roxburghii
- 111 Roxburghii-shallu

12 Guinea-durra
- 120 Durra-roxburghii
- 121 Membraneceum
- 122 Durra-membranaceum

13 Kafir-caudatum
- 130 Caudatum-kafir
- 131 Caffrorum-birdproof
- 132 Caffrorum-darso
- 133 Caffrorum-feterita

14 Durra-caudatum
- 140 Caudatum-durra
- 141 Nigricans-durra
- 142 Durra-nigricans
- 143 Durra-feterita/Kaura

15 Kafir-durra
- 150 Durra-kafir
- 151 Caffrorum-durra

16 Perennial wild
- 160 *S. halepense*
- 161 *S. propinquum*

17 Annual wild
- 170 S. bicolor subsp. drummondii

18 S. bicolor subsp. verticilliforum
- 180 verticilliforum
- 181 arundinaceum
- 182 virgatum
- 183 aethiopicum

19 Unclassified

20 Breeding material
- 200 Unclassified

21 Mixed

Plant height [cm] (4.1.1)

From the ground (base of plant) to the tip of the panicle at 50% flowering. Mean of 10 randomly selected plants

Stalk juiciness (4.1.3)

0 Not juicy
1 Slightly juicy
3 Juicy

Fodder yield (4.1.a)

3 Low
5 Medium
7 High

Days to 50% flowering (4.2.1)

From planting date until 50% of the plants have started flowering

Planting date [YYYYMMDD] (5.4)

When planting is done (if moisture is sufficient) or when irrigation is done after planting

Flowering behaviour (4.2.a)

If grown under long days

0 Absent
3 Early
7 Late

Inflorescence compactness and shape (4.2.2)

1 Very lax panicle (typical of wild sorghums)
2 Very loose erect primary branches
3 Very loose drooping primary branches
4 Loose erect primary branches
5 Loose drooping primary branches
6 Semi-loose erect primary branches
7 Semi-loose drooping primary branches
8 Semi-compact elliptic
9 Semi-compact oval
10 Compact elliptic
11 Compact oval
12 Half broom corn
13 Broomcorn
99 Other (specify in the descriptor **Notes**)

Grain covering (4.2.4)

Amount of grain covered by glumes at maturity. Involuted grain is found when the grain has completely twisted inside of the glumes and is fully exposed such as in the Guinea race

1 25% grain covered
2 50% grain covered
3 75% grain covered
4 Grain fully covered
5 Glumes longer than grain
6 Involuted

Shattering (4.2.6)

Observed at maturity

3 Low
5 Intermediate
7 High

Grain colour (4.3.1)
Phenotypic colour of the grain
1 White
2 Chalky white
3 Straw
4 Grey
5 Light red
6 Red
7 Yellow
8 Light brown
9 Brown
10 Black
11 Purple
12 Variegated (when streaks of red or white appear in the grain)
13 Reddish brown
14 Mixed (when there are mixed grain colours in the grain)

100-seed weight [g] (4.3.3)
Measured at 12% moisture content

Pigmented testa (Grain sub-coat) (4.3.5)
Tannins are not present without the presence of a pigmented testa
0 Absent ($b_1b_1b_2b_2$ or B_1-b_2b_2 or $b_1b_1B_2$-)
1 Present (B_1-B_2-)

Endosperm texture (4.3.8)
1 Completely corneous
2 Mostly corneous
3 Intermediate-partly corneous
4 Mostly starchy (floury)
5 Completely starchy (floury)

Genotypic pericarp colour (4.3.a)
Genetically, there are three pericarp colours in sorghum
1 White (R-yy or rryy)
2 Lemon Yellow (rrY-)
3 Red (R-Y-)

Seedling vigour (6.1.1)
Observed 15 days after emergence
3 Low
5 Intermediate
7 High

Lodging susceptibility (6.1.2)
Indicate if root or stalk
3 Low
5 Intermediate
7 High

Senescence rating [%] (6.1.3)
Death of leaves and stalk at grain maturity
1 Very slightly senescent (10%)
3 Slightly senescent (25%)
5 Intermediate (about half of leaves dead) (50%)
7 Mostly senescent (75%)
9 Completely senescent (leaves and stalk dead)

Desirability rating (6.1.4)

Overall agronomic desirability (use and yield potential) of the total plant as observed visually

1 Very good
2 Good
3 Average
4 Poor
5 Very poor

Photosensitivity (6.2.1)

Recorded on the basis of rainy season (long days): post-rainy season (short days) ratios of plant height (4.1.1) and days to flowering (4.2.1) above

1 Insensitive
2 Partially sensitive
3 Very sensitive

Inflorescence exsertion (6.2.4)

1 Slightly exserted (<2 cm but ligule of flag leaf definitively below inflorescence base)
2 Exserted (2-10 cm between ligule and inflorescence base)
3 Well-exserted (>10 cm between ligule and inflorescence base)
4 Peduncle recurved (inflorescence below ligule and clearly exposed splitting the leaf sheath)

Inflorescence length [cm] (6.2.5)

From base of inflorescence (head) to tip. Mean of five randomly selected plants

Restoration response (Milo source) (6.2.7)

The reaction of the F_1 plant when a male sterile (A line) is pollinated with the accession

1 Maintainer
2 Partial maintainer/restorer
3 Restorer

Male sterile cytoplasm system (6.2.8)

There are four major distinct cytoplasmic-genetic systems

1 A_1
2 A_2
3 A_3
4 A_4
5 Other (specify in the descriptor **Notes**)

Pollen shed (6.2.a)

Visual score (early morning) when the panicle is lightly tapped. Observed at 50% flowering. Mean of five randomly selected plants

3 Low
5 Intermediate
7 High

Grain yield (6.3.a)

Overall estimation of the grain yield for the accession based upon the particular growing conditions in which it was accessed

3 Low
5 Medium
7 High

ABIOTIC STRESSES

Reaction to low temperature (7.1)

Pollen susceptibility (7.1.a)
Measured as reduction in pollen production at low temperatures (10ºC to 15ºC)

Seedling susceptibility (7.1.1)
Measured as reduction in seed germination at low temperatures (10ºC to 15ºC)

Reproductive susceptibility (7.1.2)
Measured as reduction in seed set at low temperatures (10ºC to 15ºC)

Reaction to drought (7.3)

Pre-anthesis drought reaction (7.3.a)
Measured as plants stressed prior to flowering. Plant symptoms include leaf rolling, leaf erectness, leaf bleaching, leaf firing, delayed flowering, poor panicle exsertion, saddle effect, panicle/floret blasting, and reduced panicle size. Ratings may be on individual symptoms or a combination of symptoms

Post-anthesis drought reaction (stay-green ability) (7.3.b)
Measured as plants stressed post-flowering. Plant symptoms include premature leaf and plant death, stalk collapse and lodging, charcoal rot (*Macrophomina phaseolina*) infestation, and reduced seed size

BIOTIC STRESSES

Sorghum shoot fly *(Atherigona soccata)* (8.1.1)

Spotted stem borer *(Chilo partellus)* (8.1.2)

Sorghum midge (Stenodiplosis sorghicola) (8.1.5)

Anthracnose *(Colletotrichum graminicola)* (8.2.3)

Grain moulds *(Curvularia lunata*; *Fusarium* spp.*)* (8.2.4)

NOTES
Any additional information may be specified here, particularly that referring to the category '99=Other' present in some of the descriptors above.

CONTRIBUTORS

Bioversity is grateful to all the scientists and researchers who have contributed to the development of this strategic set of 'Key access and utilization descriptors for sorghum genetic resources', and in particular to Dr Jeff Dahlberg (United Sorghum Checkoff Program, USA) and Dr Hari D. Upadhyaya (ICRISAT, India) for providing valuable scientific direction. Adriana Alercia (Bioversity Interntional) provided technical expertise and guided the entire production process.

The valuable substantial scientific advice provided by ICRISAT scientists is gratefully acknowledged.

CORE ADVISORY GROUP

Jeff Dahlberg, United Sorghum Checkoff Program, USA
Hari D. Upadhyaya, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India
Joël Guiard, Groupe d'Etude et de contrôle des Variétés et des Semences (GEVES), France
C. Tom Hash, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India
R.G. Henzell, Queensland Department of Primary Industries, Australia
Mario A. Lira, Agricultural Research Institute of Pernambuco (IPA), Brazil
Prem Mathur, Bioversity International, India
Frederick R. Miller, MMR Genetics L.L.C., USA
S.R. Pandravada, National Bureau of Plant Genetic Resources (NBPGR), Regional Station, Rajendranagar, Hyderabad, India
Gary A. Pederson, United States Department of Agriculture, Agricultural Research Service (USDA, ARS), Plant Genetic Resources Conservation Unit, USA
A. Seetharam, Indian Council of Agricultural Research (ICAR), India
N. Seetharama, Directorate of Sorghum Research (formerly National Research Centre for Sorghum), India

REVIEWERS

Australia
David Jordan, Queensland Primary Industries and Fisheries

Brazil
Jurandir Magalhaes, Embrapa Maize and Sorghum

Burundi
Espérance Habindavyi, Institute of Agricultural Research - Burundi (ISABU)

China P. R.
Lu Ping, Institute of Crop Science, Chinese Academy of Agricultural Sciences (CAAS)

Czech Republic
Zdenek Stehno, Crop Research Institute

Ethiopia
Asfaw Adugna, Ethiopian Institute of Agricultural Research (EIAR)
Taye Tadesse, Ethiopian Institute of Agricultural Research (EIAR)

Germany
Heiko K. Parzies, University of Hohenheim, Stuttgart
Baerbel Schmidt, Leibniz Institute of Plant Genetics and Crop Plant Research (IPK), Gatersleben

India
Kumar Ashok, National Bureau of Plant Genetic Resources (NBPGR)
S.T. Borikar, Marathwada Agricultural University (MAU)
M. Elangovan, Directorate of Sorghum Research (DSR)
Belum V.S. Reddy, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
V. Gopal Reddy, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
H.C. Sharma, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
Shivali Sharma, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
Tara Satyavathi, Indian Agricultural Research Institute (IARI)
R.P. Thakur, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
Vincent Vadez, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)

Japan
Makoto Kawase, National Institute of Agrobiological Sciences (NIAS)
Hisato Okuizumi, National Institute of Agrobiological Sciences (NIAS)

Mali
Sidi Bekaye Coulibaly, Institut d'Economie Rurale

Nigeria
Ranajit Bandyopadhyay, International Institute of Tropical Agriculture (IITA)

Sudan
A. Ahmed Awadelkarim, Agricultural Research Cooperation

The United Arab Emirates
N. Kameswara Rao, International Center for Biosaline Agriculture

USA
John Erpelding, United States Department of Agriculture, Agricultural Research Service (USDA, ARS)
Jeff Pedersen, United States Department of Agriculture, Agricultural Research Service (USDA, ARS)

Methodology for the definition of a key set of characterization and evaluation descriptors for sweet potato [*Ipomoea batatas*]

Information collection and preparation of the Minimum Descriptor List (MDL)

Information for the definition of a Minimum Descriptor List for sweet potato [*Ipomoea batatas*] was drawn from the publication 'Descriptors for Sweet Potato' [CIP, AVRDC, IBPGR (now Bioversity International), 1991]. The original list was compared to descriptors mentioned in a number of documents, namely:

1. Main output of the Germplasm Characterization National Workshop held from January 24-26, 2006 at the Philippines Root Crop Research and Training Center (PhilRootcrops) in Leyte, central Philippines;
2. Basic list of descriptors for sweet potato, drawn from Guarino, L and Jackson, GVH 'Describing and documenting root crops in the South Pacific'. Suva, Fiji, 1986. FAO. RAS/83/001, Field document 12;
3. 'Global Strategy for *Ex-situ* Conservation of Sweetpotato Genetic Resources', (the Trust, 2007);
4. Descriptors that were awarded funds for further research by the Global Crop Diversity Trust 2008 Award Scheme 'Enhancing the Value of Crop Diversity in a World of Climate Change' (EAS);
5. Criteria for evaluating sweet potato cultivars drawn from the Report on the ACIAR sweet potato workshop, held in Madang, Papua New Guinea from 28-29 June 2006;
6. Important descriptors mentioned in the CIP website;
7. 'Descriptors for Characterization and Evaluation of Sweet potato' (National Institute of Agrobiological Sciences, NIAS, Genebank of Japan);
8. 'Descriptors for SWEETPOTATO' (USDA, ARS, GRIN).

Evaluation traits such as important pests and diseases for sweet potato, tuber quality and other agronomic characteristics were included. An Excel summary table was prepared comparing traits listed in all of the above mentioned sources (see Annex I).

Preparation of the List of Experts

Experts were drawn from the 'Global Strategy for *Ex-situ* Conservation of Sweetpotato Genetic Resources' (the Trust, 2007) and from the participants' list of the ACIAR sweet potato workshop, held in Madang, Papua New Guinea from 28–29 June 2006. The list was further integrated with names of participants in the Symposium of the International Society for Tropical Root Crops (ISTRC), held in Peru on 2-6 November 2009 and with two additional expert names, suggested by EMBRAPA (Empresa Brasileira de Pesquisa Agropecuária, Brazil), who are the curators of the EMBRAPA genebank. Reviewers from the 1991 descriptors list were excluded due to their outdated contact information.

Overall, 77 experts were identified, from 27 countries and 42 different organizations. Out of these, two Crop Leaders, Genoveva Rossel and David Tay [both from the International Potato Centre (CIP), Peru] and a Core Advisory Group consisting of 10 experts (see Annex II) were selected to assist in the definition of a minimum set of descriptors for this crop. Core Advisory Group members were drawn from prestigious academic and scientific organizations including the International Potato Centre (CIP), the Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), and the United States Department of Agriculture, Agricultural Research Service (USDA, ARS).

Survey preparation and distribution

On 26 November 2008 a letter was sent out to the Crop Leaders, along with the comparison table described above (Annex I), to help define a key set of characterization and evaluation descriptors for sweet potato utilization. A reminder requesting the revised list was sent to CIP on 30 March 2009. In order to accelerate the process, the comparison table with an additional column, where CIP experts could indicate their selection, was sent by email on 28 July 2009. Two further reminders were sent on 2 September 2009 and 15 October 2009, after which Dr Tay sent back the comparison table with CIP'experts input. The table included many descriptors (39) only related to characterization data. It was suggested to refine their selection of characteristics and concentrate on the most important abiotic and biotic stresses, taking into account their cosmopolitan nature, wide geographical coverage and significant economical impact. Because of the tight timeframe, and wanting to take advantage of the Symposium of the International Society for Tropical Root Crops (ISTRC), being held in November 2009, the Coordinator of Component 1, Ms Adriana Alercia (Bioversity International) travelled to Peru to meet with experts and discuss the draft list that would be included in the survey.

During the meeting, a detailed workplan was defined listing steps to be followed and relevant deadlines. Crop Leaders were also contacted by telephone and, on 31 January 2010, they provided their selection for an initial key set of evaluation and characterization descriptors for sweet potato to be included in the online survey (see Annex III). A draft survey on sweet potato was therefore prepared listing the descriptors approved by consultations with Dr Genoveva Rossel. The final draft of the survey was uploaded into the SurveyMonkey application and sent out to the list of identified experts on 5 April 2010. Experts were invited to validate this initial 'Key set of descriptors' of sweet potato accessions to facilitate their use by researchers, and asked to make suggestions regarding any additional characterization and/or evaluation traits yet missing from the proposed List (see Annex IV).

The deadline for the survey was set at 2 March 2010. A first reminder was sent out on 19 February 2010 and a second one on 25 February 2010, to ensure that the greatest possible feedback was obtained.

Survey analysis and refinement of the Minimum List

Of the 77 experts who were identified and involved in the exercise, 27 from 15 countries and 18 organizations recorded their comments using the online survey (see Annex V). Results from the survey were analyzed and descriptors were ranked by rating average and percentage of importance (see Annex VI). The summary results of the survey together with a report containing comments received by the participants (see Annex VII) were sent to the Core Advisory Group asking them to select those descriptors they considered essential for the minimum key set. The feedback received was collated in the comparison table resulting from the survey (rating and percentages) and sent to the Crop Leaders. They were asked to validate or select traits from the list to define a priority list of descriptors that would be shared and approved by the whole group of experts.

Following the advice of Drs Rossel and Tay, it was decided that the final set of descriptors would be composed of the complete list of descriptors proposed in the survey (see Annex VIII). A first draft of the final document listing the above set was produced including relevant descriptor states and all the contributors and was submitted to Crop Leaders for final validation (see Annex IX). It was further refined by adding five descriptors as Dr Rossel strongly suggested them, indicating that they were extremely useful for sweet potato. These additional traits are listed below:

Ground cover	(4.1.3)
Vine internode length	(4.1.4.1)
Vine internode diameter	(4.1.4.2)
Storage root surface defects	(4.2.2)
Storage root cortex thickness	(4.2.3)

Definition of a final key set of descriptors for sweet potato

The final document was shared with the whole group of experts, including all the descriptor states and contributors (see Annex X). Six out of nine members of the Core Advisory Group, validated the list with the exception of Dr Grahame Jackson who raised a number of issues regarding: 1. storage root colours (viruses may alter the colours giving much paler colours of *B carotene* varieties); 2. doubts on the validity of certain descriptors to be included, such as petiole length, vine tip pubescence, mature leaf size and in particular root surface defects (4.2.2) as viruses, especially feathery mottle strains, produce root symptoms; 3. the inclusion of SP chlorotic stunt virus since it is often latent, and 4. naming the weevil species.

The Coordinator of Component 1, Ms Adriana Alercia, sent Dr Jackson's comments together with the following information to the Crop Leaders asking them for make a final decision in this regard.

> ***Petiole length, mature leaf size and Vine tip pubescence***: *According to the comparison table available in Annex I, these characteristics are included also in the Guarino and Jackson publication, as well as listed in USDA, ARS descriptors and in NIAB's List.*
>
> *With regard to storage root colours, again there are two drawn from Guarino and Jackson publication, but generally all of them are well ranked according to the survey responses. The species name should be included for weevil.*

After consulting with the Crop Leaders, changes were implemented and the key set was edited and laid out. It was then sent to the Bioversity Publications Unit for on-line publication process. Furthermore, the publication was shared with the ECPGR Secretariat; the Generation Challenge Programme (GCP) Ontology and the SGRP Crop Genebank Knowledge Base partners. Additionally, data were converted into Excel files for uploading into the GRIN-Global genebank data-management system being developed by USDA and into the Germplasm Information on Genebank Accessions global portal (GENESYS), linking national, regional and international genebank databases in support of the conservation and use of plant genetic resources for food and agriculture (PGRFA). The Excel files were also provided to the System-wide Information Network for Genetic Resources (SINGER) and to EURISCO.

Acknowledgement

Bioversity is grateful to all the scientists and researchers who have contributed to the development of the strategic key set of descriptors for sweet potato, and to the Global Crop Diversity Trust for their financial support. Particular recognition goes to the Crop Leaders, Dr Genoveva Rossel and Dr David Tay from CIP (Peru), as well as to Dr Grahame Jackson (Australia) for providing valuable scientific direction during the development of the Key access and utilization descriptors for sweet potato.

Annex I – Summary comparison table weighing up important descriptors for sweet potato drawn from different sources[i]

Desc. no.	Descriptor name	CIP/ AVRDC/ IBPGR 1991 (a)	CIP-UPWARD 2006 (b)	MDL G. Jackson/ L. Guarino (c)	Crop Strategy 2007 (d)	EAS (e)	ACIAR sweet potato workshop 2006 (f)	Important descriptors mentioned in the CIP website (g)	NIAS (h)	ARS-GRIN (i)
4.1.1	Twining	*		*					*	*
4.1.2	Plant type	*		*					*	*
4.1.3	Ground cover	*		* (Vine growth rate?)						
4.1.4	Vine internode	*								
4.1.4.1	Vine internode length	*		*					*	*
4.1.4.2	Vine internode diameter	*								*
4.1.5	Vine pigmentation	*		*					*	
4.1.5.1	Predominant vine colour	*	*							
4.1.5.2	Secondary vine colour	*	*							*
4.1.6	Vine tip pubescence	*	*	*					*	*
4.1.7	Mature leaf shape	*		*					*	
4.1.7.1	General outline of leaf	*	*	*						
4.1.7.2	Leaf lobe type	*	*	*						
4.1.7.3	Leaf lobe number	*	*	*						
4.1.7.4	Shape of central leaf lobe	*	*							
4.1.8	Mature leaf size	*		*					*	*
	Breadth of leaf [cm]			*						
4.1.9	Abaxial leaf vein pigmentation	*	*	*					*	*
4.1.10	Foliage colour	*								
4.1.10.1	Mature leaf colour	*	*							*
4.1.10.2	Immature leaf colour	*	*	*					*	*
4.1.11	Petiole length	*		*					*	*
4.1.12	Petiole pigmentation	*	*	*						*
4.2.1	Storage root shape	*					*		*	*
4.2.2	Storage root surface defects	*								*
4.2.3	Storage root cortex thickness	*								*
4.2.4	Storage root skin colour	*					*		*	*
4.2.4.1	Predominant storage root skin colour	*	*	*						
4.2.4.2	Intensity of predominant storage root skin colour	*	*							*
4.2.4.3	Secondary storage root skin colour	*	*						*	

4.2.5	Storage root flesh colour	*					*		*	*
4.2.5.1	Predominant storage root flesh colour	*	*	*			*			
4.2.5.2	Secondary storage root flesh colour	*	*	*			*			
4.2.5.3	Distribution of secondary storage root flesh colour	*	*	*						
4.3.1	Flowering habit	*		*						
4.3.2	Flower colour	*		*					*	*
4.3.3	Flower size	*								
4.3.3.1	Flower length [cm]	*		*					*	*
4.3.3.2	Flower width [cm]	*		*					*	*
4.3.4	Shape of limb	*								*
4.3.5	Equality of sepal length	*		*					*	*
4.3.6	Number of sepal veins	*								*
4.3.7	Sepal shape	*		*					*	*
4.3.8	Sepal apex	*		*					*	*
4.3.9	Sepal pubescence	*		*						
4.3.10	Sepal colour	*		*						
4.3.11	Colour of stigma	*								*
4.3.12	Colour of style	*		*						*
4.3.13	Stigma exertion	*		*						*
4.3.14	Seed capsule set	*								*
6.1.1	Storage root formation	*								
6.1.2	Storage root stalk	*								
6.1.3	Number of storage roots per plant	*					*			*
	Weight of storage roots						*			
6.1.4	Variability of storage root shape	*							*	*
6.1.5	Variability of storage root size	*							*	*
6.1.6	Storage root cracking	*					*		*	
6.1.7	Latex production in storage roots	*								
6.1.8	Oxidation in storage roots	*								
6.2	Quality characters					*				
6.2.1	Storage root dry matter content [%]	*					*		*	
6.2.2	Storage root nitrogen content [%]	*								*
6.2.3	Storage root crude fibre [% fresh weight]	*					*			*
6.2.4	Storage root starch content [% dry weight]	*							*	

6.2.5	Storage root total alcohol soluble sugar content [%]	*								
6.2.6	Storage root carotene content [mg/100g fresh weight]	*				*	*			
6.2.7	Keeping quality of stored storage roots	*					*			*
6.2.8	Sprouting ability	*							*	*
6.2.9	Boiled storage root	*								
6.2.9.1	Consistency of boiled storage root	*								
6.2.9.2	Undesirable colour of boiled storage root	*								
6.2.9.3	Texture of boiled storage root flesh	*					*			
6.2.9.4	Sweetness of boiled storage root flesh	*					*			
7.1	Reaction to drought	*				*	*			
7.2	Reaction to flooding	*								
7.3	Reaction to heat	*								
7.4	Reaction to salinity	*			*	*				
7.5	Reaction to shade	*								
7.6	Reaction to soil pH below 5.0	*								
7.7	Reaction to high soil temperature	*								
8.1	Insects	*								
8.1.1	*Cylas* spp. (Sweet potato weevil)	*					*	*	*	*
8.1.2	*Euscepes postfasciatus* Fairmaire (West Indian sweet potato weevil)	*							*	
8.1.3	*Alcidodes* sp. (Sweet potato weevils)	*								
8.1.4	*Conoderus* sp. (Sweet potato wire worms)	*								*
8.1.5	*Melanotus* spp. (Wire worms)	*								
8.1.6	*Chaetocnema confinis* Crotch (Sweet potato flea beetle)	*								*
8.1.7	*Systena* sp. (Flea beetles)	*								
8.1.8	*Typophorus* sp. (Sweet potato leaf beetles)	*								
8.1.9	*Diabrotica* sp., *Aspidomorpha* sp., *Calasposoma dauricum* Mennerheim (Beetles or rootworms)	*			*					
8.1.10	*Phyllophaga* sp., *Plectris aliena* Chapin (Grubworm)	*								*
8.1.11	*Agrius cingulatus* Fabricius (Hornworm); *Acraea acerata* (Defoliating caterpillar)	*					*			
8.1.12	*Aphis gossypii* Glov.; *Myzus persicae* Sulzer (Aphids)	*								

8.1.13	*Bemisia tabaci* Gennadius (Sweet potato whytefly)	*								
8.1.14	*Herse convolvuli* L. (Sweet potato moth)	*								
8.1.15	*Bedellia sommulentella* Zellar; *Brachmia macroscopa* Meyrick; *Prodenia litura* F. (Moth)	*								
8.1.16	*Omphisa anastomasalis* Guernee (Sweet potato stem borer)	*								
8.2	Nematodes	*			*					
8.2.1	*Meloidogyne* spp. (Root-knot nematode)	*						*	*	
8.2.2	*Rotylenchulus reniformis* Linford and Oliveira (Reniform nematode)	*								
8.2.3	*Belonolaimus* sp. (Sting nematode)	*								
8.2.4	*Ditylenchus* sp. (Brown ring rot)	*								
8.2.5	*Pratylenchus coffeae (Zimmermann) Goodey (Root lesion nematode)*	*							*	
8.3	Fungi	*								
8.3.1	*Fusarium oxysporum* f. sp. *batatas* (*Fusarium* wilt or stem rot)	*			*				*	
8.3.2	*Fusarium oxysporum* Schlect. (*Fusarium* surface rot)	*			*					
8.3.3	*Fusarium solani* (Mart.) Appel & Wr. (*Fusarium* root rot)	*			*					*
8.3.4	*Sclerotium rolfsii* Sacc. (Sclerotial blight and circular spot)	*								
8.3.5	*Ceratocystis fimbriata* Ell. & Halst (Black rot)	*			*				*	
8.3.6	*Monilochaetes infuscans* Ell. & Halst. ex. Harter (Scurf)	*								
8.3.7	*Rhizopus stolonifer* (Ehr. ex. Fr.) (Lind.) (Soft rot)	*			*					
8.3.8	*Diplodia gossypina* (Cke.) (Java black rot)	*								*
8.3.9	*Diaporthe batatatis* Harter & Field (Diaporthe dry rot)	*			*					
8.3.10	*Elsinoe batatas* (Saw.) Viegas & Jenkins (Scab or spot anthracnose)	*					*			
8.3.11	*Phyllosticta batatas* (Thuem.) Cbe.; *Cercospora batatae* Zimm; *Septoria bataticola* Taub. (Leaf spot)	*								
8.3.12	*Albugo ipomoeae-panduratae* (Schw.) Swing. (White rust)	*								
8.3.13	*Plenodomus destruens* Harter (Foot rot)	*			*					
8.3.14	*Macrophomina phaseoli* (Maubl.) Ashby (Charcoal rot)	*			*					

8.4	Bacteria	*								
8.4.1	*Streptomyces ipomoea* (Person & W.T. Martin) (Pox or soil rot)	*							*	*
8.4.2	*Erwinia chrysanthemi* Dupes (Bacterial stem and root rot)	*			*					*
8.4.3	*Pseudomonas solanacearum* C.F. Smith (Bacterial wilt)	*			*					
8.5	Viruses	*								
8.5.1	Sweetpotato Feathery Mottle Virus (SPFMV)	*			*					
8.5.2	Mild mottle virus (SPMMV)	*								
8.5.3	Vein mottle virus (SPVMV)	*								
8.5.4	Sweet potato virus disease (SPVD complex)	*			*					
8.6	Mycoplasma	*								
8.6.1	Witches broom	*								
	Sweet potato stem blight (*Alternaria* sp.)					*	*			
	Sweet potato chlorotic stunt virus (SPCSV)				*					
	High protein						*			
	Flavour						*			
	Earliness (time to maturity of storage roots)						*			
	Development of tubers on the runners or at the base						*			

[i]
(a) 'Descriptors for Sweet Potato' (CIP, AVRDC, IBPGR, 1991);
(b) Main output of the Germplasm Characterization National Workshop held from 24-26 January 2006, at the Philippines Root Crop Research and Training Center (PhilRootcrops) in Leyte, central Philippines;
(c) Basic list of descriptors for Sweet Potato, drawn from Guarino, L. and Jackson, G.V.H. 'Describing and documenting root crops in the South Pacific'. Suva, Fiji, 1986. FAO. RAS/83/001, Field document 12;
(d) 'Global Strategy for *Ex-situ* Conservation of Sweetpotato Genetic Resources' (the Trust, 2007);
(e) Descriptors that were awarded funds for further research by the Global Crop Diversity Trust 2008 Award Scheme 'Enhancing the Value of Crop Diversity in a World of Climate Change' (EAS);
(f) Criteria for evaluating sweet potato cultivars drawn from the Report on the ACIAR sweet potato workshop, held in held in Madang, Papua New Guinea 28–29 June 2006;
(g) Important descriptors mentioned in the CIP website;
(h) 'Descriptors for Characterization and Evaluation of Sweet potato' (National Institute of Agrobiological Sciences, NIAS, Genebank of Japan);
(i) 'Descriptors for SWEETPOTATO' (USDA, ARS, GRIN).

Annex II – List of experts identified to participate to the survey

Role	***Name***	***Organization***	***Country***
Crop Leader	**Rossel, Genoveva**	CIP	Peru
Crop Leader	**Tay, David**	CIP	Peru
CAG/UPOV	Choi, Keun-Jin	UPOV	Republic of Korea
CAG	Hunter, Danny	Bioversity International	Italy
CAG	Jackson, Grahame		Australia
CAG	Jarret, Robert	ARS/USDA	USA
CAG (EAS)	Panta, Ana	CIP	Peru
CAG (the Trust expert)	Rao, Ramanatha	Bioversity International	India
CAG (the Trust expert)	Roca, Willy	CIP	Peru
CAG (EAS)	de Ronde, Kobie	Vegetable and Ornamental Plant Institute (ARC)	South Africa
CAG/Curator of Roots and Tubers in Embrapa Cenargen	Sias Costa, Ivo	EMBRAPA	Brazil
CAG/Curator of Embrapa's Sweet Potato Gene Bank	Suita de Castro, Luis Antônio	EMBRAPA	Brazil
Crop Strategy Expert	Andrade, Maria Isabel	International Potato Center (CIP), International Institute of Tropical Agriculture (IITA)	Mozambique
Symposium ISTRC	Agili, Sammy	CIP	Kenya
Symposium ISTRC	Akoroda, Malachy	University of Ibadan	Nigeria
Crop Strategy Expert	Apa, Annamarie	National Highlands Sweet Potato Collection - (NARI)	Papua New Guinea
Crop Strategy Expert	Borromeo, Teresita H.	University of the Philippines Los Baños, Crop Science Cluster	Philippines
Crop Strategy Expert	Bosco de Carvalho, Joao	EMBRAPA Hortalicas	Brazil
ACIAR workshop 2006	Bourke, Mike	Australian National University, Canberra	Australia
Crop Strategy Expert	Campilan, Dindo	CIP-UPWARD	Philippines
Crop Strategy Expert	Castillo, Gelia	CIP-UPWARD	Philippines
ACIAR workshop 2006	Chambers, Barbara	Australian National University, Canberra	Australia
ACIAR workshop 2006	Chang, Christie	University of New England	Australia
Symposium ISTRC	Chipungu, Felistus	Bvumbwe Research Station	Malawi
ACIAR workshop 2006	Coleman, Eric	Sweet Potato Pest and Disease Project, QDPI	Australia

Crop Strategy Expert	de Chavez, Hidelisa	CIP-UPWARD	Philippines
Reviewer	Ezeta, Fernando	CIP	Indonesia
Crop Strategy Expert	Gonzales, Ines	Northern Philippines Rootcrop Research and Training Center	Philippines
Symposium ISTRC	Gruneberg, Wolfgang	CIP	Peru
ACIAR workshop 2006	Harwood, Tracy	Australian National University, Canberra	Australia
ACIAR workshop 2006	Hombuhanje, Freddy	World Vision	Papua New Guinea
Crop Strategy Expert	Hompanera, Norma R.	Instituto Nacional de Tecnología Agropecuaria, Instituto de Recursos Biológicos, CIRN	Argentina
ACIAR workshop 2006	Hughes, Mike	Sweet Potato Ppest and Ddisease Pproject, QDPI	Australia
ACIAR workshop 2006	Ivahupa, Sharryl	World Vision	Papua New Guinea
Crop Strategy Expert	Kapinga, Regina Emilian	CIP	Uganda
ACIAR workshop 2006	Kapis, Joseph	World Vision	Papua New Guinea
ACIAR workshop 2006	Kata, Joseph	World Vision	Papua New Guinea
ACIAR workshop 2006	Katapa, Peter	WWF	Australia
ACIAR workshop 2006	Kirchhof, Gunnar	University of Queensland	Australia
Crop Strategy Expert	Kumagai Toru	NICS - NARO	Japan
Crop Strategy Expert	Kuoko, Stephen Sebastiani	Horticulture Research Institute Horti-Tengeru	Tanzania
Suggested at ISTRC	Lebot, Vincent	CIRAD	France
Crop Strategy Expert	Lee, Joon-Seol	NICS Mokpo Experimental St.	Republic of Korea
Crop Strategy Expert	Li, Hongmin	Xuzhou Sweet Potato Research Center	China
ACIAR workshop 2006	Lim, TK	ACIAR, Canberra	Australia
ACIAR workshop 2006	Liripu, Greg	Fresh Produce Development Agency	Papua New Guinea
ACIAR workshop 2006	Maltby, John	Sweet Potato Pest And Disease Project, QDPI	Australia
Reviewer	Manguiat, Proceso H.	University of the Philippines Los Baños	Philippines
Crop Strategy Expert	Mariscal, Algerico	Philippine Root Crops Research and Training Center (Philrootcrops)	Philippines
Symposium ISTRC	Maziya-Dixon, Bussie	IITA	Nigeria
ACIAR workshop 2006	Menz, Ken	ACIAR, Canberra	Australia
Crop Strategy Expert	Milián Jiménez, Marilys Diley	INIVIT	Cuba
Geneflow 2009	Morales, Francisco	CIAT	Colombia
Crop Strategy Expert	Mwanga, Robert O.M.	NARO	Uganda

Symposium ISTRC	Nandwani, Dilip	Northern Marianas College	Commonwealth of the Northern Mariana Islands
Crop Strategy Expert	Naskar, S.K.	Central Tuber Crops Research Institute (ICAR)	India
ACIAR workshop 2006	Okpul, Tom	PNG University of Technology	Papua New Guinea
Symposium ISTRC	Olojede, Adeyemi Olujide	National Root Crops Research Institute, Umudike	Nigeria
ACIAR workshop 2006	Ontiri, Enoch	WWF	Papua New Guinea
Symposium ISTRC	Pandey, Suman Kumar	Central Potato Research Institute	India
Crop Strategy Expert	Randrianaivoarivony, Jean Marc	FIFAMANOR	Madagascar
Crop Strategy Expert	Reynoso, Daniel	National Institute of Agricultural Research (INIA)	Peru
Suggested at ISTRC	Roskruge, Nick	Massey University	New Zealand
Suggested at ISTRC	Roullier, Caroline	Centre d'Ecologie Functionelle et Evolutive	France
Symposium ISTRC	Sartie, Alieu	IITA	Nigeria
ACIAR workshop 2006	Setiawan, Asep	CIP	Indonesia
Symposium ISTRC	Sharma, Kamal	IITA	Nigeria
ACIAR workshop 2006	Sharp, Timothy	Australian National University, Canberra	Australia
ACIAR workshop 2006	Spriggs, John	Australian National University, Canberra	Australia
Symposium ISTRC	Sreekanth, Attaluri	CIP	India
internet	Tairo, Fred	Mikocheni Agricultural Research Institute	Tanzania
Crop Strategy Expert	Tang, Jun	Xuzhou Sweet Potato Research Center	China
Crop Strategy Expert	Van Kien, Nguyen	Plant Genetic Resources Center, Vietnam Agricultural Science Institute	Vietnam
ACIAR workshop 2006	Wright, Jacqui	ACIAR, Port Moresby	Australia
Suggested at ISTRC	Xie, Kaiyun	CIP, Liaison Office, Beijing	China
Crop Strategy Expert	Yakub, Muhammod Jusuf	Indonesian Legumes and Tuber Crops Research Institute (ILTRI)	Indonesia

Annex III – Initial key set of evaluation and characterization descriptors for sweet potato validated by the Crop Leaders (G. Rossel and D. Tay) to be uploaded in the survey

DESCRIPTOR NAME

1. Twining (ability)	(4.1.1)
2. Plant growth habit (type)	(4.1.2)
3. Predominant vine colour	(4.1.5.1)
4. Secondary vine colour	(4.1.5.2)
5. Vine tip pubescence	(4.1.6)
6. General outline of leaf	(4.1.7.1)
7. Leaf lobes type	(4.1.7.2)
8. Leaf lobe number	(4.1.7.3)
9. Shape of central leaf lobe	(4.1.7.4)
10. Mature leaf size	(4.1.8)
11. Abaxial leaf vein pigmentation	(4.1.9)
12. Mature leaf colour	(4.1.10.1)
13. Immature leaf colour	(4.1.10.2)
14. Petiole length	(4.1.11)
15. Petiole pigmentation	(4.1.12)
16. Storage root shape	(4.2.1)
17. Predominant storage root skin colour	(4.2.4.1)
18. Intensity of predominant storage root skin colour	(4.2.4.2)
19. Secondary storage root skin colour	(4.2.4.3)
20. Predominant storage root flesh colour	(4.2.5.1)
21. Secondary storage root flesh colour	(4.2.5.2)
22. Distribution of secondary storage root flesh colour	(4.2.5.3)

QUALITY CHARACTERISTICS

23. Storage root dry matter content [%]	(6.2.1)
24. Storage root nitrogen content [%]	(6.2.2)
25. Storage root starch content [% DW]	(6.2.4)
26. Storage root total alcohol soluble sugar content [%]	(6.2.5)
27. Storage root carotene content [mg/100g FW]	(6.2.6)
28. Consistency of boiled storage root	(6.2.9.1)
29. Texture of boiled storage root flesh	(6.2.9.3)

ABIOTIC STRESS

30. Reaction to drought	(7.1)
31. Reaction to flooding	(7.2)
32. Reaction to heat	(7.3)
33. Reaction to salinity	(7.4)

BIOTIC STRESS

34. Sweet potato weevil (*Cylas* spp.)	(8.1.1)
35. Root-knot nematode (*Meloidogyne* spp.)	(8.2.1)
36. *Fusarium* wilt or stem rot (*Fusarium oxysporum* f. sp. *batatas*)	(8.3.1)
37. Black rot (*Ceratocystis fimbriata*)	(8.3.5)
38. Java black rot (*Diplodia gossypina*)	(8.3.8)
39. Scab or spot anthracnose (*Elsinoe batatas*)	(8.3.10)
40. Charcoal rot (*Macrophomina phaseoli*)	(8.3.14)
41. Bacterial stem and root rot (*Erwinia chrysanthemi*)	(8.4.2)
42. Sweet potato virus disease (SPVD complex)	(8.5.4)
43. Sweet potato chlorotic stunt virus (SPCSV)	

Annex IV – Survey to choose a key set of Descriptors for Sweet potato utilization

WELCOME

Welcome to the survey for the selection of a key set of characterization and evaluation descriptors for sweet potato utilization to support an international information system to enhance the utilization of germplasm held in genebanks.

Your knowledge and experience are being sought to define an initial **'key set'** of descriptors that identify traits important to crop production and facilitate the use of accessions by researchers.

Your participation in it is highly appreciated. The deadline for this survey is **2 March 2010**.

This key set of descriptors will be made available through a global portal for identifying sets of accessions for evaluation and use.

This survey consists of two parts:

- PART I: Characterization descriptors.

- PART II: Evaluation descriptors.

We thank you in advance for investing your time and expertise in selecting the set of descriptors.

*** Please allow us to acknowledge your contribution by completing your full contact details below:**

Name:

Position:

Organization:

Country:

Email:

Survey to choose a key set of Descriptors for Sweet potato

PART I: Characterization descriptors

These traits enable easy and quick discrimination between phenotypes. They are generally highly heritable, can be easily seen by the eye and are equally expressed in all environments.

Based on your experience, please select descriptors that provide the most impact in discriminating between accessions. It also allows you to indicate if any essential descriptor that can contribute to its use is missing from the minimum list presented.

*Numbers in parentheses on the right -hand side are the corresponding descriptors numbers as published in the CIP/AVRDC/IBPGR publication 'Descriptors for Sweet potato' (1991).

	Very important	Important	Not important
Twining (ability) (4.1.1)	○	○	○
Plant growth habit (type) (4.1.2)	○	○	○
Predominant vine colour (4.1.5.1)	○	○	○
Secondary vine colour (4.1.5.2)	○	○	○
Vine tip pubescence (4.1.6)	○	○	○
General outline of leaf (4.1.7.1)	○	○	○
Leaf lobes type (4.1.7.2)	○	○	○
Leaf lobe number (4.1.7.3)	○	○	○
Shape of central leaf lobe (4.1.7.4)	○	○	○
Mature leaf size (4.1.8)	○	○	○
Abaxial leaf vein pigmentation (4.1.9)	○	○	○
Mature leaf colour (4.1.10.1)	○	○	○
Immature leaf colour (4.1.10.2)	○	○	○
Petiole length (4.1.11)	○	○	○
Petiole pigmentation (4.1.12)	○	○	○
Storage root shape (4.2.1)	○	○	○
Predominant storage root skin colour (4.2.4.1)	○	○	○
Intensity of predominant storage root skin colour (4.2.4.2)	○	○	○
Secondary storage root skin colour (4.2.4.3)	○	○	○
Predominant storage root flesh colour (4.2.5.1)	○	○	○
Secondary storage root flesh colour (4.2.5.2)	○	○	○
Distribution of secondary storage root flesh colour (4.2.5.3)	○	○	○

If you consider that an essential trait is missing from this list, please indicate it here along with a substantiated justification.

Survey to choose a key set of Descriptors for Sweet potato

PART II: Evaluation descriptors

These descriptors include characters such as abiotic andbiotic stresses. They are the most interesting traits in crop improvement. Please consider the following factors relating to the trait when making your final decision: (i) Global impact, (ii) Initial strategic set, (iii) Importance for germplasm utilization, (iv) Data availability, (v) True economic damage, and (vi) Wide geographical occurrence.

Please, rate these traits in order of importance at the global level. It also allows you to indicate if any essential trait for crop production is missing from the minimum list presented or indicate any that may not be very significant to global production.

	Very important	Important	Not Important
Storage root dry matter content [%] (6.2.1)	○	○	○
Storage root nitrogen content [%] (6.2.2)	○	○	○
Storage root starch content [% DW] (6.2.4)	○	○	○
Storage root total alcohol soluble sugar content [%] (6.2.5)	○	○	○
Storage root carotene content [mg/100g FW] (6.2.6)	○	○	○
Consistency of boiled storage root (6.2.9.1)	○	○	○
Texture of boiled storage root flesh (6.2.9.3)	○	○	○
Reaction to drought (7.1)	○	○	○
Reaction to flooding (7.2)	○	○	○
Reaction to heat (7.3)	○	○	○
Reaction to salinity (7.4)	○	○	○
Sweet potato weevil (*Cylas* spp.) (8.1.1)	○	○	○
Root-knot nematode (*Meloidogyne* spp.) (8.2.1)	○	○	○
Fusarium wilt or stem rot (*Fusarium oxysporum* f. sp. *batatas*) (8.3.1)	○	○	○
Black rot (*Ceratocystis fimbriata*) (8.3.5)	○	○	○
Java black rot (*Diplodia gossypina*) (8.3.8)	○	○	○
Scab or spot anthracnose (*Elsinoe batatas*) (8.3.10)	○	○	○
Charcoal rot (*Macrophomina phaseoli*) (8.3.14)	○	○	○
Bacterial stem and root rot (*Erwinia chrysanthemi*) (8.4.2)	○	○	○
Sweet potato virus disease (SPDV complex) (8.5.4)	○	○	○
Sweet potato Chlorotic Stunt Virus (SPCSV)	○	○	○

If you consider that an essential trait important for crop improvement and production is missing from this list, or, if any of the descriptors listed is not clearly useful to promote utilization, please indicate it here along with a substantiated justification.

Annex V – List of respondents to the survey

Role	***Name***	***Position***	***Organization***	***Country***
Crop Leader	**Rossel, Genoveva**		CIP	Peru
Crop Leader	**Tay, David**		CIP	Peru
CAG	Hunter, Danny	Project Scientist	Bioversity International	Italy
CAG	Jackson, Grahame			Australia
CAG	Jarret, Robert	Curator	USDA	USA
CAG	Panta, Ana	*In vitro* Genbank Curator	CIP	Peru
CAG	Rao, Ramanatha	Honorary Research Fellow	Bioversity International	India
CAG	Sias Costa, Ivo Roberto		EMBRAPA	Brazil
CAG	Suita de Castro, Luis Antônio		EMBRAPA	Brazil
Reviewer	Agili Makanginya, Sammy	Sweet potato breeder	International Potato Center	Kenya
Reviewer	Akoroda, Malachy	Scientific Advisor	Sweetpotato Promotion Group	Nigeria
Reviewer	Arizio, Carla Marcela	Investigadora	INTA	Argentina
Reviewer	Borromeo, Teresita H.	Professor and Head, PGR Division	University of the Philippines Los Baños	Philippines
Reviewer	Cao, Qinghe	Division leader	Xuzhou Sweet Potato Research Centre	China
Reviewer	de Chavez, Hidelisa	Network Affiliate	CIP-UPWARD	Philippines
Reviewer	Chipungu, Felistus	Chief Sweet potato breeder	Department of Agricultural Research Services	Malawi
Reviewer	Campilan, Dindo	Regional Leader - South, West and Central Asia	CIP	India

Reviewer	Hughes, Michael	Extension Agronomist	Department of Employment, Economic Development and Innovation (DEEDI), Queensland – Primary Industries and Fisheries	Australia
Reviewer	Kapis, Joseph	Area Manager - Madang Program	World Vision	Papua New Guinea
Reviewer	Kirchhof, Gunnar	Senior research fellow	University of Queensland	Australia
Reviewer	Manguiat, Proceso H.	Researcher	University of the Philippines Los Baños	Philippines
Reviewer	Mariscal, Algerico M.	Professor/Plant Breeder	Philippine Root Crop Research and Training Center (PhilRootcrops)	Philippines
Reviewer	Naskar, S.K.	Director	Central Tuber Crops Research Institute	India
Reviewer	Okpul, Tom	Lecturer	PNG University of Technology	Papua New Guinea
Reviewer	Sebastiani, Stephen Kuoko	Principal agric research officer	Horticulture Research Institute (HORTI Tengeru)	Tanzania
Reviewer	Xie, Kaiyun	Liaison scientist	CIP, Liaison Office China	China
Reviewer	Yakub, Muhammad Jusuf	Sweetpotato breeder and cuarator	Indonesian Legumes and Tuber Crops Research Institute	Indonesia

Annex VI – List of descriptors proposed in the survey ranked by rating average and percentage of importance, sent to the Core Advisory Group for their selection[i]

Descriptor	Rating Average	Your selection
Characterization		
Predominant storage root flesh colour (4.2.5.1)	4.91	
Predominant storage root skin colour (4.2.4.1)	4.45	
Storage root shape (4.2.1)	4.32	
Plant growth habit (type) (4.1.2)	4.00	
General outline of leaf (4.1.7.1)	3.95	
Secondary storage root flesh colour (4.2.5.2)	3.86	
Leaf lobes type (4.1.7.2)	3.32	
Distribution of secondary storage root flesh colour (4.2.5.3)	3.29	
Mature leaf colour (4.1.10.1)	3.09	
Predominant vine colour (4.1.5.1)	2.95	
Leaf lobe number (4.1.7.3)	2.73	
Intensity of predominant storage root skin colour (4.2.4.2)	2.73	
Secondary storage root skin colour (4.2.4.3)	2.59	
Abaxial leaf vein pigmentation (4.1.9)	2.50	
Petiole pigmentation (4.1.12)	2.50	
Shape of central leaf lobe (4.1.7.4)	2.45	
Immature leaf colour (4.1.10.2)	2.36	
Twining (ability) (4.1.1)	2.35	
Vine tip pubescence (4.1.6)	2.24	
Mature leaf size (4.1.8)	2	
Secondary vine colour (4.1.5.2)	1.81	
Petiole length (4.1.11)	1.50	

Descriptor	% Importance (very important)	% Importance (important)
Characterization		
Predominant storage root flesh colour (4.2.5.1)	95.5% (21)	4.5% (1)
Predominant storage root skin colour (4.2.4.1)	72.7% (16)	27.3% (6)
Storage root shape (4.2.1)	72.7% (16)	22.7% (5)
Plant growth habit (type) (4.1.2)	57.1% (12)	38.1% (8)
General outline of leaf (4.1.7.1)	54.5% (12)	40.9% (9)
Secondary storage root flesh colour (4.2.5.2)	50.0% (11)	45.5% (10)
Leaf lobes type (4.1.7.2)	50.0% (11)	27.3% (6)
Predominant vine colour (4.1.5.1)	47.6% (10)	19.0% (4)
Distribution of secondary storage root flesh colour (4.2.5.3)	42.9% (9)	38.1% (8)
Abaxial leaf vein pigmentation (4.1.9)	36.4% (8)	22.7% (5)
Petiole pigmentation (4.1.12)	36.4% (8)	22.7% (5)
Immature leaf colour (4.1.10.2)	36.4% (8)	18.2% (4)
Mature leaf colour (4.1.10.1)	31.8% (7)	50.0% (11)
Leaf lobe number (4.1.7.3)	27.3% (6)	45.5% (10)
Shape of central leaf lobe (4.1.7.4)	27.3% (6)	36.4% (8)
Twining (ability) (4.1.1)	20.0% (4)	45.0% (9)
Vine tip pubescence (4.1.6)	19.0% (4)	42.9% (9)
Secondary vine colour (4.1.5.2)	19.0% (4)	28.6% (6)
Mature leaf size (4.1.8)	18.2% (4)	36.4% (8)
Intensity of predominant storage root skin colour (4.2.4.2)	13.6% (3)	68.2% (15)
Secondary storage root skin colour (4.2.4.3)	13.6% (3)	63.6% (14)
Petiole length (4.1.11)	0.0% (0)	50.0% (11)

[i] Descriptors highlighted in yellow are those that received a wide consensus amongst the experts.

List of descriptors proposed in the survey ranked by rating average and percentage of importance, sent to the Core Advisory Group for their selection[i]

Descriptor	Rating Average	Your selection
Evaluation		
Storage root dry matter content [%] (6.2.1)	4.74	
Sweet potato virus disease (SPVD complex) (8.5.4)	4.52	
Sweet potato weevil (*Cylas* spp.) (8.1.1)	4.35	
Storage root carotene content [mg/100g FW] (6.2.6)	4.26	
Reaction to drought (7.1)	4.13	
Reaction to salinity (7.4)	4.13	
Storage root starch content [% DW] (6.2.4)	4.04	
Scab or spot anthracnose (*Elsinoe batatas*) (8.3.10)	3.83	
Sweet potato chlorotic stunt virus (SPCSV)	3.78	
Reaction to flooding (7.2)	3.57	
Root-knot nematode (*Meloidogyne* spp.) (8.2.1)	3.52	
Texture of boiled storage root flesh (6.2.9.3)	3.48	
Fusarium wilt or stem rot (*Fusarium oxysporum* f. sp. *batatas*) (8.3.1)	3.43	
Consistency of boiled storage root (6.2.9.1)	3.39	
Reaction to heat (7.3)	3.22	
Black rot (*Ceratocystis fimbriata*) (8.3.5)	3.17	
Bacterial stem and root rot (*Erwinia chrysanthemi*) (8.4.2)	3.05	
Storage root total alcohol soluble sugar content [%] (6.2.5)	2.96	
Java black rot (*Diplodia gossypina*) (8.3.8)	2.96	
Charcoal rot (*Macrophomina phaseoli*) (8.3.14)	2.91	
Storage root nitrogen content [%] (6.2.2)	2.43	

Descriptor	% Importance (Very important)	% Importance (important)
Evaluation		
Storage root dry matter content [%] (6.2.1)	87.0% (20)	13.0% (3)
Sweet potato virus disease (SPVD complex) (8.5.4)	82.6% (19)	13.0% (3)
Sweet potato weevil (*Cylas* spp.) (8.1.1)	73.9% (17)	21.7% (5)
Storage root carotene content [mg/100g FW] (6.2.6)	69.6% (16)	26.1% (6)
Storage root starch content [% DW] (6.2.4)	65.2% (15)	26.1% (6)
Reaction to drought (7.1)	56.5% (13)	43.5% (10)
Reaction to salinity (7.4)	56.5% (13)	43.5% (10)
Sweet potato chlorotic stunt virus (SPCSV)	52.2% (12)	39.1% (9)
Scab or spot anthracnose (*Elsinoe batatas*) (8.3.10)	47.8% (11)	47.8% (11)
Reaction to flooding (7.2)	47.8% (11)	39.1% (9)
Texture of boiled storage root flesh (6.2.9.3)	43.5% (10)	43.5% (10)
Root-knot nematode (*Meloidogyne* spp.) (8.2.1)	39.1% (9)	52.2% (12)
Consistency of boiled storage root (6.2.9.1)	39.1% (9)	47.8% (11)
Fusarium wilt or stem rot (*Fusarium oxysporum* f. sp. *batatas*) (8.3.1)	34.8% (8)	56.5% (13)
Reaction to heat (7.3)	30.4% (7)	56.5% (13)
Storage root total alcohol soluble sugar content [%] (6.2.5)	30.4% (7)	47.8% (11)
Bacterial stem and root rot (*Erwinia chrysanthemi*) (8.4.2)	22.7% (5)	63.6% (14)
Charcoal rot (*Macrophomina phaseoli*) (8.3.14)	22.7% (5)	59.1% (13)
Black rot (*Ceratocystis fimbriata*) (8.3.5)	21.7% (5)	69.6% (16)
Java black rot (*Diplodia gossypina*) (8.3.8)	17.4% (4)	69.6% (16)
Storage root nitrogen content [%] (6.2.2)	17.4% (4)	52.2% (12)

[i] Descriptors highlighted in yellow are those that received a wide consensus amongst the experts.

Annex VII – Additional descriptors included in the open-ended section of the survey

Sweet potato descriptor	Name of expert								
		Panta, Ana (CIP, Peru)	**Chipungu, F.** (Dept. of Agric. Res. Services, Malawi)	**Hughes, M.** (Dept. of Employment Economic Development and Innovation, Australia)	**Cao, Qinghe** (Xuzhou Sweet Potato Research Centre, China)	**Naskar, S.K.** (Central Tuber Crops Research Institute, India)	**Agili Makanginya, S.** (CIP, Kenya)	**Yakub, M. Jusuf** (Indonesian Legume and Tuber Crops Research Institute, Indonesia)	**Jackson, G.*** (Australia)
Additional traits									
Root length			X						
Root size			X						
Post harvest strorage period for storage roots. In Papua New Guinea, sweet potato is grown in the highlands, packed & driven to Lae, then shipped to Port Moresby for resale. This probably takes at least 1 week in less than ideal conditions. Varieties being grown for this market are now being selected to some degree on their postharvest shelf-lives				X					
Sweet potato stem nematode					X				
Sweet potato feathery mottle virus (SFMV)	**2**	**X**				**X**			
Reaction to Begomovirus/Sweet potato leaf viruses	**2**	**X**				**X**			
Storage root formation- closed cluster, open, cluster, dispersed, very dispersed- can be used to discriminate varieties in the field							X		
Adaptation to environment - Temperate, Cool tropical, Warm tropical and Hot tropical - Exchange of germplasm across regions is on the increase, hence need to include this description							X		
Storage root anthocyanin (mg/100g wb)								X	
Vitamin C content (% wb)								X	
Vine thickness									X
Too many descriptors for leaf, general outline of leaf may be all that is required, it is difficult to distinguish between some of those states									X

Weevil may be of interest, but I doubt that there are varieties resistant to *C. formicarius*									X
Comments									
Most of these descriptors are of little interest									X

*varieties do differ consistently on their vine thickness. Luigi Guarino and I chose Thin and Thick, not wanting to measure it. Not easy. Also, there seem to be too many descriptors for leaf, and I wonder if they are all necessary. The general outline of leaf may be all that is required. And for 4.1.7.1, it is difficult to distinguish between some of those states. I have done away with leaf lobe type and number in the selections above. It's just too complicated! If we go back to the fig of Yen 1984 of the leaves then shape, lobe number and dissection are all recorded in one.

*I find most of these descriptors of little interest. They would never be ones that I would use before advising introductions; they seem to be for commercial user rather than household use. Weevil may be of interest, but I doubt that there are varieties resistant to *C. formicarius*, although IITA bred some resistant to the weevil of Africa years ago. Scab is the only one that I would rate very important. I presume that the pathogens listed are important somewhere globally - I have not come across many of them, so I can't say. None except nematode, scab and SPDV seem to be important globally, but I may be wrong.

Annex VIII – Table comparing the CAG's selection and the rating and percentages obtained in the survey. Crop Leaders Drs G. Rossel and D. Tay approved the complete list of descriptors proposed in the survey for inclusion in the final key set

Sweet potato descriptor	Rating Average	% Very important N=23	% Important	S. Costa (EMBRAPA)	G. Jackson (Australia)	R. Rao (India)	D. Hunter (Bioversity International)	Total	G. Rossel and D. Tay (CIP)
Characterization									
Predominant storage root flesh colour (4.2.5.1)	4.91	95.5% (21)	4.5% (1)	X	X	X	X	**4**	Yes
Predominant storage root skin colour (4.2.4.1)	4.45	72.7% (16)	27.3% (6)	X	X	X	X	**4**	Yes
Storage root shape (4.2.1)	4.32	72.7% (16)	22.7% (5)	X	X	X	X	**4**	Yes
Plant growth habit (type) (4.1.2)	4.00	57.1% (12)	38.1% (8)	X	X	X	X	**4**	Yes
General outline of leaf (4.1.7.1)	3.95	54.5% (12)	40.9% (9)	X	X		X	**3**	Yes
Secondary storage root flesh colour (4.2.5.2)	3.86	50.0% (11)	45.5% (10)	X	X	X	X	**4**	Yes
Leaf lobes type (4.1.7.2)	3.32	50.0% (11)	27.3% (6)	X	X	X	X	**4**	Yes
Distribution of secondary storage root flesh colour (4.2.5.3)	3.29	42.9% (9)	38.1% (8)		X			**1**	Yes
Mature leaf colour (4.1.10.1)	3.09	31.8% (7)	50.0% (11)	X				**1**	Yes
Predominant vine colour (4.1.5.1)	2.95	47.6% (10)	19.0% (4)	X	X	X	X	**4**	Yes
Leaf lobe number (4.1.7.3)	2.73	27.3% (6)	45.5% (10)	X				**1**	Yes
Intensity of predominant storage root skin colour (4.2.4.2)	2.73	13.6% (3)	68.2% (15)					**0**	Yes
Secondary storage root skin colour (4.2.4.3)	2.59	13.6% (3)	63.6% (14)					**0**	Yes
Abaxial leaf vein pigmentation (4.1.9)	2.50	36.4% (8)	22.7% (5)		X			**1**	Yes
Petiole pigmentation (4.1.12)	2.50	36.4% (8)	22.7% (5)	X	X		X	**3**	Yes
Shape of central leaf lobe (4.1.7.4)	2.45	27.3% (6)	36.4% (8)					**0**	Yes
Immature leaf colour (4.1.10.2)	2.36	36.4% (8)	18.2% (4)					**0**	Yes
Twining (ability) (4.1.1)	2.35	20.0% (4)	45.0% (9)					**0**	Yes
Vine tip pubescence (4.1.6)	2.24	19.0% (4)	42.9% (9)	X				**1**	Yes
Mature leaf size (4.1.8)	2	18.2% (4)	36.4% (8)					**0**	Yes

Secondary vine colour (4.1.5.2)	1.81	13.6% (3)	63.6% (14)					**0**	Yes
Petiole length (4.1.11)	1.50	0.0% (0)	50.0% (11)					**0**	Yes
Evaluation									
Storage root dry matter content [%] (6.2.1)	4.74	87.0% (20)	13.0% (3)	X	X	X	X	**4**	Yes
Sweet potato virus disease (SPDV complex) (8.5.4)	4.52	82.6% (19)	13.0% (3)	X	X	X	X	**4**	Yes
Sweet potato weevil (*Cylas* spp.) (8.1.1)	4.35	73.9% (17)	21.7% (5)	X	X	X	X	**4**	Yes
Storage root carotene content [mg/100g FW] (6.2.6)	4.26	69.6% (16)	26.1% (6)	X	X	X	X	**4**	Yes
Reaction to drought (7.1)	4.13	56.5% (13)	43.5% (10)	X	X	X	X	**4**	Yes
Reaction to salinity (7.4)	4.13	56.5% (13)	43.5% (10)		X			**1**	Yes
Storage root starch content [% DW] (6.2.4)	4.04	65.2% (15)	26.1% (6)	X	X	X	X	**4**	Yes
Scab or spot anthracnose (*Elsinoe batatas*) (8.3.10)	3.83	47.8% (11)	47.8% (11)	X	X	X	X	**4**	Yes
Sweet potato Chlorotic Stunt Virus (SPCSV)	3.78	52.2% (12)	39.1% (9)	X		X	X	**3**	Yes
Reaction to flooding (7.2)	3.57	47.8% (11)	39.1% (9)		X			**1**	Yes
Root-knot nematode (*Meloidogyne* spp.) (8.2.1)	3.52	39.1% (9)	52.2% (12)	X				**1**	Yes
Texture of boiled storage root flesh (6.2.9.3)	3.48	43.5% (10)	43.5% (10)			X		**1**	Yes
Fusarium wilt or stem rot (*Fusarium oxysporum* f. sp. *batatas*) (8.3.1)	3.43	34.8% (8)	56.5% (13)					**0**	Yes
Consistency of boiled storage root (6.2.9.1)	3.39	39.1% (9)	47.8% (11)					**0**	Yes
Reaction to heat (7.3)	3.22	30.4% (7)	56.5% (13)	X				**1**	Yes
Black rot (*Ceratocystis fimbriata*) (8.3.5)	3.17	21.7% (5)	69.6% (16)					**0**	Yes
Bacterial stem and root rot (*Erwinia chrysanthemi*) (8.4.2)	3.05	22.7% (5)	63.6% (14)					**0**	Yes
Storage root total alcohol soluble sugar content [%] (6.2.5)	2.96	30.4% (7)	47.8% (11)					**0**	Yes
Java black rot (*Diplodia gossypina*) (8.3.8)	2.96	17.4% (4)	69.6% (16)					**0**	Yes

Charcoal rot (*Macrophomina phaseoli*) (8.3.14)	2.91	22.7% (5)	59.1% (13)					**0**	Yes
Storage root nitrogen content [%] (6.2.2)	2.43	17.4% (4)	52.2% (12)					**0**	Yes
Comments from G. Jackson									
There are not many leaf characters chosen, and this may be a worry. Of those that MAY be useful are the following 2: - there does not seem to be clear consensus on these, with very important and not important with similar scores! **Abaxial leaf vein pigmentation (4.1.9)** (1 green; 2 half or less of main vein purple; 3 purple spotting; 4 pale purple; 5 all purple); **Petiole pigmentation (4.1.12)** (1 green; 2 moderately purple; 3 purple)					X			**1**	
Not sure that you would want dry matter and starch; dry matter is a good indicator of starch content					X			**1**	
I doubt that Chlorotic stunt virus can be detected unless it's in a complex, usually with feathery mottle; unless you do molecular tests of course - not really a useful descriptor					X			**1**	
I would think that reaction to viruses specifically and all other pathogens (except scab) is best left for evaluation locally.					X			**1**	
No idea about texture of boiled roots; is this a constant characterisitic?					X			**1**	

Annex IX – First draft of the key access and utilization descriptors for sweet potato sent to Crop Leaders and the CAG for validation

Key access and utilization descriptors for sweet potato genetic resources

This list consists of an initial set of characterization and evaluation descriptors for sweet potato (*Ipomoea batatas*) genetic resources utilization. This strategic set of descriptors, together with passport data, will become the basis for the global accession level information portal being developed by Bioversity International with the financial support of the Global Crop Diversity Trust (the Trust). It will facilitate access to and utilization of sweet potato accessions held in genebanks and does not preclude the addition of further descriptors, should data subsequently become available.

Based on the comprehensive list 'Descriptors for Sweet potato' published by the International Potato Center (CIP), the Asian Vegetable Research and Development Center (AVRDC) and IBPGR (now Bioversity International) in 1991, the list was subsequently compared with a number of sources[1].

A worldwide distribution of experts was involved in an online survey to define a first priority set of descriptors to describe, to access and to utilize sweet potato genetic resources. This key set was afterwards validated by a Core Advisory Group (see 'Contributors') led by Dr Genoveva Rossel and Dr David Tay of CIP.

Biotic and abiotic stresses included in the list were chosen because of their wide geographic occurrence and significant economic impact at a global level.

Numbers in parentheses on the right-hand side are the corresponding descriptor numbers listed in the 1991 publication. Descriptors with numbers ending in 'letters' are either modified or are new descriptors that were added during the development of the list below.

---

[1]
(a) Main output of the Germplasm Characterization National Workshop held on 24-26 January 2006, at the Philippines Root Crop Research and Training Center (PhilRootcrops) in Leyte, Central Philippines;
(b) Basic list of descriptors for Sweet Potato, drawn from Guarino, L. and Jackson, G.V.H. 'Describing and documenting root crops in the South Pacific'. Suva, Fiji, 1986. FAO. RAS/83/001, Field document 12;
(c) 'Global Strategy for *Ex-Situ* Conservation of Sweetpotato Genetic Resources' (the Trust, 2007);
(d) Descriptors that were awarded funds for further research by the Trust in 2008 Evaluation Awards Scheme (EAS);
(e) Criteria for evaluating sweet potato cultivars drawn from the Report on the ACIAR sweet potato workshop, held in Madang, Papua New Guinea on 28-29 June 2006;
(f) Important descriptors mentioned in the CIP website;
(g) 'Descriptors for Characterization and Evaluation of Sweet potato' (National Institute of Agrobiological Sciences, Genebank of Japan);
(h) 'Descriptors for SWEETPOTATO' (USDA, ARS, GRIN).

PLANT DATA

Twining (ability) (4.1.1)

Ability of vines to climb adjacent stakes placed in those accessions showing twining characteristics

0 Non-twining
3 Slightly twining
5 Moderately twining
7 Twining
9 Very twining

Plant growth habit (type) (4.1.2)

Length of the main vines

3 Erect (<75cm)
5 Semi-erect (75-150 cm)
7 Spreading (151-250 cm)
9 Extremely spreading (>250 cm)

Predominant vine colour (4.1.5.1)

1 Green
3 Green with few purple spots
4 Green with many purple spots
5 Green with many dark purple spots
6 Mostly purple
7 Mostly dark purple
8 Totally purple
9 Totally dark purple

Secondary vine colour (4.1.5.2)

0 Absent
1 Green base
2 Green tip
3 Green nodes
4 Purple base
5 Purple tip
6 Purple nodes
7 Other (specify in the descriptor **Notes**)

Vine tip pubescence (4.1.6)

Degree of hairiness of immature leaves recorded at the apex of the vines

0 Absent
3 Sparse
5 Moderate
7 Heavy

General outline of the leaf (4.1.7.1)

1 Rounded
2 Reniform (kidney-shaped)
3 Cordate (heart-shaped)
4 Triangular
5 Hastate (trilobular and spear-shaped with the basal lobes more or less divergent)
6 Lobed
7 Almost divided

Leaf lobes type (4.1.7.2)

0 No lateral lobes (entire)
1 Very slight (teeth)
3 Slight
5 Moderate
7 Deep
9 Very deep

Leaf lobe number (4.1.7.3)

Most leaves of sweet potatoes have two basal lobes and they should not be counted. Record the predominant number of lateral and central leaf lobes observed on the leaves located in the middle section of the vine.

Generally sweet potatoes have 1, 3, 5, 7 or 9 leaf lobes. If the leaf has no lateral lobes but shows a central tooth this number is 1. If the apical portion of the leaf is rounded this number is 0

Shape of central leaf lobe (4.1.7.4)

0 Absent
1 Toothed
2 Triangular
3 Semi-circular
4 Semi-elliptic
5 Elliptic
6 Lanceolate
7 Oblanceolate
8 Linear (broad)
9 Linear (narrow)

Mature leaf size (4.1.8)

Length from the basal lobes to the tip of the leaves. Record the average expression of at least three leaves located in the middle section of the vine

3 Small (<8 cm)
5 Medium (8-15 cm)
7 Large (16-25 cm)
9 Very large (>25 cm)

Abaxial leaf vein pigmentation (4.1.9)

Describe the most frequent expression of the distribution of anthocyanin (purple) pigmentation shown in the veins of the lower surface of the leaves

1 Yellow
2 Green
3 Purple spot in the base of main rib
4 Purple spots in several veins
5 Main rib partially purple
6 Main rib mostly or totally purple
7 All veins partially purple
8 All veins mostly or totally purple
9 Lower surface and veins totally purple

Mature leaf colour (4.1.10.1)

1 Yellow-green
2 Green
3 Green with purple edge
4 Greyish-green (due to heavy pubescence)
5 Green with purple veins on upper surface
6 Slightly purple
7 Mostly purple
8 Green upper, purple lower
9 Purple both surfaces

Immature leaf colour (4.1.10.2)

1 Yellow-green
2 Green
3 Green with purple edge
4 Greyish-green (due to heavy pubescence)
5 Green with purple veins on upper surface
6 Slightly purple
7 Mostly purple
8 Green upper, purple lower
9 Purple both surfaces

Petiole length (4.1.11)

Average petiole length, from the base to the insertion with the blade, of at least three leaves in the middle portion of a main vine

1 Very short (<10 cm)
3 Short (10-20 cm)
5 Intermediate (21-30 cm)
7 Long (31-40 cm)
9 Very long (>40 cm)

Petiole pigmentation (4.1.12)

Distribution of anthocyanin (purple) pigmentation in the petioles of leaves. Indicate the most predominant colour first

1 Green
2 Green with purple near stem
3 Green with purple near leaf
4 Green with purple at both ends
5 Green with purple spots throughout petiole
6 Green with purple stripes
7 Purple with green near leaf
8 Some petioles purple, others green
9 Totally or mostly purple

Storage root shape (4.2.1)

Storage root outline shown in longitudinal section

1 Round – almost a circular outline with a length to breadth (L/B) ratio of about 1:1
2 Round elliptic – a slightly circular outline with acute ends. L/B ratio not more than 2:1
3 Elliptic – symmetrical outline with about the maximum breadth at equal distance from both ends which are slightly acute. L/B ratio not more than 3:1
4 Ovate – outline resembling the longitudinal section of an egg. The broadest part is at the distal end (i.e. away from the root stalk)
5 Obovate – inversely ovate outline. The broadest part is at the proximal end (i.e. close to the root stalk)
6 Oblong – almost rectangular outline with sides nearly parallel and corners rounded. L/B ratio about 2:1
7 Long oblong – oblong outline with a L/B ratio of more than 3:1
8 Long elliptic – elliptic outline with a L/B ratio of more than 3:1
9 Long irregular or curved

Predominant storage root skin colour (4.2.4.1)

1 White
2 Cream
3 Yellow
4 Orange
5 Brownish orange
6 Pink
7 Red
8 Purple-red
9 Dark purple

Intensity of predominant storage root skin colour (4.2.4.2)

1 Pale
2 Intermediate
3 Dark

Secondary storage root skin colour (4.2.4.3)

0 Absent
1 White
2 Cream
3 Yellow
4 Orange
5 Brownish orange
6 Pink
8 Purple-red
9 Dark purple

Predominant storage root flesh colour (4.2.5.1)

1 White
2 Cream
3 Dark cream
4 Pale yellow
5 Dark yellow
6 Pale orange
7 Intermediate orange
8 Dark orange
9 Strongly pigmented with anthocyanins

Secondary storage root flesh colour (4.2.5.2)

0 Absent
1 White
2 Cream
3 Yellow
4 Orange
5 Pink
6 Red
7 Purple-red
8 Purple
9 Dark purple

Distribution of secondary storage root flesh colour (4.2.5.3)

0 Absent
1 Narrow ring in cortex
2 Broad ring in cortex
3 Scattered spots in flesh
4 Narrow ring in flesh
5 Broad ring in flesh
6 Ring and other areas in flesh
7 In longitudinal sections
8 Covering most of the flesh
9 Covering all flesh

Storage root dry matter content [%] (6.2.1)

Storage root nitrogen content [%] (6.2.2)

Use the Kjeldahl Method

Storage root starch content [% DW] (6.2.4)

Storage root total alcohol soluble sugar content [%] (6.2.5)

The phenol-sulphuric method is suggested

Storage root carotene content [mg/100g FW] (6.2.6)

Consistency of boiled storage root (6.2.9.1)

1 Watery
2 Extremely soft
3 Very soft
4 Soft
5 Slightly hard
6 Moderately hard
7 Hard
8 Very hard
9 Very hard and non-cooked

Texture of boiled storage root flesh (6.2.9.3)

1 Dry
3 Somewhat dry
5 Intermediate
7 Moist
9 Very moist

ABIOTIC STRESSES

Reaction to drought (7.1)

Observe after 6 weeks without irrigation or rainfall in a soil without subsurface water and in a season of high evaporation (4-6 mm per day)

Reaction to flooding (7.2)

Late season flooding during storage root formation. The environmental conditions could consist of about 2 weeks' flooding (water-saturated soil) in a heavy soil

Reaction to heat (7.3)

Hot season with night temperatures of more than 22°C. The yield comparisons could be versus yields obtained under cooler conditions

Reaction to salinity (7.4)

In a soil with salinity levels of more than 8 mmhos/cm. The yield comparisons could be versus yields obtained in soils with less than 2 mmhos/cm

BIOTIC STRESSES

Sweet potato weevil (*Cylas* spp.) (8.1.1)

Root-knot nematode (*Meloidogyne* spp.) (8.2.1)

Fusarium wilt or stem rot (*Fusarium oxysporum* f. sp. *batatas*) (8.3.1)

Black rot (*Ceratocystis fimbriata*) (8.3.5)

Java black rot (*Diplodia gossypina*) (8.3.8)

Scab or spot anthracnose (*Elsinoe batatas*) (8.3.10)

Charcoal rot (*Macrophomina phaseoli*) (8.3.14)

Bacterial stem and root rot (*Erwinia chrysanthemi*) (8.4.2)

Sweet potato virus disease (SPVD complex) (8.5.4)

Sweet potato chlorotic stunt vrus (SPCSV) (8.5.X)

NOTES

Any additional information may be specified here, particularly that referring to the category '99=Other' present in some of the descriptors above.

CONTRIBUTORS

Bioversity is grateful to all the scientists and researchers who have contributed to the development of this strategic set of 'Key access and utilization descriptors for sweet potato genetic resources', and in particular to Dr D. Tay and Dr G. Rossel of the International Potato Centre (CIP) for providing valuable scientific direction. Adriana Alercia provided technical expertise and guided the entire production process.

CORE ADVISORY GROUP

Genoveva Rossel, International Potato Centre (CIP), Peru
David Tay, International Potato Centre (CIP), Peru
Danny Hunter, Bioversity International, Italy
Grahame Jackson, Australia
Robert Jarret, United States Department of Agriculture, Agricultural Research Service (USDA, ARS), USA
Ana Panta, International Potato Centre (CIP), Peru
Ramanatha Rao, Bioversity International, India
Ivo Sias Costa, Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), Brazil

REVIEWERS

Argentina

Carla Marcela Arizio, Instituto Nacional de Tecnología Agropecuaria (INTA)

Australia

Michael Hughes, Department of Employment, Economic Development and Innovation (DEEDI), Queensland – Primary Industries and Fisheries
Gunnar Kirchhof, University of Queensland

China

Qinghe Cao, Xuzhou Sweet Potato Research Centre
Kaiyun Xie, International Potato Center (CIP), Liaison Office China

Kenya

Sammy Agili Makanginya, International Potato Center (CIP)

India

Dindo Campilan, International Potato Center (CIP)
S.K. Naskar, Central Tuber Crops Research Institute

Indonesia

Muhammad Jusuf Yakub, Indonesian Legumes and Tuber Crops Research Institute

Malawi

Felistus Chipungu, Department of Agricultural Research Services

Nigeria

Malachy Akoroda, Sweetpotato Promotion Group

Papua New Guinea
Joseph Kapis, World Vision
Tom Okpul, Papua New Guinea University of Technology

Philippines
Teresita H. Borromeo, University of the Philippines Los Baños
Hidelisa de Chavez, International Potato Center (CIP-UPWARD)
Proceso H. Manguiat, University of the Philippines Los Baños
Algerico M. Mariscal, Philippines Root Crop Research and Training Center (PhilRootcrops)

Tanzania
Stephen Kuoko Sebastiani, Horticulture Research Institute (HORTI Tengeru)

Annex X – Final key set for sweet potato genetic resources obtained after validation

Key access and utilization descriptors for sweet potato genetic resources

This list consists of an initial set of characterization and evaluation descriptors for sweet potato (*Ipomoea batatas*) genetic resources utilization. This strategic set of descriptors, together with passport data, will become the basis for the global accession level information portal being developed by Bioversity International with the financial support of the Global Crop Diversity Trust (the Trust). It will facilitate access to and utilization of sweet potato accessions held in genebanks and does not preclude the addition of further descriptors, should data subsequently become available.

Based on the comprehensive list 'Descriptors for Sweet potato' published by the International Potato Center (CIP), the Asian Vegetable Research and Development Center (AVRDC) and IBPGR (now Bioversity International) in 1991, the list was subsequently compared with a number of sources[1].

A worldwide distribution of experts was involved in an online survey to define a first priority set of descriptors to describe, to access and to utilize sweet potato genetic resources. This key set was afterwards validated by a Core Advisory Group (see 'Contributors') led by Dr David Tay and Dr Genoveva Rossel of CIP.

Biotic and abiotic stresses included in the list were chosen because of their wide geographical occurrence and significant economic impact at a global level.

Numbers in parentheses on the right-hand side are the corresponding descriptor numbers listed in the 1991 publication. Descriptors with numbers ending in 'letters' are either modified or are new descriptors that were added during the development of the list below.

---

[1] (a) Main output of the Germplasm Characterization National Workshop held on January 24-26, at the Philippine Root Crop Research and Training Center (PhilRootcrops) in Leyte, Central Philippines
(b) Basic list of descriptors for Sweet Potato, drawn from Guarino, L. and Jackson, G.V.H. 'Describing and documenting root crops in the South Pacific'. Suva, Fiji, 1986. FAO. RAS/83/001, Field document 12
(c) 'Global Strategy for *Ex-Situ* Conservation of Sweet potato Genetic Resources' (Trust, 2007)
(d) Descriptors that were awarded funds for further research by the Trust in 2008 Evaluation Awards Scheme (EAS);
(e) Criteria for evaluating sweet potato cultivars drawn from the Report on the ACIAR sweet potato workshop, held in Madang, Papua New Guinea on 28-29 June 2006
(f) Important descriptors mentioned in the CIP website
(g) 'Descriptors for Characterization and Evaluation of Sweet potato' (National Institute of Agrobiological Sciences, Genebank of Japan)
(h) 'Descriptors for SWEETPOTATO' (USDA, ARS, GRIN)

PLANT DATA

Twining (ability) (4.1.1)

Ability of vines to climb adjacent stakes placed in those accessions showing twining characteristics

0 Non-twining
3 Slightly twining
5 Moderately twining
7 Twining
9 Very twining

Plant growth habit (type) (4.1.2)

Length of the main vines

3 Erect (<75cm)
5 Semi-erect (75-150 cm)
7 Spreading (151-250 cm)
9 Extremely spreading (>250 cm)

Ground cover (4.1.3)

Estimated percentage of ground cover recorded 35-40 days after planting

3 Low (<50%)
5 Medium (50-74%)
7 High (75-90%)
9 Total (>90%)

Vine internode length (4.1.4.1)

Average length of at least three internodes located in the middle section of the vine

1 Very short (<3 cm)
3 Short (3-5 cm)
5 Intermediate (6-9 cm)
7 Long (10-12 cm)
9 Very long (>12 cm)

Vine internode diameter (4.1.4.2)

Average diameter of at least three internodes located in the middle section of the vine

1 Very thin (<4 mm)
3 Thin (4-6 mm)
5 Intermediate (7-9 mm)
7 Thick (10-12 mm)
9 Very thick (>12 mm)

Predominant vine colour (4.1.5.1)

1 Green
2 Green with few purple spots
3 Green with many purple spots
4 Green with many dark purple spots
5 Mostly purple
6 Mostly dark purple
7 Totally purple
8 Totally dark purple

Secondary vine colour (4.1.5.2)

0 Absent
1 Green base
2 Green tip
3 Green nodes
4 Purple base
5 Purple tip
6 Purple nodes
99 Other (specify in the descriptor **Notes**)

Vine tip pubescence (4.1.6)

Degree of hairiness of immature leaves recorded at the apex of the vines

0 Absent
3 Sparse
5 Moderate
7 Dense

General outline of the leaf (4.1.7.1)

1 Rounded
2 Reniform (kidney-shaped)
3 Cordate (heart-shaped)
4 Triangular
5 Hastate (trilobular and spear-shaped with the basal lobes more or less divergent)
6 Lobed
7 Almost divided

Leaf lobes type (4.1.7.2)

0 No lateral lobes (entire)
1 Very slight (teeth)
3 Slight
5 Moderate
7 Deep
9 Very deep

Leaf lobe number (4.1.7.3)

Most leaves of sweet potatoes have two basal lobes and they should not be counted. Record the predominant number of lateral and central leaf lobes observed on the leaves located in the middle section of the vine.

Generally sweet potatoes have 1, 3, 5, 7 or 9 leaf lobes. If the leaf has no lateral lobes but shows a central tooth this number is 1. If the apical portion of the leaf is rounded this number is 0

Shape of central leaf lobe (4.1.7.4)

0 Absent
1 Toothed
2 Triangular
3 Semi-circular
4 Semi-elliptic
5 Elliptic
6 Lanceolate
7 Oblanceolate
8 Linear (broad)
9 Linear (narrow)

Mature leaf size (4.1.8)

Length from the basal lobes to the tip of the leaves. Record the average expression of at least three leaves located in the middle section of the vine

3 Small (<8 cm)
5 Medium (8-15 cm)
7 Large (16-25 cm)
9 Very large (>25 cm)

Abaxial leaf vein pigmentation (4.1.9)

Describe the most frequent expression of the distribution of anthocyanin (purple) pigmentation shown in the veins of the lower surface of leaves

1 Yellow
2 Green
3 Purple spot in the base of main rib
4 Purple spots in several veins
5 Main rib partially purple
6 Main rib mostly or totally purple
7 All veins partially purple
8 All veins mostly or totally purple
9 Lower surface and veins totally purple

Mature leaf colour (4.1.10.1)

1 Yellow-green
2 Green
3 Green with purple edge
4 Greyish-green (due to dense pubescence)
5 Green with purple veins on upper surface
6 Slightly purple
7 Mostly purple
8 Green upper surface, purple lower surface
9 Purple on both surfaces

Immature leaf colour (4.1.10.2)

1 Yellow-green
2 Green
3 Green with purple edge
4 Greyish-green (due to dense pubescence)
5 Green with purple veins on upper surface
6 Slightly purple
7 Mostly purple
8 Green upper surface, purple lower surface
9 Purple on both surfaces

Petiole length (4.1.11)

Average petiole length, from the base to the insertion with the blade, of at least three leaves in the middle portion of a main vine

1 Very short (<10 cm)
3 Short (10-20 cm)
5 Intermediate (21-30 cm)
7 Long (31-40 cm)
9 Very long (>40 cm)

Petiole pigmentation (4.1.12)

Distribution of anthocyanin (purple) pigmentation in the petioles of leaves. Indicate the most predominant colour first

1 Green
2 Green with purple near stem
3 Green with purple near leaf
4 Green with purple at both ends
5 Green with purple spots throughout petiole
6 Green with purple stripes
7 Purple with green near leaf
8 Some petioles purple, some others green
9 Totally or mostly purple

Storage root shape (4.2.1)

Storage root outline shown in longitudinal section

1 Round – almost a circular outline with a length to breadth (L/B) ratio of about 1:1
2 Round elliptic – a slightly circular outline with acute ends. L/B ratio not more than 2:1
3 Elliptic – symmetrical outline with about the maximum breadth at equal distance from both ends which are slightly acute. L/B ratio not more than 3:1
4 Ovate – outline resembling the longitudinal section of an egg. The broadest part is at the distal end (i.e. away from the root stalk)
5 Obovate – inversely ovate outline. The broadest part is at the proximal end (i.e. close to the root stalk)
6 Oblong – almost rectangular outline with sides nearly parallel and corners rounded. L/B ratio about 2:1
7 Long oblong – oblong outline with a L/B ratio of more than 3:1
8 Long elliptic – elliptic outline with a L/B ratio of more than 3:1
9 Long irregular or curved

Storage root surface defects (4.2.2)

0 Absent
1 Alligator-like skin
2 Veins
3 Shallow horizontal constrictions
4 Deep horizontal constrictions
5 Shallow longitudinal grooves
6 Deep longitudinal grooves
7 Deep constrictions and deep grooves
99 Other (specify in the descriptor **Notes**)

Storage root cortex thickness (4.2.3)

1 Very thin (<1 mm)
3 Thin (1-2 mm)
5 Intermediate (2-3 mm)
7 Thick (3-4 mm)
9 Very thick (>4 mm)

Predominant storage root skin colour (4.2.4.1)

1 White
2 Cream
3 Yellow
4 Orange
5 Brownish orange
6 Pink
7 Red
8 Purple-red
9 Dark purple

Intensity of predominant storage root skin colour (4.2.4.2)

1 Pale
2 Intermediate
3 Dark

Secondary storage root skin colour (4.2.4.3)

0 Absent
1 White
2 Cream
3 Yellow
4 Orange
5 Brownish orange
6 Pink
7 Red
8 Purple-red
9 Dark purple

Predominant storage root flesh colour (4.2.5.1)

1 White
2 Cream
3 Dark cream
4 Pale yellow
5 Dark yellow
6 Pale orange
7 Intermediate orange
8 Dark orange
9 Strongly pigmented with anthocyanins

Secondary storage root flesh colour (4.2.5.2)

0 Absent
1 White
2 Cream
3 Yellow
4 Orange
5 Pink
6 Red
7 Purple-red
8 Purple
9 Dark purple

Distribution of secondary storage root flesh colour (4.2.5.3)

0 Absent
1 Narrow ring in cortex
2 Broad ring in cortex
3 Scattered spots in flesh
4 Narrow ring in flesh
5 Broad ring in flesh
6 Ring and other areas in flesh
7 In longitudinal sections
8 Covering most of the flesh
9 Covering all flesh

Storage root dry matter content [%] (6.2.1)

Storage root nitrogen content [%] (6.2.2)
Use the Kjeldahl Method

Storage root starch content [% DW] (6.2.4)

Storage root total alcohol soluble sugar content [%] (6.2.5)
The phenol-sulphuric method is suggested

Storage root carotene content [mg/100g FW] (6.2.6)

Consistency of boiled storage root (6.2.9.1)

1 Watery
2 Extremely soft
3 Very soft
4 Soft
5 Slightly hard
6 Moderately hard
7 Hard
8 Very hard
9 Very hard and non-cooked

Texture of boiled storage root flesh (6.2.9.3)

1 Dry
3 Somewhat dry
5 Intermediate
7 Moist
9 Very moist

ABIOTIC STRESSES

Reaction to drought (7.1)
Observed after six weeks without irrigation or rainfall in a soil without subsurface water and in a season of high evaporation (4-6 mm per day)

Reaction to flooding (7.2)
Late season flooding during storage root formation. The environmental conditions could consist of about two weeks' flooding (water-saturated soil) in a heavy soil

Reaction to heat (7.3)
Hot season with night temperatures of more than 22°C. The yield comparisons could be versus yields obtained under cooler conditions

Reaction to salinity (7.4)
In a soil with salinity levels of more than 8 mmhos/cm. The yield comparisons could be versus yields obtained in soils with less than 2 mmhos/cm

BIOTIC STRESSES

Sweet potato weevil (*Cylas* spp.) (8.1.1)

Root-knot nematode (*Meloidogyne* spp.) (8.2.1)

Fusarium wilt or stem rot (*Fusarium oxysporum* f. sp. *batatas*) (8.3.1)

Black rot (*Ceratocystis fimbriata*) (8.3.5)

Java black rot (*Diplodia gossypina*) (8.3.8)

Scab or spot anthracnose (*Elsinoe batatas*) (8.3.10)

Charcoal rot (*Macrophomina phaseoli*) (8.3.14)

Bacterial stem and root rot (*Erwinia chrysanthemi*) (8.4.2)

Sweet potato virus disease (SPVD complex) (8.5.4)

Sweet potato chlorotic stunt virus (SPCSV) (8.5.X)

NOTES
Any additional information may be specified here, particularly that referring to the category ‘99=Other’ present in some of the descriptors above.

CONTRIBUTORS

Bioversity is grateful to all the scientists and researchers who have contributed to the development of this strategic set of 'Key access and utilization descriptors for sweet potato genetic resources', and in particular to Dr D. Tay and Dr G. Rossel of the International Potato Centre (CIP) for providing valuable scientific direction. Adriana Alercia provided technical expertise and guided the entire production process.

CORE ADVISORY GROUP

Genoveva Rossel, International Potato Centre (CIP), Peru
David Tay, International Potato Centre (CIP), Peru
Danny Hunter, Bioversity International, Italy
Grahame Jackson, Australia
Robert Jarret, United States Department of Agriculture, Agricultural Research Service (USDA, ARS), USA
Ana Panta, International Potato Centre (CIP), Peru
Ramanatha Rao, Bioversity International, India
Ivo Sias Costa, Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), Brazil
Luis Antônio Suita de Castro, Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), Brazil

REVIEWERS

Argentina
Carla Marcela Arizio, Instituto Nacional de Tecnología Agropecuaria (INTA)

Australia
Michael Hughes, Department of Employment, Economic Development and Innovation (DEEDI), Queensland – Primary Industries and Fisheries
Gunnar Kirchhof, University of Queensland

China
Qinghe Cao, Xuzhou Sweet Potato Research Centre
Kaiyun Xie, International Potato Center (CIP), Liaison Office China

Kenya
Sammy Agili Makanginya, International Potato Center (CIP)

India
Dindo Campilan, International Potato Center (CIP)
S.K. Naskar, Central Tuber Crops Research Institute

Indonesia
Muhammad Jusuf Yakub, Indonesian Legumes and Tuber Crops Research Institute

Malawi
Felistus Chipungu, Department of Agricultural Research Services

Nigeria
Malachy Akoroda, Sweetpotato Promotion Group

Papua New Guinea
Joseph Kapis, World Vision
Tom Okpul, Papua New Guinea University of Technology

Philippines
Teresita H. Borromeo, University of the Philippines Los Baños
Hidelisa de Chavez, International Potato Center (CIP-UPWARD)
Proceso H. Manguiat, University of the Philippines Los Baños
Algerico M. Mariscal, Philippines Root Crop Research and Training Center (PhilRootcrops)

Tanzania
Stephen Kuoko Sebastiani, Horticulture Research Institute (HORTI Tengeru)

Methodology for the definition of a key set of characterization and evaluation descriptors for taro (*Colocasia esculenta*)

Information collection and preparation of a Minimum Descriptor List (MDL)

Information for the definition of a strategic key set for Taro was drawn from the publication 'Descriptors for Taro *(Colocasia esculenta)*' (IPGRI, 1999), subsequently integrated and harmonized with descriptors suggested in the draft document 'Edible Aroid Conservation Strategy' being developed by the Global Crop Diversity Trust. Important evaluation traits, such as main pests and diseases and abiotic stresses, were added to the original descriptors lists, including traits that were awarded funds for further research by the Global Crop Diversity Trust 2008 Award Scheme 'Enhancing the Value of Crop Diversity in a World of Climate Change' (EAS).

Preparing List of Experts

The list of experts was prepared taking into account the list of original reviewers engaged in the publication of 'Descriptors for Taro' (IPGRI, 1999), as well as experts taking part in crop-specific consultations for the definition of the draft document 'Edible Aroid Conservation Strategy'. Overall, 90 experts were identified, coming from 55 countries and 77 different organizations. Out of these, a Crop Leader (Danny Hunter) and a Core Advisory group consisting of six experts (See Annex I) were selected to assist in the definition of a minimum set of descriptors, which was later circulated for validation among the wider group of experts. Members of the CAG were selected amongst in-house specialists and experts working for world renowned institutions such as USDA/ARS, CIRAD, the Secretariat of the Pacific Community and the University of Maribor, Slovenia.

Survey preparation and distribution

A draft survey on Taro was prepared listing the descriptors as approved by consultations with the Crop Leader and the CAG. Once approved, the final draft of the survey was uploaded into the Survey Monkey application on the internet and sent out to the list of identified experts. A link was provided to experts who were invited to comment on the suitability of this initial 'Minimum set of descriptors' of Taro accessions in fostering the use of taro germplasm. Experts were also encouraged to specify any additional trait(s) that were found to be relevant yet missing from the proposed Minimum List, along with a substantiated justification for their inclusion. Email invitations to respond to the survey were sent out on the 28th of July 2008 and the survey deadline set at the 29th of August 2008. A reminder was sent out on the 22nd of August to ensure that the greatest possible feedback was obtained (see Annex II).

Survey analysis and refinement of the Minimum List

Of the 90 experts who were identified and involved in the exercise, 13, coming from 11 countries, recorded their comments using the online survey. Their inputs were summarized in a comparison table and comments weighed against each other (see Annex III). As part of the refinement process, further sources of information on Taro descriptors were analyzed, namely:

- Guarino, L. & Jackson, G. (1986). Strengthening plant protection and root crops development in the South Pacific. FAO. RAS/83/001. Field document 12
- Lebot, V. *et al.* (2004). Characterisation of taro (*Colocasia esculenta* (L.) Schott genetic resources in Southeast Asia and Oceania. Genetic Resources and Crop Evolution **51**: 381-392.

Descriptors highlighted as important in these papers were harmonised as far as possible with comments received from Taro experts during the survey, with the Minimum List of descriptors published in *Descriptors for Taro* (IPGRI, 1999) and with evaluation traits for which the Trust awarded grants to various organizations to undertake evaluation on. Special attention was given to descriptors for which data are available. Suggested changes were further discussed with Danny Hunter, Bioversity's root crop expert and the refined Minimum List sent out once again to the CAG group on 26 September 2008 for validation and finalization. Six out of seven CAG members submitted their comments.

Definition of a Final key set of Descriptors for Taro

Comments received were compared to IPGRI's original Minimum List and to comments received during the survey using a comparison table (see Annex IV). Results obtained were further discussed with the Crop leader Danny Hunter for final approval. The final Minimum List (see Annex V) was approved on 17 October and published in December 2008 (see Annex VI).

Once the core subset of characterization and evaluation standards for Taro was finalized, data were transformed into Excel files for uploading into the GRIN-Global genebank data-management system being developed by USDA, and subsequently into GENESYS, linking national, regional and international genebank databases in support of the conservation and use of plant genetic resources for food and agriculture (PGRFA). The files were also shared with SGRP Crop Genebank Knowledge Base, the Generation Challenge Programme (GCP) Ontology, the System-wide Information Network for Genetic Resources (SINGER) and with EURISCO.

Acknowledgement

Bioversity is grateful to all the scientists and researchers who have contributed to the development of the strategic set of 'Key access and utilization descriptors for taro genetic resources', and to the Global Crop Diversity Trust for their financial support.

Annex I - List of experts identified for participation to the Survey for the definition of a minimum set of descriptors for Taro

Role	Name	Organization	Country
Crop Leader	**Hunter, Danny**	**Bioversity**	Italy
Core Group	Jackson, Graeme		Australia
Core Group	Ayala-Silva, Tomas	USDA-ARS National Germplasm Repository	USA
Core Group	Ivancic, Anton	Faculty of Agriculture, University of Maribor	Slovenia
Core Group	Lebot, Vincent	CIRAD	Vanuatu
Core Group	Ramanatha, Rao V.R.	Bioversity (HF)	India
Core Group	Taylor, Mary	SPC	Fiji
TaroGen expert	Harding, Rob	University of Queensland	Australia
TaroGen expert	Singh, Davinder	University of Sydney	Australia
Crop Strategy Expert	Akonaay, Herman B.	National Plant Genetic Resources Centre (TPRI)	Tanzania
Crop Strategy Expert	Akoroda, Malachy	IITA	Nigeria
Crop Strategy Expert	Autar, Moti	Koronivia Research Station	Fiji
Crop Strategy Expert	Baniya, B.K.	Nepal Agricultural Research Council	Nepal
Crop Strategy Expert	Baramburiye, Juven	Institut des Sciences Agronomiques du Burundi (ISABU)	Burundi
Crop Strategy Expert	Bennett-Lartey, Samuel	Institute of Plant genetic Resources	Ghana
Crop Strategy Expert	Bosques Vega, Angel	Estación Experimental Agricola de Isabela	Puerto Rico
Crop Strategy Expert	Cadima, Ximena	PROINPA	Brazil
Crop Strategy Expert	Castiñeiras, Leonor	Instituto de Investigaciones Fundamentales en Agriculturea Tropical (INIFAT)	Cuba
Crop Strategy Expert	Davidson, Campbell	NORGEN	Canada

Role	Name	Organization	Country
Crop Strategy Expert	Del Rosario, Aurora	Palau Community College R&D Station	Palau
Crop Strategy Expert	Edison, S .	CTCRI	India
Crop Strategy Expert	Embaye, Kassahun	Institute of BiodiversityConservation and Research	Ethiopia
Crop Strategy Expert	Englberger, Konrad	SPC	Federated States of Micronesia
Crop Strategy Expert	Ferraren, Dilberto O.	Philippine Root Crops Research and Training Centre (PRCRTC)	Philippines
Crop Strategy Expert	Gonçalves, Eduardo	Botanical Gardens of the Universidade Católica de Brasília	Brazil
Crop Strategy Expert	Gumedze, T.	Department of Agricultural Research	Swaziland
Crop Strategy Expert	Herscovitch, Claire	Royal Botanic Gardens Sydney	Australia
Crop Strategy Expert	Höfte, Monica	University of Ghent	Belgium
Crop Strategy Expert	Iosefa, Tolo	University of the South Pacific	Samoa
Crop Strategy Expert	Islam, Obaidul M.	Plant Genetic Resources Centre, Bangladesh Agricultural Research Council	Bangladesh
Crop Strategy Expert	Jusuf, Muhammed	Research Institute for Legume and Tuber Crops	Indonesia
Crop Strategy Expert	Ke, Weidong	Wuhan Vegetable Research Institute	China
Crop Strategy Expert	Kusena, Kudzai	National Genebank of Zimbabwe	Zimbabwe
Crop Strategy Expert	Lamine, Doumbouya Mohamed	National Gene Bank	Guinea
Crop Strategy Expert	Lawrence, Janet	CARDI	Jamaica
Crop Strategy Expert	Lezar, Andre	National Plant Genetic Resources Centre	South Africa

Role	Name	Organization	Country
Crop Strategy Expert	Liyange, A.	Plant Genetic Resources Centre	Sri Lanka
Crop Strategy Expert	Loots, Sonja	National Botanical Research Institute	Namibia
Crop Strategy Expert	Lupupa, Thandie	SADC Plant Genetic Resources Centre (SPGRC)	Zambia
Crop Strategy Expert	Mahdere, Amanuel	PGR & Agronomy, Department of Agricultural Research & HRD	Eritrea
Crop Strategy Expert	Marceau, Farant	INRA	Guadaloupe
Crop Strategy Expert	Marischal, Algerico	Philippine Root Crops Research and Training Centre (PRCRTC)	Philippines
Crop Strategy Expert	Mbanaso, Ada	National Root Crops Research Institute	Nigeria
Crop Strategy Expert	Milian, Marilys	Instituto de Investigaciones de Viandas Tropicales	Cuba
Crop Strategy Expert	Moçambique, Pedro Antonio	Centro Nacional De Recursos Fitogeneticos	Angola
Crop Strategy Expert	Mohloboli, M.	Department of Agricultural Research	Lesotho
Crop Strategy Expert	Morales, Sergio Rodríguez	Instituto Nacional de Investigaciones de Viandas Tropicales (INIVIT)	Cuba
Crop Strategy Expert	Munisse, Paulino	IIAM - Instituto de Investigacao Agraria de Mozambique	Mozambique
Crop Strategy Expert	Munyuli, Theodore	National Centre for Research in Natural Sciences CRSN-LWIRO	DR Congo
Crop Strategy Expert	Mutaganda, Amini	Institut des Sciences Agronomiques du Rwanda (ISAR),	Rwanda
Crop Strategy Expert	Mwila, G.	Zambia NPGRC	Zambia
Crop Strategy Expert	Nahimana, Melchior	Institut de Recherche Agronomique et Zootechnique (IRAZ)	Burundi
Crop Strategy Expert	Nsapato, Lucius	Chitedze Research Station	Malawi
Crop Strategy Expert	Ofentse, Ounce	NPGRC	Botswana

Role	Name	Organization	Country
Crop Strategy Expert	Ofentse, Tlhaloganyo O.	DAR	Botswana
Crop Strategy Expert	Ofori, Kwadwo	University of Ghana	Ghana
Crop Strategy Expert	Ortiz, Carlos	University of Puerto Rico	Puerto Rico
Crop Strategy Expert	Prana, Made	LIPI	Indonesia
Crop Strategy Expert	Premathilaka, A.	Horticultural Crop research Development Institute	Sri Lanka
Crop Strategy Expert	Pungulani, Lawrent	Malawi Plant Genetic Resources Centre	Malawi
Crop Strategy Expert	Ramanantosoarina, Allain	SRR FOFIFA	Madagascar
Crop Strategy Expert	Reyes Castro, Guillermo	National Agrarian University	Nicaragua
Crop Strategy Expert	Rios Lobo, Llerme	INIEA	Peru
Crop Strategy Expert	Robin, Gregory	ISTRC	Jamaica
Crop Strategy Expert	Saborio, Francisco	Universidad de Costa Rica	Costa Rica
Crop Strategy Expert	Sagoe, Regina		Ghana
Crop Strategy Expert	Sharma, S.K.	National Bureau of Plant Genetic Resources	India
Crop Strategy Expert	Shirata, Kazuto	National Center for Seeds & Seedlings	Japan
Crop Strategy Expert	Tshewang, Ugygen	National Biodiversity Programme, Ministry of Agriculture,	Bhutan
Crop Strategy Expert	Vargas, Clemente	Estación Experimental Pucallpa - Ucayali, INIEA	Peru
Crop Strategy Expert	Varin, Didier	Centre des Tubercules Tropicaux	New Caledonia

Role	Name	Organization	Country
Crop Strategy Expert	Verma, Virendra Mohan	MPPRC	Federated States of Micronesia
Crop Strategy Expert	Villavicencio, Maria Lea	National Plant Genetic Resources Laboratory, Institute of Plant Breeding-Crop Science Cluster	Philippines
Crop Strategy Expert	Wasswa, John Mulumba	Entebbe Botanical Gardens	Uganda
Crop Strategy Expert	Wetzel, Magaly	INPA	Brazil
Crop Strategy Expert	Wigmore, William & Poeschko, Maja	MAF	Cook Islands
Crop Strategy Expert	Xande, Alain	INRA	Guadaloupe
Reviewer (MDL)	Fullerton, Bob	NZODA/Hort-research	New Zealand
Reviewer (MDL)	Greenough, Diana R.	ADAP Plant Diagnostic/ Research Lab, Northern Marianas College	
Reviewer (MDL)	Hay, Alistair	formerly Royal Botanic Gardens Sydney	Australia
Reviewer (MDL)	Kambuou, Rosa	NARI Dry Lowlands Program	Papua New Guinea
Reviewer (MDL)	Konishi, Tatsuo	Tokyo University of Agriculture	Japan
Reviewer (MDL)	Matthews, Peter	National Museum of Ethnology	Japan
Reviewer (MDL)	Okpul, Tom	University of Queensland	Australia
Reviewer (MDL)	Paofa, Janet	NARI, Laloki	Papua New Guinea
Reviewer (MDL)	Risimeri, Jimmy	NARI, Laloki	Papua New Guinea
Reviewer (MDL)	Sauerborn, Joachim	University of Hohenheim	Germany
Reviewer (MDL)	Sivan, Param	Taro Genetic Resources Project (SPC)	Fiji
Reviewer (MDL)	Takayanagi, Kenji	Institute of Agriculture and Forestry, University of Tsukuba	Japan
Reviewer (MDL)	Velayudhan, K.C.	National Bureau of Plant Genetic Resources (ICAR)	India
Reviewer (MDL)	Yoshino, Hiromichi	Faculty of Agriculture, Okayama University	Japan

Annex II – Survey to choose a Minimum set of Descriptors for Taro (*Colocasia esculenta*)

WELCOME

Welcome to the survey for the selection of a key set of characterization and evaluation descriptors to support an international system of information to enhance the utilization of germplasm held in genebanks.

Your knowledge and experience is requested to validate this initial 'Minimum set of descriptors' of Taro accessions to facilitate their use by researchers.

This key set of characterization and evaluation descriptors will be made available through a global facility for identifying sets of accessions for evaluation and use. For characterization, the aim is a small set of maximally differentiating traits that provide the most impact in discriminating between accessions and, sometimes, may be also relevant to choosing accessions for evaluation. For evaluation, the aim is to focus on a few important traits for production, such as tolerance to drought or salinity stress. This initial set of characterization and evaluation data will constitute the basis of an international facility for researchers to identify the sets of accessions more likely to contain the genetic variation they require for their specific crop improvement programmes.

The list presented here has been drawn from the IPGRI publication "Descriptors for Taro" (1999) and, as discussed during the Trust Crop Strategy Meeting for the ex-situ conservation for edible aroids (2007), while morphological information has been documented, more work is needed for agronomic evaluations.

This survey should take no longer than 15 minutes. Your participation in it is highly appreciated. The deadline for this survey is August the 29th 2008.

We thank you in advance for investing your time and expertise in validating this initial, key set of descriptors.

This survey consists of two parts:

PART I: Lists important characterization descriptors for Taro. It also allows you to indicate if any essential descriptor that can contribute to its use is missing from the minimum list presented.

PART II: Lists important evaluation descriptors for Taro. It also allows you to indicate if any essential trait for production is missing from the minimum list presented or indicate any that may not be very significant to global production.

2. PART I: Characterization descriptors

Characterization descriptors* are those that permit accessions to be easily described and categorized into groups. They are generally highly heritable, can be easily seen by the eye and are expressed equally in all environments.

*Numbers in parentheses on the right-hand side are the corresponding descriptors numbers as published in the Bioversity publication ‘Descriptors for Taro’ (1999).

NUMBER OF STOLONS (Side shoots) (7.1.3)
0 None
1 1 – 5
2 6 – 10
3 11 – 20
4 >20

LEAF BLADE COLOUR (7.2.4)
Observed on fully expanded and mature leaves
1 Whitish
2 Yellow or yellow green
3 Green
4 Dark green
5 Pink
6 Red
7 Purple
8 Blackish (violet-blue)

LEAF LAMINA LENGTH/WIDTH RATIO (7.2.7)
Recorded at maximum width and length of leaf lamina excluding petiole

LEAF VEIN MAIN COLOUR (7.2.11)
Observe the upper side of the leaf blade, beyond junction
1 Whitish
2 Yellow
3 Orange
4 Green
5 Pink
6 Red
7 Brownish
8 Purple

VEIN PATTERN (7.2.12)
Shape of pigmentation on veins on leaf lower surface
1 V pattern (in a ‘V’ space)
2 I pattern (in an ‘I’ shape)
3 Y pattern (in a ‘Y’ shape)
4 Y pattern and extending to secondary veins

PETIOLE/LAMINA LENGTH RATIO (7.2.13)

PETIOLE COLOUR (7.2.14)
1 Whitish
2 Yellow
3 Orange
4 Light green
5 Green
6 Red
7 Brown
8 Purple

PETIOLE COLOUR OF TOP THIRD (7.2.14.1)
Same colours as 7.2.14

PETIOLE COLOUR OF MIDDLE THIRD (7.2.14.2)
Same colours as 7.2.14

PETIOLE COLOUR OF BASAL THIRD (7.2.14.3)
Same colours as 7.2.14

FLOWER FORMATION (7.3.1)
0 Absent
1 Rarely flowering (less than 10% of plants flowering)
2 Flowering (more than 10% of plants flowering)

CORM BRANCHING (7.5.3)
0 Unbranched
1 Branched

CORM SHAPE (7.5.4)
1 Conical
2 Round
3 Cylindrical
4 Elliptical
5 Dumb-bell
6 Elongated
7 Flat and multifaced
8 Clustered
9 Hammer-shaped

CORM FLESH COLOUR OF CENTRAL PART (7.5.7)
1 White
2 Yellow
3 Orange
4 Pink
5 Red
6 Red-purple
7 Purple

CORM FLESH FIBRE COLOUR (7.5.8)
1 White
2 Light yellow
3 Yellow or orange
4 Red
5 Brown
6 Purple

If you consider that an essential trait for the identification of the crop to promote its use is missing from this list, please add it here along with a substantiated justification.

4. PART II: Evaluation Descriptors

This type of descriptor includes those traits of significant importance to sustainable production, including abiotic and biotic stresses. In this case we want to target a few key evaluation traits for which we can initially collect data. This list is the starting point and would grow over time.

DRY MATTER CONTENT OF CORMS AT SHORT STORAGE [mg/100g, DM] (8.1.2)
Less than 1 week

CORM ACRIDITY [mg/100 g, DM]
(8.1.5)
1 Very low ≤ 50 mg
2 Low 51 – 100 mg
3 Intermediate 101-300 mg
4 High > 300 mg

PALATABILITY (8.1.7)
Taste panel test
3 Bad
5 Fair
7 Good

REACTION TO HIGH TEMPERATURE (9.1)
Scored under natural conditions during the hot season

REACTION TO DROUGHT (9.2)
Scored under natural conditions during day period for at least four weeks

REACTION TO SOIL SALINITY (9.4)

BEETLES (Papuana spp.) (10.1.1)

TARO LEAF BLIGHT (Phytophthora colocasiae) (10.2.1)

PYTHIUM ROOT ROT (Pythium spp.) (10.2.2)

VIRUSES (Please specify below, i.e. Dasheen mosaic virus (DsMV); Colocasia bobone disease virus).

If you consider that an essential trait important for crop improvement and production is missing from this list, or, if any of the descriptors listed is not clearly useful to promote utilization, please indicate it here along with a substantiated justification.

Could you please indicate if you think the key descriptors chosen are suitable for the stated purpose?

Could you please indicate if you think the key descriptors chosen are suitable for the stated purpose?

- [ ] Yes
- [ ] No

NOTE: Please remember, this list is the starting point and will grow over time, as required.

THANK YOU VERY MUCH FOR YOUR PARTICIPATION.

Annex III – Summary of comments received from Survey for the definition of a key set of descriptors for Taro

Name	Characterization descriptors to be added	Characterization descriptors to be deleted	Evaluation descriptors to be added	Evaluation descriptors to be deleted	Do you think the key descriptors chosen are suitable for the stated purpose?
					Yes/No
Ayala-Silva, Tomas	*	*	*	*	Yes
Ferraren, Dilberto O.	Petiole stripe (7.2.15)	*	*	Corm acridity	Yes
Iosefa, Tolo	Petiole junction pattern (7.2.8); Petiole junction colour (7.2.9)		Plant maturity (earliness); Reaction to waterlogging		Yes
Ivancic, Anton	Number of suckers; Leaf blade margin	Vein pattern; Flower formation	*	Reaction to salinity; Resistance to Beetles	No
Matthews, Peter	*Absolute measurements should be recorded, not ratios Corm shape to be combined with branching habit; Shapes to be recorded in 3D; Basal ring colour	*	Mouth feel; Reactions to temperature salinity, and drought need to be clarified more. *More detail in reaction to pests	Corm acridity	No
Mbanaso, Egbichi N.A.	*	*	*	*	*
Okpul, Tom	*Replace no. of stolons with stolon formation	*	*	*	Yes
Ortiz, C. E.	*	*	*	*	Yes
Rao, Ramanatha V.	Critical descriptors: No. of stolons, leaf blade colour, leaf vein main colour, corm shape, corm flesh colour	Corm flesh fibre colour	Critical descriptors: Dry matter content, corm acridity, palatability, Taro leaf blight	Reaction to temperature, drought, salinity; resistance to Beetles and to Pythium root rot	Yes
Reyes Castro, G.	*	*	*	*	Yes
Ríos Lobo, Llermé	Important descriptors: Petiole junction colour; No. of corms per plant; Corm size; Corm skin colour; Corm weight per plant; Corm yield Leaf colour; Leaf vein main colour	*	*	*	Yes
Villavicencio, Maria Lea H.	Hairiness of corms	*	*	*	Yes
Weidong, Ke	*Petiole junction colour		* Consistency of cooked corms or cormels		Yes

Annex IV - Table comparing all inputs received from the Expert Survey and from CAG consultations. Comments were weighed against descriptors mentioned in Descriptors for Taro (IPGRI, 1999) and evaluation descriptors that have been granted evaluation awards by the Trust

	Descriptor name	Desc. no.	Bioversity	Lebot	Jackson/ Guarino	Ferraren	Iosefa	Ivancic	Matthews	Okpul	Rao	Rios Lobo	Villavicencio	Weidong	Taylor
Original MDL proposed by Bioversity	Number of stolons (Side shoots)	(7.1.3)	*	Stolon formation	Stolon formation **					Replace with Stolon formation	*				
	Leaf blade colour	(7.2.4)	*	*	*						*	*			
	Leaf lamina length/width ratio	(7.2.7)	*		*				Delete						
	Leaf vein main colour	(7.2.11)	*								*	*			
	Vein pattern	(7.2.12)	*		**			Delete							
	Petiole/lamina length ratio	(7.2.13)	*		*				Delete						
	Petiole colour	(7.2.14)	*	*	*										
	Petiole colour of top third	(7.2.14.1)	*	*	**										
	Petiole colour of middle third	(7.2.14.2)	*		*										
	Petiole colour of basal third	(7.2.14.3)	*		**										
	Flower formation	(7.3.1)	*	*	*		*	Delete							
	Corm branching	(7.5.3)	*												
	Corm shape	(7.5.4)	*	* (combined with corm branching)	*				* (combine with corm branching)		*				
	Corm flesh colour of central part	(7.5.7)	*	*	**						*				

	Descriptor name	Desc. no.	Bioversity	Lebot	Jackson/ Guarino	Ferraren	Iosefa	Ivancic	Matthews	Okpul	Rao	Rios Lobo	Villavicencio	Weidong	Taylor
	Corm flesh fibre colour	(7.5.8)	*		*						Delete				
	Dry matter content of corms at short storage	(8.1.2)	*								*				
	Corm acridity	(8.1.5)	*	See art.		Problem evaluating trait			Delete		*				
	Corm Palatability	(8.1.7)	*	*							*				
	Reaction to high temperature	(9.1)	*						* (record with altitude)						*
	Reaction to drought (EAS)	(9.2)	*						* (to be clarified)						
	Reaction to soil salinity (EAS)	(9.4)	*					* (to be clarified)	* (to be clarified)						
	Resistance to Beetles (*Papuana* spp.)	(10.1.1)	*					* (to be clarified)							*
	Resistance to Taro Leaf Blight (*Phytophthora colocasiae*)	(10.2.1)	*	*	*						*				
	Resistance to Pythium root rot (*Pythium* spp.)	(10.2.2)	*												*
	Resistance to viruses (Please specify)		*				*		* (more detail)						

** = data available

EAS = Evaluation Awards granted by the Trust

	Descriptor name	Desc. no.	Bioversity	Lebot	Jackson/ Guarino	Ferraren	Iosefa	Ivancic	Matthews	Okpul	Rao	Rios Lobo	Villavicencio	Weidong	Taylor
Additional descriptors	Plant height	(7.1.2)		*											
	No. of suckers	(7.1.4)			*			*							
	Leaf base shape	(7.2.1)												*	
	Sap colour of leaf blade tip	(7.2.10)			**										
	Petiole stripe	(7.2.15)													
	Petiole stripe colour	(7.2.15.1)		*		*									
	Petiole basal-ring colour	(7.2.16)			**				* (important)						
	Leaf sheath colour	(7.2.19)			**										
	Predominant position/orientation of leaf lamina surface	(7.2.2)		*	**										
	Leaf blade margin	(7.2.3)		*				* Very important							
	Variegation of lamina	(7.2.4.1)		*	**										
	Leaf blade margin colour	(7.2.5)			*										
	Petiole junction pattern	(7.2.8)			**		*								
	Petiole junction colour	(7.2.9)		*	**		*					*		*	
	Corm weight	(7.5.5)		*								*			
	Corm cortex colour	(7.5.6)										*			
	Plant maturity (earliness)	(8.3.1)		*			*								
	Altitude			*											
	Botanical variety			*											
	Corm Hairiness												*		
	Corm size											*			

	Descriptor name	Desc. no.	Bioversity	Lebot	Jackson/ Guarino	Ferraren	Iosefa	Ivancic	Matthews	Okpul	Rao	Rios Lobo	Villavicencio	Weidong	Taylor
	Corm yield											*			
	Germplasm type	(2.13)		*											
	Growing conditions	(2.17.15)		*											
	Growth habit			*											
	Mouth feel (Consistency of cooked corms)								*					*	
	Number of corms per plant											*			
	Reaction to waterlogging						*								
	Resistance to Corm rot disease (*Hirschmaniella miticausa*)				*										
	Sinus			*											
	Taro large and small bacilliform virus diseases				*										
	Ratio of sheath length/total petiole length	(7.2.18)			*										
	Beta Carotene content														* (linked to flesh colour)

Annex V – Key set of descriptors for Taro (*Colocasia esculenta*) as defined by survey analysis, consultations with Core Advisory Group composed of world-recognised Taro experts and in-house discussion with Bioversity root crop experts

Numbers in parentheses on the right-hand side are the corresponding descriptors numbers as published in the publication 'Descriptors for Taro (*Colocasia esculenta*)' (IPGRI, 1999).

1.	Number of stolons (side shoots)	(7.1.3)
2.	Number of suckers	(7.1.4)
3.	Leaf blade colour	(7.2.4)
4.	Petiole junction colour	(7.2.9)
5.	Leaf vein main colour	(7.2.11)
6.	Petiole colour	(7.2.14)
7.	Petiole basal-ring colour	(7.2.16)
8.	Flower formation	(7.3.1)
9.	Corm branching	(7.5.3)
10.	Corm shape	(7.5.4)
11.	Corm flesh colour of central part	(7.5.7)
12.	Dry matter content of corms at short storage [mg/100g DM]	(8.1.2)
13.	Corm acridity [mg/100 g DM]	(8.1.5)
14.	Palatability	(8.1.7)
15.	Plant maturity (earliness)	(8.3.1)
16.	Reaction to drought	(9.2)
17.	Reaction to soil salinity	(9.4)
18.	Resistance to Taro leaf blight (*Phytophthora colocasiae*)	(10.2.1)

Annex VI – Final key set of descriptors for taro genetic resources

Key access and utilization descriptors for taro genetic resources

This list consists of an initial set of characterization and evaluation descriptors for taro utilization. This key set of strategic descriptors, together with passport data, will become the basis for the global accession-level information system being developed by the Bioversity-led project, Global Information on Germplasm Accessions (GIGA). It will facilitate access to and utilization of taro accessions held in genebanks, and does not preclude the addition of further descriptors, should data subsequently become available.

Based on the comprehensive list of 'Descriptors for Taro (*Colocasia esculenta*)' (IPGRI, 1999), this minimal set, listed below with the original descriptor states, was developed in consultation with taro experts worldwide, and further refined by a Core Advisory Group (see 'Contributors') led by Dr Danny Hunter of Bioversity International.

Biotic and abiotic stresses included in the list were chosen because of their wide geographic occurrence and significant economic impact.

The numbers in parentheses on the right-hand side are the corresponding descriptors numbers as published in the publication 'Descriptors for Taro (*Colocasia esculenta*)' (IPGRI, 1999).

Number of stolons (side shoots) (7.1.3)

0 None
1 1–5
2 6–10
3 11–20
4 >20

Number of suckers (direct shoot) (7.1.4)

0 Absent
1 1–5
2 6–10
3 11–20
4 >20

Leaf blade colour (7.2.4)

Observed on fully expanded and mature leaves

1 Whitish
2 Yellow or yellow green
3 Green
4 Dark green
5 Pink
6 Red
7 Purple
8 Blackish (violet–blue)
99 Other (specify in the **Notes** descriptor)

Petiole junction colour (7.2.9)

Observed on the upper side

0 Absent
1 Yellow
2 Green
3 Red
4 Purple
99 Other (specify in the **Notes** descriptor)

Leaf main vein colour (7.2.11)

Observe the upper side of leaf blade, beyond junction

1 Whitish
2 Yellow
3 Orange
4 Green
5 Pink
6 Red
7 Brownish
8 Purple
99 Other (specify in the **Notes** descriptor)

Petiole colour (7.2.14)

Colour of top third (7.2.14.1)

1 Whitish
2 Yellow
3 Orange
4 Light green
5 Green
6 Red
7 Brown
8 Purple
99 Other (e.g. 'bronze', black; specify in the **Notes** descriptor)

Colour of middle third (7.2.14.2)

Same colours as for **7.2.14.1**

Colour of basal third (7.2.14.3)

Same colours as for **7.2.14.1**

Petiole basal-ring colour (7.2.16)

1 White
2 Green (yellow green)
3 Pink
4 Red
5 Purple
99 Other (specify in the **Notes** descriptor)

Flower formation (7.3.1)

0 Absent
1 Rarely flowering (less than 10% of plants flowering)
2 Flowering (more than 10%[1] of plants flowering)

---

[1] 10% is considered to be the level of frequent flowering.

Corm branching (7.5.3)

0 Unbranched
1 Branched

Corm shape (7.5.4)

1 Conical
2 Round
3 Cylindrical
4 Elliptical
5 Dumb-bell
6 Elongated
7 Flat and multifaced
8 Clustered
9 Hammer-shaped
99 Other (specify in the **Notes** descriptor)

Corm flesh colour of central part (7.5.7)

1 White
2 Yellow
3 Orange
4 Pink
5 Red
6 Red–purple
7 Purple
99 Other (e.g. if colour is not uniform—blotches of lighter or darker pigmentation—specify in **Notes** descriptor)

Dry matter content of corms [mg/100 g DM] (8.1.2)

At short storage (<1 week)

Corm acridity [mg/100 g DM] (8.1.5)

1 Very low ≤50 mg
2 Low 51–100 mg
3 Intermediate 101–300 mg
4 High >300 mg

Palatability (8.1.7)

Taste panel test

3 Bad
5 Fair
7 Good

Plant maturity (earliness) (8.3.1)

1 Very early (<4 months)
2 Early (4 to 6 months)
3 Intermediate (6 to 8 months)
4 Late (8 to 10 months)
5 Very late (>10 months)
6 Undetermined growth (wild types)

Reaction to drought (9.2)

Scored under natural conditions during day period for at least four weeks

Reaction to soil salinity (9.4)

Stress susceptibility to Taro leaf blight (*Phytophthora colocasiae*) (10.2.1)

Notes

Any additional information may be specified here, particularly that referring to the category 'Other' present in some of the descriptors above.

CONTRIBUTORS

Bioversity is grateful to all the scientists and researchers who contributed to the development of this strategic set of key access and utilization descriptors for taro genetic resources. The following Bioversity staff contributed to this exercise: Danny Hunter, who provided scientific direction, and Adriana Alercia who provided technical expertise and guided the whole production process.

CORE ADVISORY GROUP

Danny Hunter, Bioversity International, Italy
Tomas Ayala-Silva, USDA-ARS National Germplasm Repository, USA
Anton Ivancic, Faculty of Agriculture, University of Maribor, Slovenia
Grahame Jackson, Australia
Vincent Lebot, CIRAD, Vanuatu
V. Ramanatha Rao, Bioversity, India
Mary Taylor, SPC, Fiji

REVIEWERS

China
Ke Weidong, Wuhan Vegetable Research Institute

Japan
Peter Matthews, National Museum of Ethnology

Nicaragua
Guillermo Reyes Castro, Universidad Nacional Agraria

Nigeria
Egbichi Nnenna Adaoha Mbanaso, National Root Crops Research Institute

Papua New Guinea
Tom Okpul, PNG University of Technology

Peru
Llermé Rios Lobo, INIEA

Philippines
Dilberto O. Ferraren, Philippine Root Crops Research and Training Centre (PRCRTC)
Maria Lea Villavicencio, National Plant Genetic Resources Laboratory, Institute of Plant Breeding-Crop Science Cluster

Samoa
Tolo Iosefa, University of the South Pacific

USA
Carlos Ortiz, University of Puerto Rico

Methodology for the definition of a key set of characterization and evaluation descriptors for wheat (*Triticum* spp.)

Bioversity International

GLOBAL CROP DIVERSITY TRUST
A FOUNDATION FOR FOOD SECURITY

Information collection and preparation of the initial set of Descriptor List

Information for the definition of a key set of descriptors and traits for Wheat was drawn from the publication "Revised Descriptor List for Wheat (*Triticum* spp.)" (IBPGR, 1985). The list was subsequently integrated and harmonized with descriptors suggested in the Crop Strategy for the *ex-situ* conservation of Triticale Genetic Resources (the Trust 2007), and with descriptors being funded for further research by the Global Crop Diversity Trust 2008 Award Scheme 'Enhancing the Value of Crop Diversity in a World of Climate Change' (EAS).

Preparing List of Experts

Experts were drawn from participants to the crop-specific consultations for the definition of the Crop Strategy for the *ex-situ* conservation of Triticale Genetic Resources, and from those taking part in the 11th Wheat Genetic Symposium (Brisbane, August 2008). Reviewers from the 1985 descriptors list were excluded due to the outdated nature of their contact information. Overall, 63 experts were identified, coming from 16 countries and 40 different organizations. Out of these, the Group Leader (Michael Mackay) selected a Core Advisory group (CAG) consisting of 15 experts to assist in the definition of a minimum set of descriptors. Core Group members were chosen among experts from institutes and organizations at the forefront in wheat breeding and research, namely USDA/ARS, Agriculture and Agri-Food Canada, ICARDA, CIMMYT, the Research Institute of Crop Production, the John Innes Centre, the N.I. Vavilov Research Institute of Plant Industry, the Wheat Genetics and Genomics Resource Centre, the Department of Primary Industries NSW, the University of Zurich and the Komugi Network of Japan.

Survey preparation and distribution

As a preliminary step, on 19 August 2008, Michael Mackay sent out an email to a select number of wheat experts (see Annex I) explaining the important goal raised by a number of the global strategies for the conservation and utilization of various important crop species supported by the Global Crop Diversity Trust. Their purpose was to identify a limited set of characterization and evaluation descriptors to provide users with options for accessing and identifying candidate wheat accessions for further evaluation/utilization.

In his email (see Annex II) he provided a 'short' list of characterization descriptors and evaluation traits requesting experts to provide their feedback and comments on the suitability of those traits for the purpose outlined above (see Annex III). Comments received were analysed (see Annex IV) and a revised key set of descriptors was prepared to be shared among participants to the 11th International Wheat Genetics Symposium held in Brisbane, Australia, in August 2008.

During the Wheat Plant Genetic Resources Workshop held during the Symposium, on 26 August 2008, Michael Mackay presented the revised key set of descriptors for wheat to about 50 participants who discussed the proposed list and provided their input.

On return to Bioversity Headquarter, comments received by email and during the meeting were harmonized to produce a revised key set of descriptors to be further discussed with the CAG prior to final selection of the 'roll-out' descriptors. Thus, in place of a survey, an informal letter was sent out to the 15 experts forming the CAG on 29 October 2008 (see Annex V). CAG members were invited to submit their comments and/or validate the final key set of characterization and evaluation descriptors of *Wheat* accessions. Comments received were collected in a summary table (see Annex VI), analyzed and harmonized with the original descriptors list. This exercise led to the definition of the final key set of descriptors for wheat (Annex VII). Afterwards a final key set was prepared adding descriptor states and contributors and validated again by Michael Mackay (see Annex VIII).

Once the core subset of characterization and evaluation standards for Wheat was finalized, data were transformed into Excel files for uploading into the GRIN-Global genebank data-management system being developed by USDA and into GENESYS, linking national, regional and international genebank databases in support of the conservation and use of plant genetic resources for food and agriculture (PGRFA). The Excel files were also shared with the System-wide Information Network for Genetic Resources (SINGER) and EURISCO.

Acknowledgement

Bioversity is grateful to all the scientists and researchers who have contributed to the development of the strategic set of 'Key access and utilization descriptors for wheat genetic resources', and to the Global Crop Diversity Trust for their financial support.

Annex I – Core Group of experts identified for participation to the definition of a key set of descriptors for Wheat

Role	Name	Organization	Country
Core Group	Bockelman, Harold E.	USDA/ARS National Small Grains Research Facility	USA
Core Group (IWGS)	Clarke, John	Agriculture and Agri-Food Canada	Canada
Core Group (IWGS)	Dotlacil, Ladislav	Research Institute of Crop Production	Czech Republic
Core Group (the Trust/IWGS)	Endo, Takashi R.	Graduate School of Agriculture (JPN Komugi Network)	Japan
Core Group	Faberova, Iva	Research Institute of Crop Production (RICP)	Czech Republic
Core Group (the Trust)	Gill, Bikram S.	Wheat Genetics and Genomics Resource Center (WGGRC)	USA
Core Group (IWGS)	Grimes, Greg	Department of Primary Industries NSW	Australia
Core Group (IWGS)	Keller, Beat	University of Zurich	Switzerland
Core Group (the Trust)	Mitrofanova, Olga P.	N.I. Vavilov Research Institute of Plant Industry	Russia
Core Group (IWGS)	Ogbonnaya, Francis	ICARDA	Syria
Core Group	Payne, Thomas	CIMMYT	Mexico
Core Group	Braun, Hans	CIMMYT	Mexico
Core Group	Singh, Ravi	CIMMYT	Mexico
Core Group (the Trust)	Snape, John	John Innes Centre (JIC)	United Kingdom
Core Group	Zonghu, He	National Centre for Wheat Research and Engineering	China

Annex II – Email sent by Michael Mackay to selected group of Wheat experts on 19 August 2008

Dear Colleague,

Firstly, please accept my greetings in my new role at Bioversity International.

Secondly, this request for your assistance is aimed at identifying some key descriptors that will assist researchers to utilize wheat germplasm. These key descriptors, along with passport data, will become the foundation information to be made available to researchers in a global accession level information system. This system will provide access to some 2.5 million accessions (not all wheat!) held in important genebanks worldwide.

I have identified a 'short' list of characterization descriptors and evaluation traits below, as well as a longer list. The short list is, in my opinion, fundamental in categorizing accessions and should be helpful to utilization, while the longer lists are provided for reference. The short list of evaluation traits represents those for which the Global Crop Diversity Trust (the Trust) has awarded grants to various organizations to undertake evaluation; hence there will be results and data available from this work in due course. The numbers in parentheses following the descriptors refer to the original descriptor numbers contained in the "Revised Descriptor List for Wheat (*Triticum* spp.)" (IBPGR, 1985).

So, I am seeking your opinion/comment on the short list of characterization descriptors and evaluation traits as being applicable to the objectives I have outlined above. For those of you who will be present at the 11th International Wheat Genetics Symposium (Brisbane 24-29 August) I intend to present these lists at the Wheat Plant Genetic Resources Workshop on Tuesday 26th August and seek comment / agreement from the wider audience that will be present. If you won't be present at the IWGS, could I ask you to please send your comment/suggestions to Teresa Borelli (T.Borelli@CGIAR.ORG) by 12 September? The agreed key descriptors will be included as those wheat descriptors to be initially available for searching in the global system when it is deployed in 2010. Your contribution will be much appreciated and, later, acknowledged in the global system.

Should you require any further assistance, please don't hesitate to contact one of my colleagues, Adriana (A.Alercia@CGIAR.ORG) and Teresa (T.Borelli@CGIAR.ORG), or myself by email.

Sincerely,

Michael Mackay

Annex III – First attempt at a 'short' list of characterization and evaluation descriptors for Wheat, sent out by email to Core Advisory Group on 19/08/08

Proposed Minimum/Key Descriptor List

Growth class (seasonality)	(4.1.1)
Spike density	(4.2.2)
Awnedness	(4.2.3)
Glume colour	(4.2.4)
Glume hairiness	(4.2.5)
Seed colour	(4.3.1)

Proposed Key Evaluation Trait List:

Pre-harvest sprouting tendency	(6.3.1)
Protein content	(6.3.3)
Tolerance to drought	(7.4)
Tolerance to salinity	(7.7)
Susceptibility to Hessian fly (*Mayetiola destructor*)	(8.1.2)
Susceptibility to Stem Rust (*Puccinia graminis*)	(8.2.2)
Susceptibility to Powdery mildew (*Erysiphe graminis* f.sp. *hordei*)	(8.2.4)
Susceptibility to Glume blotch (*Septoria nodorum*)	(8.2.5)
Susceptibility to Russian wheat aphid (*Diuraphis noxia*)	
Susceptibility to Sunn pest	

Annex IV – Comments on proposed key set of Descriptor List for Wheat sent out on 19 August 2008. Descriptor numbers with an asterisk (*) are considered 1st priority descriptors

Descriptor no.	Descriptor name	Thomas Payne (CIMMYT)	Bockelman, Harold E. (USDA/ARS)	Hans Braun
4.1.1*	Growth class (seasonality)			
4.1.2	Plant height			Reduced height (Rht) genes if known
4.2.2*	Spike density			
4.2.3*	Awnedness			
4.2.4*	Glume colour			
4.2.5*	Glume hairiness			
4.3.1*	Seed colour			
6.3.1*	Pre-harvest sprouting tendency	Note: Presumably only for white grained materials?		
6.3.3*	Protein content		Wonders about value of this trait, since it is easily manipulated in breeding	Relative to what? - Dependent on environment; 12% protein means nothing
7.4*	Tolerance to drought		Wonders about value of this trait, since it is extremely difficult to quantify	Not sure how you measure this - in what environment?
7.7*	Tolerance to salinity			How accurate will this screening be? What is the reference?
8.1.2*	Susceptibility to Hessian fly (*Mayetiola destructor*)			Against which biotype?

Descriptor no.	Descriptor name	Thomas Payne (CIMMYT)	Bockelman, Harold E. (USDA/ARS)	Hans Braun
8.2.2*	Susceptibility to Stem Rust (*Puccinia graminis*)	Note: Until virulence is wider spread, this may be difficult to usefully screen. Without adequate virulence, some locations may record mostly resistant types.		Why stem rust only? Susceptibility/resistance means nothing without knowing races/genes. This info could be very misleading without additional info.
8.2.4	Susceptibility to Powdery mildew (*Erysiphe graminis* f.sp. *hordei)*	[tritici ?]		Not sure why; reaction to Yellow Rust and Leaf Rust would be more useful to the developing world
8.2.5*	Susceptibility to Glume blotch (*Septoria nodorum*)			Worldwide *Septoria tritici* much more important!
*****	Susceptibility to Russian wheat aphid (*Diuraphis noxia*)	I believe more than a dozen resistance genes have been identified for RWA. Are more sources required?		
*****	Susceptibility to Sunn pest	Has genetic resistance been identified?		

Further comments

Thomas Payne (CIMMYT):
May consider also including:
• Grain micronutrient content (Iron, Zinc) for those cooperators working with HarvestPlus
• Winter survival (=winter kill) important for winter wheat environments
• Aphid damage [postulated to be increasingly important with warmer climates]
• *Helminthosporium sativum* [particularly important for hotter environments, e.g. Eastern Gangetic Plains, Bangladesh]
• *Septoria tritici*, as it is very important in Mediterranean countries, perhaps more so for durum
• Plant height, as an indicator of semi-dwarf ("modern"), etc. [either in cm or relative to a check]. Easy and routinely measured.
• Phenology, as days to heading and/or anthesis. Again, easy and routinely measured.
• Breeders are often asked for high industrial quality materials. I've never been asked for this type of material. I suspect genebanks have the "reputation" for holding materials with poor industrial quality. I wonder if we could redress this issue by including traits such as HMW-Glu, HMW-Gli or easily determined NIR quality traits? Also, yellow berry and pigmentation may be included for durums. Need to find traits that are easily measured, and meaningful. Response to vernalization - vrn genes if known

Hans Braun:
* Response to light - ppd genes if known Protein quality Glu/gli HMG bands - easy to measure (could use existing data sets from Australia); 1B/1R data (existing data sets available); If you want to increase use by breeders than the info should be supported where possible by gene info - rust resistance, hessian fly, Russian Wheat Aphid - Should add info on diseases for which large collections were screened for, e.g. fusarium head blight, helminthosporium leaf blight, nematodes, root rots. **Protein quality not protein content** - latter highly dependent on environment. Better Gli / Glu / genes and High molecular weight (HMW); presence of translocations, etc. Thousand kernel wt (TKW) if seed size expressed relative to known check

Annex V – Email sent by Michael Mackay to selected group of Wheat experts on 29 October 2008

Subject: GIGA Project wheat descriptors - final phase

Dear members of the Wheat Core Advisory Group,

Many thanks to those of you who provided feedback for defining the initial GIGA (Global Information on Germplasm Accessions) Project set of characterization and evaluation descriptors for Wheat **utilization** prior to the 11th IWGS in August.

At the IWGS I conducted a wheat plant genetic resources workshop where about 50 participants discussed the initial list of descriptors I circulated and had their various inputs, which together with any suggestions you made, have brought us to the **final phase** in choosing this initial set. In order to **validate** the revised initial list (see below), your final comment is sought.

In the initial rollout of GIGA we need to develop a model system whereby information that is helpful to germplasm users in identifying candidate accessions (from up to 500,000 accessions in the case of wheat), for research and pre-breeding purposes, we only want to focus on a small number of descriptors that will be useful for this purpose. This will not exclude other descriptors from being added at a later date. Based on the feedback received we have identified descriptors and traits considered as the '1st priority' and listed them below. Some additional descriptors which people raised as of interest I have listed as '2nd priority' and we will include these in the GIGA project if at all possible. As previously mentioned, this is the first step in an evolving process and later on we will be able to include additional descriptors, based on feedback from users and on availability of data.
This first set of GIGA descriptors, along with passport data, will become the basis of the global accession level information system that will facilitate access and use of wheat germplasm.

Could you please have a final look at the list and forward any questions or suggested modifications to my colleague, Adriana Alercia A.Alercia@cgiar.org by the end of next week (**Friday November 7th)**.

Thanks again to all of you for your valuable contribution in this process and look forward to hearing from you.

Best regards,
Michael

1st Priority - Revised initial set of descriptors for Wheat utilization:

- Growth class (seasonality) (4.1.1)
- Spike density (4.2.2)
- Awnedness (4.2.3)
- Glume colour (4.2.4)
- Glume hairiness (4.2.5)
- Seed colour (4.3.1)
- Tolerance to drought (7.4)
- Tolerance to salinity (7.7)
- Susceptibility to Stem Rust (*Puccinia graminis*) (8.2.2)

2nd Priority - Descriptors to be included if possible or in a second phase:

- Plant height (4.1.2)
- Days to flower (4.2.1)
- Percentage protein content (6.3.3)
- Hessian fly (*Mayetiola destructor*) (8.1.2)
- Powdery mildew (*Erysiphe graminis*) (8.2.4)
- Glume blotch (*Septoria nodorum*) (8.2.5)
- Susceptibility to Russian wheat aphid (*Diuraphis noxia*)
- Susceptibility to Sunn pest (*Eurygaster* spp.)

Annex VI – Comments received from CAG to final key set of descriptors sent out for validation on 29/10/2008

1st Priority - Revised initial set of descriptors for Wheat utilization					
Desc no.	**Descriptor name**	**Hans Braun/Thomas Payne (CIMMYT)**	**Mike Ambrose/John Snape (JIC)**	**Bikram Gill (WGGRC)**	**He Zhonghu (NCWRE)**
4.1.1	Growth class (seasonality)		OK	OK	OK
4.2.2	Spike density		OK	OK - but suggests replacing by seeds per spikelet and number of seeds per spike	OK
4.2.3	Awnedness		OK	OK	OK
4.2.4	Glume colour		OK	OK	OK
4.2.5	Glume hairiness		OK	OK	OK
4.3.1	Seed colour		OK	OK	OK
7.4	Tolerance to drought	Not sure how you measure this - in what environment?	Not deliverable across collections	Doubtful on obtaining data for this trait	Agrees with Gill
7.7	Tolerance to salinity	How accurate will this screening be? what is reference?	Not deliverable across collections	Doubtful on obtaining data for this trait	Agrees with Gill
8.2.2	Susceptibility to Stem Rust (*Puccinia graminis*)	Why stem rust only? susceptibility / resistance means nothing without knowing races / genes. This info could be very misleading without additional info.	Not deliverable across collections	Doubtful on obtaining data for this trait	Agrees with Gill
2nd Priority - Descriptors to be included if possible or in a second phase					
4.1.2	Plant height	Reduced height (Rht) genes if known	**Move to 1st list**	**Move to 1st list**	Agrees with Gill
4.2.1	Days to flower		**Move to 1st list**	**Move to 1st list**	Suggests changing to **heading dates** and **maturity**

Desc no.	Descriptor name	Hans Braun/Thomas Payne (CIMMYT)	Mike Ambrose/John Snape (JIC)	Bikram Gill (WGGRC)	He Zhonghu (NCWRE)
6.3.3	Percentage protein content	Relative to what? - Dependent on environment; 12% protein means nothing. Highly dependent on E. Protein quality Glu/gli HMG bands - easy to measure (could use existing data sets from Australia) - Protein quality not protein content - latter highly dependent on environment. Better Gli / Glu / genes and (High molecular weight) HMW; presence of translocations, etc			
8.1.2	Hessian fly (*Mayetiola destructor*)	Against which biotype?			
8.2.4	Powdery mildew (*Erysiphe graminis*)	Not sure why; reaction to Yellow Rust and Leaf Rust would be more useful to the developing world			
8.2.5	Glume blotch (*Septoria nodorum*)	Worldwide *Septoria tritici* much more important!			
	Susceptibility to Russian wheat aphid (*Diuraphis noxia*)				
	Susceptibility to Sunn pest (*Eurygaster* spp.)				
Other comments		If you want to increase use by breeders than the info should be supported where possible by gene info - rust resistance, hessian fly, RWA - Should add info on diseases for which large collections were screened for, e.g. *Fusarium* head blight, *Helminthosporium* leaf blight, nematodes, root rots. . TKW if seed size expressed relative to known check	Suggests dividing the 1st priority list into 2 groups: 1) **Traits of high heritability** 2) **Complex traits of high importance** (see email of 4 Nov) and including **plant height** and **flowering time** in key set	Suggests adding a descriptor each for biotic and abiotic stresses and then have an options for specifying which one	Overall agrees with comments by Gill.Suggests adding **leaf rust** and **yellow rust; Wheat type: winter, spring**

Annex VII – Final key access and utilization descriptors for Wheat genetic resources, defined on 25 November 2008

Numbers in parentheses on the right-hand side are the corresponding descriptors numbers as published in ''Revised Descriptor List for Wheat (*Triticum* spp.)" (IBPGR, 1985).

1.	Growth class (seasonality)	(4.1.1)
2.	Plant height [cm]	(4.1.2)
3.	Days to flower	(4.2.1)
4.	Spike density	(4.2.2)
5.	Awnedness	(4.2.3)
6.	Glume colour	(4.2.4)
7.	Glume hairiness	(4.2.5)
8.	Seed colour	(4.3.1)
9.	Tolerance to drought	(7.4)
10.	Tolerance to salinity	(7.7)
11.	Susceptibility to Stem Rust (*Puccinia graminis*)	(8.2.2)

Annex VIII – Final key set of descriptors for wheat genetic resources validated by Michael Mackay

Key access and utilization descriptors for wheat genetic resources

This list consists of an initial set of characterization and evaluation descriptors for wheat utilization. This key set of strategic descriptors, together with passport data, will become the basis for the global accession-level information system being developed by the Bioversity-led project, Global Information on Germplasm Accessions (GIGA). It will facilitate access to and utilization of wheat accessions held in genebanks and does not preclude the addition of further descriptors, should data subsequently become available.

Based on the comprehensive 'Revised Descriptor List for Wheat (*Triticum* spp.)' (IBPGR, 1985), this set, listed below with the original descriptor states, was developed in consultation with a Core Advisory Group (see 'Contributors') led by Michael Mackay of Bioversity International.

Biotic and abiotic stresses included in the list were chosen because of their wide geographic occurrence and significant economic impact.

The numbers in parentheses on the right-hand side are the corresponding descriptors numbers as published in the 'Revised Descriptor List for Wheat (*Triticum* spp.)' (IBPGR, 1985).

Growth class (seasonality) (4.1.1)

1 Winter
2 Facultative (intermediate)
3 Spring

Plant height [cm] (4.1.2)

Height of plant at maturity, measured in cm from ground to top of spike, excluding awns

Days to flower (4.2.1)

Counted as days from sowing to 50% of plants in flower. However, when planting in dry soils in dryland areas it is counted from the first day of rainfall or irrigation which is sufficient for germination

Spike density (4.2.2)

A visual measure of the density of a spike measured on a 1-9 scale
(N.B. spike density is not the same as spike shape.)

1 Very lax
3 Lax
5 Intermediate
7 Dense
9 Very dense

Awnedness (4.2.3)

0 Awnless
3 Awnletted (short awns)
7 Awned (conspicuous awns)

Glume colour (4.2.4)

Observed on the outer glume

1 White
2 Red to brown
3 Purple to black

Glume hairiness (4.2.5)

Measured on outer side of sterile glume

0 Absent
3 Low
7 High

Seed colour[1] (4.3.1)

1 White
2 Red
3 Purple

Tolerance to drought (7.4)

Coded on a 1-9 scale, where:

3 Low susceptibility
5 Medium susceptibility
9 High susceptibility

Tolerance to salinity (7.7)

Coded on a 1-9 scale, where:

3 Low susceptibility
5 Medium susceptibility
9 High susceptibility

Susceptibility to stem rust (*Puccinia graminis*) (8.2.2)

Coded on a 1-9 scale, where:

3 Low susceptibility
5 Medium susceptibility
9 High susceptibility

Notes

Any additional information may be specified here, particularly that referring to the category 'Other' present in some of the descriptors above.

---

[1] If this is difficult to decide then the sodium hydroxide test can be used. Place grains in a petri-dish and add 25 ml of a 5% solution of NaOH for 60-90 minutes. Original red grains will be dark brownish orange, and white grains will be straw yellow

CONTRIBUTORS

Bioversity is grateful to all the scientists and researchers who contributed to the development of this strategic set of key access and utilization descriptors for wheat genetic resources, and in particular to the participants in the Wheat Plant Genetic Resources Workshop organised during the 11th International Wheat Genetics Symposium held in Brisbane, Australia, in August 2008. The following Bioversity staff contributed to this exercise: Michael Mackay, who provided scientific direction, and Adriana Alercia, who provided technical expertise and guided the entire production process.

CORE ADVISORY GROUP

Michael Mackay, Bioversity International, Italy
Mike Ambrose, John Innes Centre (JIC), United Kingdom
Harold E. Bockelmann, USDA/ARS, USA
Hans Braun, CIMMYT, Mexico
Ladislav Dotlacil, Research Institute of Crop Production, Czech Republic
Bikram Gill, Wheat Genetics and Genomics Resource Centre (WGGRC), USA
Greg Grimes, Department of Primary Industries New South Wales, Australia
Beat Keller, University of Zurich, Switzerland
Francis Ogbonnaya, ICARDA, Syria
Thomas Payne, CIMMYT, Mexico
John Snape, John Innes Centre (JIC), United Kingdom
He Zhonghu, National Centre for Wheat Research and Engineering, China

Methodology for the definition of a key set of characterization and evaluation descriptors for yam (*Dioscorea* spp.)

Bioversity International

GLOBAL CROP DIVERSITY TRUST
A FOUNDATION FOR FOOD SECURITY

Information collection and preparation of a Minimum Descriptor List (MDL)

Information for the definition of a MDL for Yam was based on the publication 'Descriptors for Yam' (*Dioscorea* spp.) (IPGRI/IITA, 1997). The original list contained therein was compared to descriptors mentioned in a number of documents, namely:

1. Basic list of descriptors for Yam (*Dioscorea alata*) from 'Describing and documenting Root Crops in the South Pacific' (Guarino L. and Jackson G, 1986. RAS/83/001. Field Document 12).
2. Basic list of descriptors for Yam (*Dioscorea esculenta*) from 'Describing and documenting Root Crops in the South Pacific' (Guarino L. and Jackson G, 1986. RAS/83/001. Field Document 12).
3. Traits that were awarded funds for further research by the Global Crop Diversity Trust (the Trust) 2008 Award Scheme 'Enhancing the Value of Crop Diversity in a World of Climate Change' (EAS).
4. 'Development of a West African yam *Dioscorea* spp. core collection' (Mahalakshmi V. *et al*., 2007, in Genetic Resources and Crop Evolution 54: 1817–1825)
5. 'Genetic relationships between *Dioscorea alata* L. cultivars' (Lebot V. *et al.* 1998, in Genetic Resources and Crop Evolution 45: 499–509)
6. 'Morphological variability of greater yam (*Dioscorea alata* L.) in Malaysia' (Sayed M. Zain Hasan *et al.,* 2008 in Plant Genetic Resources: Characterization and Utilization **6**(1); 52–61)
7. Selection of the descriptors done by Danny Hunter (Bioversity).

Evaluation traits such as important pests and diseases for Yam, tuber quality and other agronomic characteristics were included.

The Comparison table is presented in Annex I.

Preparation of List of Experts

The list of experts was compiled including authors and contributors of the above mentioned IPGRI/IITA publication; experts that were listed in the Standard Regeneration Guidelines as focal points for Yam, researchers that had been awarded funds for further research on this crop by the Trust 2008 Award Scheme: 'Enhancing the Value of Crop Diversity in a World of Climate Change' (EAS) and experts from the Consultative Group on International Agricultural Research (CGIAR) centres.

In addition some reviewers were drawn from the Taro and Cassava lists of experts participating to the development of the key access and utilization descriptors for those crops. Overall 43 experts were identified coming from 25 countries and 31 different organizations. Although Dr Dominique Dumet at the International Institute of Tropical Agriculture (IITA) was initially invited to be the Crop Leader and she suggested to appoint her colleague Dr Ranjana Bhattacharjee instead, since she was working for IITA genebank and had a long experience in crop characterization. Dr Bhattacharjee accepted the invitation but felt necessary to seek further advice in order to achieve a wider geographical coverage in the definition of biotic and abiotic stresses for Yam. Therefore, Danny Hunter (Bioversity) was sought to lead this crop considering his wide expertise on root and tuber crops.

The Core Advisory Group (CAG), consisting of five experts, was also selected to assist in the definition of a minimum set of descriptors for this crop. Core Group members were chosen from prestigious academic and scientific organizations including the National Root Crops Research Institute, the Secretariat of the Pacific Community (SPC), L'Institut de Recherché pour le Développement (IRD) and the Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) (See Annex III).

Survey preparation and distribution

On 2nd December 2008 Dr Bhattacharjee was contacted to ask advice on a first comparison table. She expressed the need of further inputs from other experts. Thus Danny Hunter was asked to act as Crop Leader too considering his wide experience on this crop. An initial key set was prepared based on descriptors that recurrently appear across species and across different information sources plus on those identified by Danny Hunter. On 2nd March 2009 the revised comparison table, the initial key set of descriptors further refined by Dr Hunter and the tentative list of experts (see Annex II) were sent to Dr Bhattacharjee. A draft survey, listing the descriptors approved by the Crop Leaders (see Annex IV), was prepared and sent to them for their validation. Once approved, the final draft of the survey was uploaded into the SurveyMonkey application on internet and sent out on 24th March 2009 to the list of identified experts (see Annex V). They were invited to validate this initial 'Minimum set of descriptors' of Yam accessions to facilitate their use by researchers. Furthermore, they were asked to make suggestions regarding any characterization and/or evaluation descriptors that were found to be relevant yet missing from the proposed Minimum List.

The survey deadline was set at 20th April 2009. A reminder was sent out on 7th April and a second one on 16th April to ensure that the greatest possible feedback was obtained.

Survey analysis and refinement of Minimum List

Of the 43 experts who were identified and involved in the exercise, 18 coming from 10 countries and 13 organizations recorded their comments using the online survey (Annex VI). Results from the survey were analyzed and descriptors ranked by rating average and percentage of importance (Annex VII). The summary results of the survey together with a report containing open-ended responses received by the participants (see Annex VIII) were shared with Danny Hunter, Ranjana Bhattacharjee and the members of the Core Advisory Group in order to reach a consensus on the final list. Comments received from Dr Perla Hammon (Institut de Recherché pour le Développement) were streamlined and harmonised with Dr Bhattacharjee's ones to define a Minimum List (see Annex IX). Approval of the final List was sought with Danny Hunter on 9th July 2009 (Annex X). Afterwards a final key set was prepared adding descriptor states and then discussed and validated again by Danny Hunter on 30th September 2009.

The final document, including all the contributors (see Annex XI), was proofread by an external Editor and sent to the Publication Unit for layout and on-line publication processes. Furthermore, the publication was shared with the European Cooperative Programme for Plant Genetic Resources (ECPGR) Secretariat; the Generation Challenge Programme (GCP) Ontology and the SGRP Crop Genebank Knowledge Base partners. Additionally, data were converted into Excel files for uploading into the GRIN-Global genebank data-management system being developed by USDA and into the global accession level information portal (GENESYS), linking national, regional and international genebank databases in support of the conservation and use of plant genetic resources for food and agriculture (PGRFA). The Excel files were also provided to the System-wide Information Network for Genetic Resources (SINGER) of the CGIAR and to EURISCO.

Acknowledgement

Bioversity is grateful to all the scientists and researchers who have contributed to the development of the strategic set of 'Key access and utilization descriptors for yam genetic resources', and to the Global Crop Diversity Trust for their financial support.

Annex I – Comparison table for the definition of a Key set of traits for Yam*

IPGRI/IITA[i] Descriptor no.	IPGRI/IITA[i] Descriptor name	IPGRI/IITA[i] *D. esculenta*	IPGRI/IITA[i] *D. alata*	IPGRI/IITA[i] *D. bulbifera*	IPGRI/IITA[i] *D. nummularia*	IPGRI/IITA[i] *D. cayenensis-rotundata*	IPGRI/IITA[i] *D. pentaphylla*	*D. alata* (1)	*D. esculenta* (2)	*EAS (3)*	*IITA article (4)*	*D. alata* (5)	*D. alata Morpho article (6)* (**=most important)	*Descriptors refined by D. Hunter (7)*
7.1.1	Number of days to emergence												**	
7.1.2	Stem length at 20d after emergence												**	
7.1.4	**Young stem colour**	*	*	*		*		*	*			*		*
7.1.7	**Young stem wing colour**		*					*						
7.1.10	**Young stem - Absence/presence of coloured spots at spine base**					*								
7.1.17	**Mature stem - number of stems per plant**											*		
7.1.18	**Mature stem colour**	*	*	*				*	*			*		*
7.1.20	**Mature stem branching**					*								
7.1.21	**Mature stem diameter [cm]**		*					*						
7.1.22	**Mature stem cross-section shape at base**		*											
7.1.23	**Internode length [cm]**											*		
7.1.24	**Mature stem absence/presence of waxiness**					*								
7.1.26	**Mature stem wing size**		*					*						
7.1.27	**Mature stem wing colour**		*					*				*		
7.1.28	**Mature stem absence/presence of ridges**		*		*									
7.1.29	**Mature stem - hairiness**											*		

IPGRI/IITA[i] Descriptor no.	IPGRI/IITA[i] Descriptor name	IPGRI/IITA[i]	IPGRI/IITA[i]	IPGRI/IITA[i]	IPGRI/IITA[i]	IPGRI/IITA[i]	IPGRI/IITA[i]	*D. alata (1)*	*D. esculenta (2)*	*EAS (3)*	*IITA article (4)*	*D. alata (5)*	*D. alata Morpho article (6)* (**=most important)	*Descriptors refined by D. Hunter (7)*
		D. esculenta	*D. alata*	*D. bulbifera*	*D. nummularia*	*D. cayenensis-rotundata*	*D. pentaphylla*							
7.1.32	**Mature stem absence/presence of scale leaves**					*								
7.1.34	**Spines on stem base (2.4.6, 2.4.7)**		*		*	*		*				*		*
7.1.35	**Spines on stem above base**		*			*		* (?)						
7.1.36	**Mature stem spine position**					*								
7.1.37	**Mature stem spine shape**					*								
7.1.38	**Mature stem spine length**					*								
7.1.39	**Mature stem absence/presence of coalescent spines**					*								
7.1.40	**Mature stem colour of spot at spine base**					*								
7.2.1	**First leaf emergence** (2.5.1)								*					
7.2.3	**Young leaf colour**	*	*	*				*	*			*		*
7.2.4	**Young leaf margin colour**	*	*					*	*					*
7.2.5	**Young leaf vein colour**		*		*			*						
7.2.6	**Young leaf petiole colour**	*	*	*				*	*					*
7.2.7	**Young leaf petiole wing colour**		*					*						
7.2.9	**Mature leaf - Position of leaves**												**	
7.2.12	**Mature leaf - leaf type**					*	*							
7.2.13	**Mature leaf - number of leaflets in compound leaf**						*							
7.2.14	**Mature leaf - colour**					*								

IPGRI/IITA[i] Descriptor no.	IPGRI/IITA[i] Descriptor name	IPGRI/IITA[i] D. esculenta	IPGRI/IITA[i] D. alata	IPGRI/IITA[i] D. bulbifera	IPGRI/IITA[i] D. nummularia	IPGRI/IITA[i] D. cayenensis-rotundata	IPGRI/IITA[i] D. pentaphylla	D. alata (1)	D. esculenta (2)	EAS (3)	IITA article (4)	D. alata (5)	D. alata Morpho article (6) (**=most important)	Descriptors refined by D. Hunter (7)
7.2.15	**Mature leaf colour**	*	*	*	*	*		*	*					*
7.2.16	**Mature leaf vein colour (upper surface)**	*	*	*	*			*	*			*	**	*
7.2.17	**Mature leaf vein colour (lower surface)**	*		*					*				**	
7.2.18	**Mature leaf margin colour**	*	*					*	*					
7.2.21	**Waxiness of upper/lower surface**											*		
7.2.22	**Mature leaf - shape**											*	**	
7.2.24	**Mature leaf - undulation of leaf**					*						*		
7.2.25	**Mature leaf - distance between lobes**					*								
7.2.26	**Mature leaf - upward folding of leaf along main vein**					*								
7.2.27	**Mature leaf - downward arching of leaf along main vein**					*								
7.2.28	**Mature leaf - upward folding of leaf lobe to form a cup**					*								
7.2.29	**Mature leaf - downward arching of leaf lobes**					*								
7.2.30	**Mature leaf - measurement**					*						(Length to width ratio (mature leaf))	**	

IPGRI/IITA[i] Descriptor no.	IPGRI/IITA[i] Descriptor name	IPGRI/IITA[i] *D. esculenta*	IPGRI/IITA[i] *D. alata*	IPGRI/IITA[i] *D. bulbifera*	IPGRI/IITA[i] *D. nummularia*	IPGRI/IITA[i] *D. cayenensis-rotundata*	IPGRI/IITA[i] *D. pentaphylla*	*D. alata* (1)	*D. esculenta* (2)	*EAS (3)*	*IITA article (4)*	*D. alata* (5)	*D. alata Morpho article (6)* (**=most important)	*Descriptors refined by D. Hunter (7)*
7.2.31	**Mature leaf - position of the widest part of the leaf**					*								
7.2.32	**Mature leaf - tip length**					*							*	
7.2.33	**Mature leaf tip colour**				*	*								
7.2.34	**Mature leaf petiole length**					*						*	*	
7.2.37	**Mature leaf petiole colour**	*	*	*	*	*		*	* (combined with leaf junction colour)			*	**	*
7.2.38	**Mature leaf petiole wing colour**		*					*						
7.2.39	**Mature leaf spininess of petiole**					*								
7.3.1	**Flowering**											*		
7.3.3	**Sex**							*				*		
7.3.11	**Flower colour**			*										
7.4.1	**Fruit formation**											*		
7.5.1	**Absence/presence of aerial tuber**		*					*				*	*	
7.5.2	**Aerial tuber shape**			*									**	
7.5.3	**Aerial tuber diameter**			*			*						*	
7.5.4	**Aerial tuber skin colour**			*									**	
7.5.5	**Aerial tuber surface texture**			*										
7.5.6	**Absence/presence of bumps on aerial tuber**			*										

IPGRI/IITA[i] Descriptor no.	IPGRI/IITA[i] Descriptor name	IPGRI/IITA[i] *D. esculenta*	IPGRI/IITA[i] *D. alata*	IPGRI/IITA[i] *D. bulbifera*	IPGRI/IITA[i] *D. nummularia*	IPGRI/IITA[i] *D. cayenensis-rotundata*	IPGRI/IITA[i] *D. pentaphylla*	*D. alata* (1)	*D. esculenta* (2)	*EAS (3)*	*IITA article (4)*	*D. alata* (5)	*D. alata Morpho article (6)* (**=most important)	*Descriptors refined by D. Hunter (7)*
7.5.7	**Aerial tuber skin thickness**			*										
7.5.8	**Aerial tuber flesh colour**			*									*	
7.6.2	**Maturity (tubers) after emergence** (2.3.2)									*				*
7.6.5	**Relationship of tuber**												*	
7.6.6	**Absence presence of corms**					*								
7.6.7	**Corm size**					*								
7.6.8	**Corm ability to be separated from tuber**					*								
7.6.11	**Spininess of roots**	*				*								
7.6.12	**Absence/presence of anchor roots**					*								
7.6.14	**Tuber shape**	*	*	*	*	*	*	*	*				*	*
7.6.15	**Tendency of tuber to branch**						*						*	
7.6.17	**Tuber length**	*										*	**	*
7.6.18	**Tuber width** [cm]	*											**	
7.6.19	**Roots on the tuber surface**					*			*					
7.6.19.1	**Spiny roots on the tuber**					*								
7.6.20	**Place of roots on the tuber**	*												
7.6.21	**Prickly appearance of the tuber**					*								
7.6.24	**Absence/presence of cracks on the tuber surface**	*												

IPGRI/IITA[i] Descriptor no.	IPGRI/IITA[i] Descriptor name	IPGRI/IITA[i] *D. esculenta*	IPGRI/IITA[i] *D. alata*	IPGRI/IITA[i] *D. bulbifera*	IPGRI/IITA[i] *D. nummularia*	IPGRI/IITA[i] *D. cayenensis-rotundata*	IPGRI/IITA[i] *D. pentaphylla*	*D. alata* (1)	*D. esculenta* (2)	*EAS (3)*	*IITA article (4)*	*D. alata* (5)	*D. alata Morpho article (6)* (**=most important)	*Descriptors refined by D. Hunter (7)*
7.6.25	**Tuber skin thickness**					*								
7.6.26	**Tuber skin colour (beneath the bark)**	*				*			*					
7.6.29	**Skin colour at head of the tuber**		*									*		
7.6.30	**Flesh colour at central transverse cross-section**	*	*				*	*	*			*	**	*
7.6.31	**Flesh colour of lower part of tuber**		*										*	
7.6.32	**Uniformity of flesh colour in cross-section**												*	
7.6.34	**Time for flesh oxidation after cutting**					*								
7.6.38	**Weight of tuber (g)**												*	
8.1.2	**Total weight of harvested tubers [kg]**									*				*
8.3.9	**Texture of cooked tuber**						*							
8.3.15	**Overall assessment of cooked tuber**													*
8.3.13	**Bitterness of cooked (aerial tuber)**			*										
9.4	**Reaction to high soil moisture**													*
9.5	**Reaction to high salinity**													*
10.1.1.4	**Yam mosaic potyvirus (YMV)**									*	*			*

IPGRI/IITA[i] Descriptor no.	IPGRI/IITA[i] Descriptor name	IPGRI/IITA[i] *D. esculenta*	IPGRI/IITA[i] *D. alata*	IPGRI/IITA[i] *D. bulbifera*	IPGRI/IITA[i] *D. nummularia*	IPGRI/IITA[i] *D. cayenensis-rotundata*	IPGRI/IITA[i] *D. pentaphylla*	*D. alata* (1)	*D. esculenta* (2)	*EAS (3)*	*IITA article (4)*	*D. alata* (5)	*D. alata Morpho article (6)* (**=most important)	*Descriptors refined by D. Hunter (7)*
10.1.2	**Anthracnose susceptibility**		*					*			*			*
10.1.3	***Fusarium* spp. (2.12.3)**									*** (Yam tuber rot disease *Fusarium oxysporum*)**				*
10.2.3.2	***Pratylenchus coffeae***													*
10.2.7	**Yam beetle damage on leaves**									*** (Resistance to Yam beetle)**				
10.2.8	**Yam beetle damage on tubers**									*** (Resistance to Yam beetle)**				*
	Stay-green ability									*				*
	Stem wing undulation											*		
8.1.1	**Number of tubers per plant**											*		

[i] IPGRI/IITA. 1997. Descriptors for Yam (*Dioscorea* spp.). International Institute of Tropical Agriculture, Ibadan, Nigeria/International Plant Genetic Resources Institute, Rome, Italy

* For number reference see section: '*Information collection and preparation of a Minimum Descriptor List (MDL)*'

Annex II – Tentative list of experts sent to Dr. Bhattacharjee for validation

Role	Name	Organization	Country
Crop Leader	**Danny Hunter Bhattacharjee, Ranjana**	IITA	Nigeria
Core Group (EAS)	Eke-Okoro, O.N.	National Root Crops Research Institute	Nigeria
Core Group	Jackson, Grahame V.H.		Australia
Core Group	Mary Taylor	Secretariat of the Pacific Community (SPC)	Fiji
Core Group (SRG)	Hamon, Perla	IRD	France
Core Group	Lebot, Vincent	CIRAD	Vanuatu
(SRG)	O'Hair, Stephen K.	University of Florida - Tropical Research. & Education. Center	USA
(SRG)	Dansi, Alexandre	National Biotechnology Laboratory, University of Abomey-Calavi	Benin
Reviewer (DL)	Carpena, Azucena L.	University of the Philippines Los Baños, Crop Science Cluster	Philippines
Reviewer (DL)	Kurup, G.T		
Reviewer (DL)	Nayar, N.M.		
Reviewer (DL)	Swee Lian, Tan		
Reviewer (DL)	Mamicpic, Noel G.		Philippines
Reviewer (DL)	Quat Ng, N.		
Reviewer (DL)	Pedralli, Gilberto	Universidade Federal de Ouro Preto	Brazil
Reviewer (DL)	Rashid, Mohammad M.		
Reviewer (DL)	Silitonga, Sudiaty T.		
Reviewer (DL)	Supatanakul, Winia		
Reviewer (DL)	Hazekamp, Tom		
Reviewer (from Internet)	Dumont, Roland	CIRAD (?)	France
Reviewer (from Internet)	Vernier, Philippe		
Reviewer (from Internet)	*Zoundjihèkpon, Jeanne	Université d'Abomey-Calavi	Benin
Reviewer (from Internet)	Bill Cable		Samoa
Reviewer (from Internet)	Sayed, M. Zain Hasan	Technology University of Malaysia	Malaysia
Reviewer (from Internet)	Norizan, Mohamad	Technology University of Malaysia	Malaysia
Reviewer (from Internet)	Johan Hurter	Lowveld National Botanical Garden	South Africa
Reviewer (from Internet)	Narina, Satya S S	Virginia State University	USA

Annex III – Identified experts to take part to the on-line survey

Role	Name	Organization	Country
Crop Leader	**Hunter, Danny**	Bioversity	Italy
Crop Leader	**Bhattacharjee, Ranjana**	IITA	Nigeria
CAG (EAS)	Ekeokoro, O.N.	National Root Crops Research Institute	Nigeria
CAG	Grahame, Jackson V.H.		Australia
CAG (SRG)	Hamon, Perla	IRD	France
CAG	Lebot, Vincent	CIRAD	Vanuatu
CAG	Taylor, Mary	Secretariat of the Pacific Community (SPC)	Fiji
Reviewer	Cable, William	Dept Agricolture	Samoa
Crop Strategy Expert (Taro)	Cadima, Ximena	PROINPA	Brazil
Core Group Cassava	Cunha Alves, Alfredo Augusto	EMBRAPA/CNPMF	Brazil
(SRG)	Dansi, Alexandre	National Biotechnology Laboratory, University of Abomey-Calavi	Benin
Core Group cultivated potato	David, Tay	International Potato Centre (CIP)	Peru
Reviewer	de Oliveira Ademar P.	Brazilian Society for Horticoltural Science	Brasil
Reviewer (DL)	Asiedu, Robert	IITA	Nigeria
Reviewer	Keller, Joachim	IPK	Germany
Reviewer (DL)	Mignouna, Hodeba D.	AATF	Kenya
Reviewer (DL)	Otoo, Emmanuel	Crops Research Institute	Ghana
Strategy expert (Taro)	Ferraren, Dilberto O.	Philippine Root Crop Research and Training Center (PhilRootcrops)	Philippines
Manihot Workshop (Cassava)	Fukuda, Wania	EMBRAPA/CNPMF	Brazil
Reviewer (DL) Yam Physiologist	Kikuno, Hidehiko	IITA	Nigeria
Reviewer	Linh Chi, Vu	Plant Resources Center	Viet Nam

Role	Name	Organization	Country
Core Group Cassava	Llerme Rios, Lobos	INIA	Peru
Reviewer	Manguiat, Proceso H.	University of the Philippines Los Baños	Philippines
Strategy expert (Taro)	Mbanaso, Egbichi Nnenna Adaoha	National Root Crops Research Institute, Umudike	Nigeria
Suggested by Bioversity Colombia	Milian, Marylis	INIVIT (Instituto de Viandas Tropicales)	Cuba
Reviewer (DL)	Nayar, N.M.	University of kerala	India
Reviewer (Taro)	Okpul, Tom	PNG University of Technology	Papua New Guinea
Strategy expert (Taro)	Ortiz, Carlos E.	University of Puerto Rico, Mayaguez	USA
Reviewer	Richards, Paul	Wageningen University	Netherlands
Reviewer	Struik, Paul C.	Wageningen University	Netherlands
Strategy expert (Taro)	Reyes Castro, Guillermo	Universidad Nacional Agraria	Nicaragua
Reviewer	Satya, Narina S S	Virginia State University	USA
Reviewer (Cassava expert)	Sias Costa, Ivo Roberto	EMBRAPA - Cenargen	Brazil
Reviewer (DL)	Silitonga, Sudiaty T.	Center of Agricultural Biotechnology and Genetic Resources Research and Development (ICABIOGRRAD)	Indonesia
Suggested by Bioversity Colombia	Soto, Andrès Àlvarez	UNIVERSIDAD DE CORDOBA	Colombia
Reviewer (DL)	Swee Lian, Tan	Malaysia Agric. Research and Development Institute (MARDI)	Malaysia
Strategy expert (Taro)	Tolo, Iosefa	University of the South Pacific	Samoa
Core Group Taro SRG	V. Rao, Ramanatha	Bioversity India	India
Reviewer	Vernier, Philippe	CIRAD	France
Strategy expert (Taro)	Villavicencio, Maria Lea H.	Institute of Plant Breeding-Crop Science Cluster	Philippines
Strategy expert (Taro)	Weidong, Ke	Wuhan Vegetable Research Institute	China
Reviewer	Zannou, Afio	Universite d'Abomey-Calavi	Benin
Reviewer	Zoundjihèkpon, Jeanne	Université d'Abomey-Calavi	Benin

Annex IV – Initial key set of descriptors for access and utilization of Yam, revised by Dr Hunter (2nd March 2009) and agreed by Dr Bhattacharjee (20th March 2009)

1.	Young stem colour	(7.1.4)
2.	Mature stem colour	(7.1.18)
3.	Spines on stem base	(7.1.34)
4.	Young leaf colour	(7.2.3)
5.	Young leaf margin colour	(7.2.4)
6.	Young leaf petiole colour	(7.2.6)
7.	Mature leaf colour	(7.2.15)
8.	Mature leaf vein colour (upper surface)	(7.2.16)
9.	Mature leaf petiole colour	(7.2.37)
10.	Maturity (tubers) after emergence	(7.6.2)
11.	Tuber shape	(7.6.14)
12.	Tuber length	(7.6.17)
13.	Flesh colour at central transverse cross-section (2.10.11)	(7.6.30)
14.	Total weight of harvested tubers [kg]	(8.1.2)
15.	Overall assessment of cooked tuber	(8.3.15)
16.	Yam mosaic potyvirus (YMV)	(10.1.1.4)
17.	Anthracnose susceptibility	(10.1.2)
18.	*Fusarium* spp.	(10.1.3)
19.	Yam beetle damage on tubers	(10.2.8)
20.	*Pratylenchus coffeae*	(10.2.3.2)
21.	Stay-green ability	
22.	Reaction to high soil moisture	(9.4)
23.	Reaction to high salinity	(9.5)

Annex V – Survey to choose a key set of Descriptors for Yam (*Dioscorea* spp.)

WELCOME

Welcome to the survey for the selection of a key set of characterization and evaluation descriptors to support an international information system to enhance the utilization of germplasm held in genebanks.

Your knowledge and experience are being sought to select this initial '**key set of descriptors**' of Yam accessions to identify traits important to crop production and to facilitate their use by researchers.

Your participation in it is highly appreciated. The deadline for this survey is **20th April 2009**.

This key set of characterization and evaluation descriptors will be made available through a global facility for identifying sets of accessions for evaluation and use. For characterization, the aim is a key set of maximally differentiating traits that provide the most impact in discriminating between accessions. For evaluation, the aim is to focus on a few important traits for production, such as tolerance to an important disease or salinity.

The list presented here has been drawn from the IPGRI/IITA publication 'Descriptors for Yam (*Dioscorea* spp.)' (1997) and, further refined under the scientific direction of Ranjana Bhattacharjee (IITA) and Danny Hunter (Bioversity).

This survey consists of two parts:

PART I: Lists important characterization descriptors for Yam. Based on your experience, please rate the descriptors according to their importance in identifying accessions. It also allows you to indicate if any essential descriptor that can contribute to its use is missing from the minimum list presented.

PART II: Lists important evaluation descriptors for Yam. Please, rate these traits in order of importance at the global level. It also allows you to indicate if any essential trait for production is missing from the minimum list presented or indicate any that may not be very significant to global production.

We thank you in advance for investing your time and expertise in selecting this initial, key set of descriptors.

Please allow us to acknowledge your contribution by completing your full contact details below:

Name:

Organization:

Address 1:

City/Town:

State/Province:

ZIP/Postal Code:

Country:

Email Address

PART I: Characterization descriptors

These traits enable easy and quick discrimination between phenotypes. They are generally highly heritable, can be easily seen by the eye and are equally expressed in all environments.

> *Numbers in parentheses on the right-hand side are the corresponding descriptors numbers as published in the IPGRI/IITA publication 'Descriptors for Yam (*Dioscorea* spp.)' (1997).

	Not important	Important	Very important
Young stem colour (7.1.4)	◌	◌	◌
Mature stem colour (7.1.18)	◌	◌	◌
Spines on stem base (7.1.34)	◌	◌	◌
Young leaf colour (7.2.3)	◌	◌	◌
Young leaf margin colour (7.2.4)	◌	◌	◌
Young leaf petiole colour (7.2.6)	◌	◌	◌
Mature leaf colour (7.2.15)	◌	◌	◌
Mature leaf vein colour (upper surface) (7.2.16)	◌	◌	◌
Mature leaf petiole colour (7.2.37)	◌	◌	◌
Maturity (tubers) after emergence (7.6.2)	◌	◌	◌
Tuber shape (7.6.14)	◌	◌	◌
Tuber length (7.6.17)	◌	◌	◌
Flesh colour at central transverse cross-section (7.6.30)	◌	◌	◌

If you consider that an essential trait is missing from this list, please indicate it here along with a substantiated justification.

PART II: Evaluation descriptors

These descriptors include characters such as yield, biotic and abiotic stresses. They are the most interesting traits in crop improvement. Please consider the following factors relating to the trait when making your final decision: (i) Global impact, (ii) Initial strategic set, (iii) Importance for germplasm utilization, (iv) Data availability, (v) True economic damage and (vi) Wide geographical occurrence.

	Not important	Important	Very important
Total weight of harvested tubers [kg] (8.1.2)	○	○	○
Overall assessment of cooked tuber (8.3.15)	○	○	○
Stay-green ability	○	○	○
Reaction to high soil moisture (9.4)	○	○	○
Reaction to high salinity (9.5)	○	○	○
Yam mosaic potyvirus (YMV) (10.1.1.4)	○	○	○
Anthracnose susceptibility (10.1.2)	○	○	○
Fusarium spp. (10.1.3)	○	○	○
Pratylenchus coffeae (10.2.3.2)	○	○	○
Yam beetle damage on tubers (10.2.9)	○	○	○

If you consider that an essential trait important for crop improvement and production is missing from this list, or, if any of the descriptors listed is not clearly useful to promote utilization, please indicate it here along with a substantiated justification.

NOTE: Please remember, this list is the starting point and will grow over time, as required.

THANK YOU VERY MUCH FOR YOUR PARTICIPATION.

Annex VI – Respondents to the survey

Name	***Organization***	***Country***
Abraham. K	Central Tuber Crops research Institute	India
Bhattacharjee, Ranjana	IITA	Nigeria
Dansi A. Alexandre	University of Abomey-Calavi	Benin
Dr Ekeokoro, O N	National Root Crops Research Institute	Nigeria
Hamon, Perla	IRD	France
Kikuno, Hidehiko	IITA	Nigeria
Linh Chi, Vu	Plant Resources Center	Viet Nam
Manguiat, Proceso H.	University of the Philippines Los Baños	Philippines
Mbanaso, E.N.A.	National Root Crops Research Institute	Nigeria
Narina, S. Satya	Virginia State University	USA
Nayar, NM	Kerala University	India
Okpul, Tom	Papua New Guinea University of Technology	Australia
Otoo, Emmanuel	CSIR-Crops Research Institute	Ghana
Rao, Ramanatha	Bioversity	India
Sheela, M.N.	Central Tuber Crops Research Institute	India
Swee-Lian Tan	Malaysian Agri R&D Institute (MARDI)	Malaysia
Vernier, Philippe	CIRAD	France
Zannou, Afio	Faculté des Sciences Agronomiques, Université d'Abomey-Calavi	Benin

Annex VII – Descriptors proposed in the survey ranked by rating average and by percentage importance

Descriptor	Rating Average
Overall assessment of cooked tuber (8.3.15)	4.53
Anthracnose susceptibility (10.1.2)	4.53
Flesh colour at central transverse cross-section (7.6.30)	4.44
Tuber shape (7.6.14)	4.39
Yam mosaic potyvirus (YMV) (10.1.1.4)	4.18
Fusarium spp. (10.1.3)	3.94
Total weight of harvested tubers [kg] (8.1.2)	3.88
Mature stem colour (7.1.18)	3.83
Tuber length (7.6.17)	3.71
Spines on stem base (7.1.34)	3.67
Yam beetle damage on tubers (10.2.9)	3.65
Young stem colour (7.1.4)	3.61
Young leaf colour (7.2.3)	3.61
Pratylenchus coffeae (10.2.3.2)	3.60
Reaction to high soil moisture (9.4)	3.50
Mature leaf petiole colour (7.2.37)	3.44
Young leaf petiole colour (7.2.6)	3.39
Stay-green ability	3.13
Mature leaf vein colour (upper surface) (7.2.16)	3.00
Maturity (tubers) after emergence (7.6.2)	2.94
Reaction to high salinity (9.5)	2.93
Mature leaf colour (7.2.15)	2.78
Young leaf margin colour (7.2.4)	2.75

Descriptor	% Importance (important)	% Importance (Very important)
Tuber shape (7.6.14)	16.7 (3)	77.8 (14)
Overall assessment of cooked tuber (8.3.15)	23.5 (4)	76.5 (13)
Anthracnose susceptibility (10.1.2)	23.5 (4)	76.5 (13)
Flesh colour at central transverse cross-section (7.6.30)	27.8 (5)	72.2 (13)
Yam mosaic potyvirus (YMV) (10.1.1.4)	41.2 (7)	58.8 (10)
Fusarium spp. (10.1.3)	37.5 (6)	56.3 (9)
Young stem colour (7.1.4)	27.8 (5)	55.6 (10)
Young leaf colour (7.2.3)	27.8 (5)	55.6 (10)
Tuber length (7.6.17)	35.3 (6)	52.9 (9)
Total weight of harvested tubers [kg] (8.1.2)	41.2 (7)	52.9 (9)
Mature stem colour (7.1.18)	44.4 (8)	50.0 (9)
Spines on stem base (7.1.34)	38.9 (7)	50.0 (9)
Stay-green ability	26.7 (4)	46.7 (7)
Young leaf petiole colour (7.2.6)	38.9 (7)	44.4 (8)
Yam beetle damage on tubers (10.2.9)	52.9 (9)	41.2 (7)
Pratylenchus coffeae (10.2.3.2)	53.3 (8)	40.0 (6)
Mature leaf petiole colour (7.2.37)	50.0 (9)	38.9 (7)
Maturity (tubers) after emergence (7.6.2)	33.3 (6)	38.9 (7)
Reaction to high soil moisture (9.4)	57.1 (8)	35.7 (5)
Reaction to high salinity (9.5)	53.3 (8)	26.7 (4)
Young leaf margin colour (7.2.4)	50.0 (8)	25.0 (4)
Mature leaf colour (7.2.15)	55.6 (10)	22.2 (4)
Mature leaf vein colour (upper surface) (7.2.16)	68.8 (11)	18.8 (3)

Annex VIII - Additional descriptors included in the Open-ended section of the survey

Yam Descriptor		Name of expert							
Additional Descriptor	**N. times selected**	**Okpul, Tom**	**Narina, S. Satya**	**Hamon, Perla**	**Rao, Ramanatha**	**Dansi A. Alexandre**	**Abraham. K**	**Sheela, M.N**	**Kikuno, Hidehiko**
Leaf shape, it is very discriminant for some varieties of D. cayenensis-D.rotundata	2			X				X	
Average number of tubers may be added. it is a varietal character. "**mean number of tubers at harvest"** for those having more than one tuber) for relative description of the inherent level of variation.	2	X					X		
Grainy or uniform look of cross section of tuber gives an idea about the cooked appearance and taste. It may be included. **Texture of inside of tuber at central transverse cross-section**	2						X		X
Appearance of cooked tuber is important	1						X		
Browning of cut surface is important. **Browining of tubers at central transverse cross-section**	2						X		X
Preharvest infestation due to fungal-insect association (this is based on the tuber damage experienced in the field--The tubers were attacked by an unknown fungi and followed by (insect) larval invasion before harvest, when we tested the larvae in the lab, we found that they belong to Dipterae ...So My guess flies are also damaging the tubers heavily in Local agroclimatic regions of Kovvur (The place where I was working on Tuber Improvement previously),Andhra Pradesh, India. This damage has economical impact as the farmers in that region faced severe loss, not even have tubers for next year planting. It should be taken into concideration, and We need to include this trait important for crop improvement and production globally.	1		X						

Complex tuber length can be dependant on the nature of the soil and the kind of preparation of the soil before planting	**1**			X					
Number of tubers per mound: very important for D. rotundata	**1**					X			
Post harvest storage: very important	**1**					X			
Tolerence of the tuber seeds to drought after planting: this is the major reason given by farmers for abandoning landraces in the arid zone of the north west of Benin.	**1**					X			
Uniform flesh colour may be added as a descriptor	**1**						X		
Dried flesh colour Important	**1**							X	
Rather than reaction to high soil moisture, **reaction to drought** may be added	**1**						X		
hairiness of tuber may be added	**1**						X		
Grainiiness Tuber cortex colour : Important	**1**							X	
Texture of epidermides of tubers	**1**								X
Drymatter Nematode incidence	**1**							X	
Scale insect damage Aerial tuber production	**1**							X	
Viscosity of tuber	**1**								X
COMMENT: Descriptor 8.1.2. Considering the varying number of tubers that can be harvested per hill from the different species of yams, I would like to suggest the use of "**mean weight of tubers at harvest**"	**1**	X							
COMMENT: Young leaf margin colour is not important for D. cayenenesis-D. rotundata but maybe could be for other cultivated species of Oceania or Asia.	**1**			X					
COMMENT: Mature leaf vein colour is not important for D. cayenenesis-D. rotundata but maybe could be for other cultivated species of Oceania or Asia	**1**			X					
COMMENT: I cannot give any comment on, Reaction to high soil moisture or salinity, *Fusarium* spp. and *Pratylenchus coffeae*.	**1**			X					
COMMENT: **Anthracnose susceptibility** is very important for *D. alata* while Yam mosaic potyvirus is *for D. cayenensis-D. rotundata* complex.	**1**			X					

COMMENT: Is total weight harvewsted per plant?	**1**				**X**				
COMMENT:1.**mature stem colour** varies in base and upper portions of stem. they may be separately recorded	**1**						**X**		
COMMENT: 2. **mature leaf petiole** will have colouration in petiole base, middle and top distinctly, usually base and top are of same colour. So petiole colour may be recorded as entire or partial	**1**						**X**		

Annex IX – Comments on survey results received from Dr Perla Hamon (CAG) and Dr Bhattacharjee

Descriptor	Rating Average	Perla Hamon	Ranjana Bhattacharjee
Overall assessment of cooked tuber (8.3.15)	4.53	B	Selected
Anthracnose susceptibility (10.1.2)	4.53	B	Selected
Flesh colour at central transverse cross-section (7.6.30)	4.44	B/I	
Tuber shape (7.6.14)	4.39	I	Selected
Yam mosaic potyvirus (YMV) (10.1.1.4)	4.18	B	Selected
Fusarium spp. (10.1.3)	3.94	B	Selected
Total weight of harvested tubers [kg] (8.1.2)	3.88	B	
Mature stem colour (7.1.18)	3.83		
Tuber length (7.6.17)	3.71		Selected
Spines on stem base (7.1.34)	3.67	I	
Yam beetle damage on tubers (10.2.9)	3.65	B	
Young stem colour (7.1.4)	3.61		
Young leaf colour (7.2.3)	3.61	I	
Pratylenchus coffeae (10.2.3.2)	3.60	B	
Reaction to high soil moisture (9.4)	3.50	B	
Mature leaf petiole colour (7.2.37)	3.44		
Young leaf petiole colour (7.2.6)	3.39		
Stay-green ability	3.13		Selected
Mature leaf vein colour (upper surface) (7.2.16)	3.00		
Maturity (tubers) after emergence (7.6.2)	2.94		Selected
Reaction to high salinity (9.5)	2.93	B	
Mature leaf colour (7.2.15)	2.78	I	
Young leaf margin colour (7.2.4)	2.75		
Leaf shape (7.2.22)		I	
Spine shape (7.1.37)		I	
Spine colour		I	
Branching (7.1.20)		I	
Total number of harvested tubers (8.1.1)		B	

I: Identification

B: Breading

Annex X – Final key set of descriptors for Yam (*Dioscorea* spp.) as defined by survey analysis, consultations with Core Advisory Group and approved by Dr Hunter

Numbers in parentheses on the right-hand side are the corresponding descriptors numbers as published in the publication *Descriptors for Yam (Dioscorea* spp. *)* (IPGRI/IITA 1997).

1.	Spines on stem base	(7.1.34)
2.	Tuber shape	(7.6.14)
3.	Tuber length	(7.6.17)
4.	Flesh colour at central transverse cross-section	(7.6.30)
5.	Total weight of harvested tubers [kg]	(8.1.2)
6.	Overall assessment of cooked tuber	(8.3.15)
7.	Stay-green ability	(8.3.X)
8.	Reaction to high soil moisture	(9.4)
9.	Yam mosaic potyvirus (YMV)	(10.1.1.4)
10.	Anthracnose susceptibility	(10.1.2)
11.	*Fusarium* spp.	(10.1.3)
12.	*Pratylenchus coffeae*	(10.2.3.2)
13.	Yam beetle damage on tubers	(10.2.9)

Annex XI - Final list of characterization and evaluation standards for Yam including descriptor states and Contributors

PLANT DATA

Spines on stem base (7.1.34)

3 Few
7 Many

Tuber shape (7.6.14)

1 Round
2 Oval
3 Oval-oblong
4 Cylindrical
5 Flattened
6 Irregular
99 Other (specify in the **Notes** descriptor)

Tuber length (7.6.17)

1 ≤20 cm
2 21–40 cm
3 ≥41 cm

Flesh colour at central transverse cross-section (7.6.30)

1 White
2 Yellowish white or off-white
3 Yellow
4 Orange
5 Light purple
6 Purple
7 Purple with white
8 White with purple
9 Outer purple/inner yellowish
99 Other (specify in the **Notes** descriptor)

Total weight of harvested tubers [kg] (8.1.2)
Calculated on ten plants per accession. At harvest

Overall assessment of cooked tuber (8.3.15)

3 Low
5 Intermediate
7 High

Stay-green ability (8.3.X)
Retention of green colour at maturity

ABIOTIC STRESSES

Reaction to high soil moisture (9.4)

BIOTIC STRESSES

Yam mosaic potyvirus (YMV) (10.1.1.4)
Anthracnose susceptibility (10.1.2)
***Fusarium* spp.** (10.1.3)
Pratylenchus coffeae (10.2.3.2)

Yam beetle damage on tubers (10.2.9)

NOTES

Any additional information may be specified here, particularly that referring to the category 'Other' present in some of the descriptors above.

CONTRIBUTORS

CORE ADVISORY GROUP

Danny Hunter, Bioversity International, Italy
Ranjana Bhattacharjee, International Institute of Tropical Agriculture (IITA), Nigeria
O. N. Ekeokoro, National Root Crops Research Institute (NRCRI), Nigeria
Perla Hamon, Institut de Recherche pour le Développement (IRD), France

REVIEWERS

Benin
A. Alexandre Dansi, Université d'Abomey-Calavi
Afio Zannou, Faculté des Sciences Agronomiques, Université d'Abomey-Calavi

France
Philippe Vernier, Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD)

Ghana
Emmanuel Otoo, CSIR-Crops Research Institute

India
K. Abraham, Central Tuber Crops Research Institute (CTCRI)
N. M. Nayar, Kerala University
R. Rao, Bioversity International
M. N. Sheela, Central Tuber Crops Research Institute (CTCRI)

Malaysia
Tan Swee-Lian, Malaysian Agricultural Research and Development Institute (MARDI)

Nigeria
Hidehiko Kikuno, International Institute of Tropical Agriculture (IITA)
E. N. A. Mbanaso, National Root Crops Research Institute (NRCRI)

Papua New Guinea
Tom Okpul, Papua New Guinea University of Technology

Philippines
Proceso H. Manguiat, University of the Philippines Los Baños

USA
Narina S. Satya, Virginia State University

Viet Nam
Vu Linh Chi, Plant Resources Center

Bioversity International

IPGRI and INIBAP
operate under the name
Bioversity International

Supported by the CGIAR

ISBN-978-92-9043-874-8