International Center for Tropical Agriculture
Since 1967 ***Science to cultivate change***

Policy Brief No. 25

Where our Food Crops Come from: A New Estimation of Countries' Interdependence in Plant Genetic Resources

Colin K. Khoury, Harold A. Achicanoy, Anne D. Bjorkman, Carlos Navarro-Racines, Luigi Guarino, Ximena Flores-Palacios, Johannes M. M. Engels, John H. Wiersema, Hannes Dempewolf, Julian Ramírez-Villegas, Nora P. Castañeda-Álvarez, Cary Fowler, Andy Jarvis, Loren H. Rieseberg, and Paul C. Struik

September 2015

Key messages:

- *Access to plant genetic resources used in crop improvement is essential for achieving food and nutrition security.*
- *All countries utilize crops whose genetic diversity originates outside their borders and therefore benefit from international collaboration to access plant genetic resources.*
- *Countries are highly interdependent in regard to these resources, as 68.7% of their diets and 69.3% of their national agricultural production systems depend on crops whose genetic diversity originates largely outside their borders, on average across countries worldwide.*
- *Countries' dependence on crops that originated in other regions has increased over the past 50 years in concert with economic and agricultural development and the globalization of food systems. Increased utilization of these "foreign" crops is correlated with greater dietary diversity and higher GDP.*
- *Global interdependence in plant genetic resources provides a strong rationale for proactively conserving and facilitating access to this diversity worldwide. We recommend more comprehensive participation of countries in the Multilateral System of Access and Benefit Sharing of the ITPGRFA, and for widening international cooperation and a multilateral approach to the exchange of plant genetic diversity in order to consider all crops of present and future international importance.*

The places where our food crops originated – where the plant species most important to humanity were initially domesticated and largely diversified over hundreds to thousands of years – are vitally important sources of genetic resources for crop improvement. Conservation and access to plant genetic resources, particularly from these primary regions of diversity, are essential for improving the productivity, resilience, and ultimately security of the food systems of all countries (see Figure 1).

Erosion of plant genetic resources in the primary regions of diversity over the past century has made it urgent to conserve both in these regions as well as in genebanks able to make this genetic variation widely available to crop breeders. Meanwhile, climate change, natural resource limitations, population growth, changing dietary expectations, and other challenges to agricultural production are increasing the need for diverse genetic materials in crop breeding. Yet, despite these pressures, important crop diversity remains unprotected *in situ*, and many genebanks lack the resources necessary to fulfill their conservation and distribution mandates. Moreover, access to genetic resources of crops critical to food security has not yet been fully facilitated internationally.

The case for enhancing conservation and access to plant genetic resources relies on persuasive information on the significance of this diversity, and its geographic patterns, for food systems worldwide. Nearly 20 years ago, initial research on interdependence among countries on crop diversity provided information that helped countries establish a global mechanism for conserving and making available

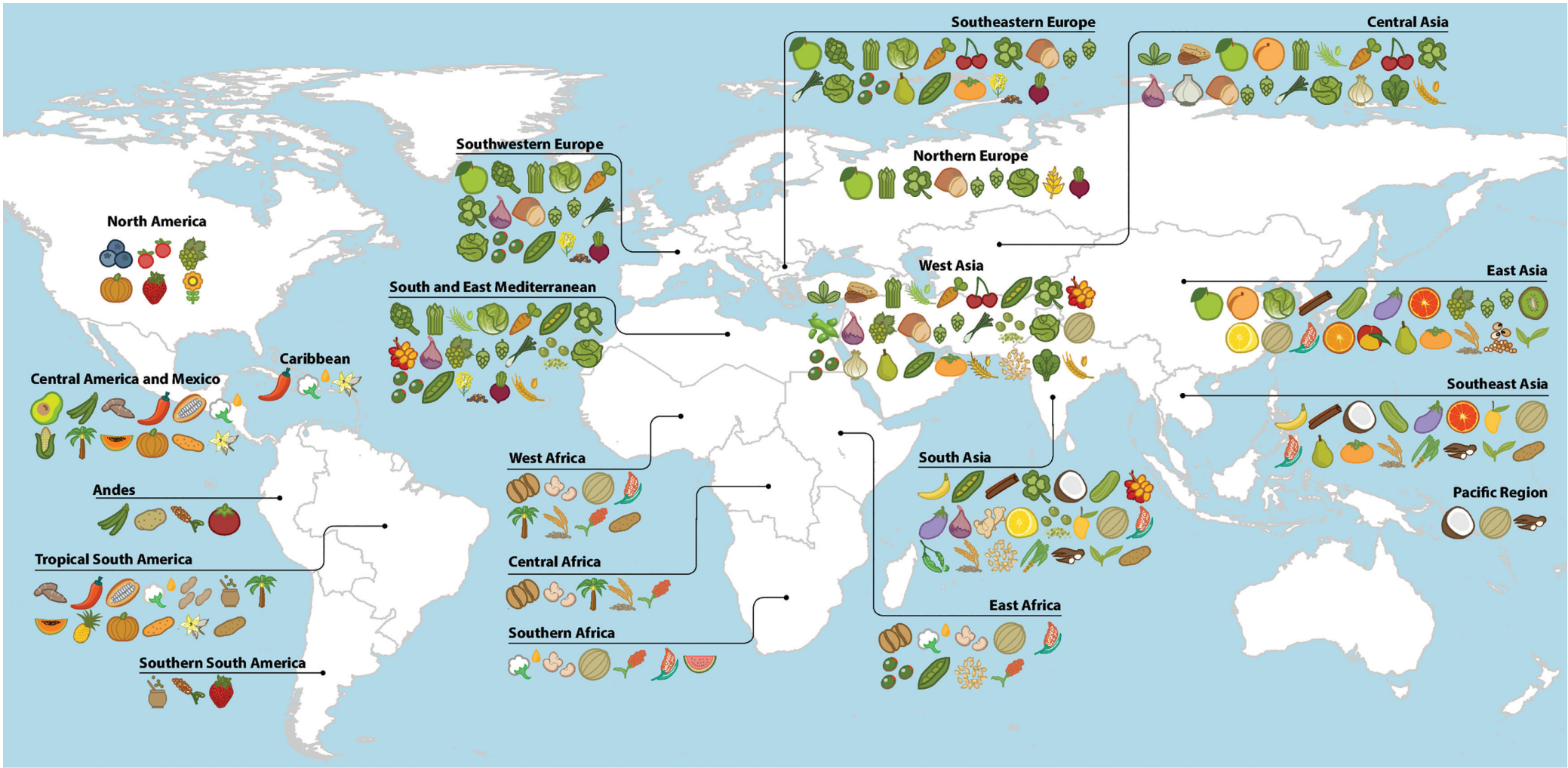

Figure 1. Primary regions of diversity of major agricultural crops are distributed across the tropics and subtropics, extending into temperate regions in both hemispheres.

the genetic diversity of key crops through the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA).

A recent analysis conducted by the International Center for Tropical Agriculture (CIAT) and partners offers a fully updated estimation of interdependence among countries. This novel study confirms the results of the initial research and makes significant improvements in the breadth and depth of the analyses, using powerful visualization tools to display the results. While the initial research focused only on calories, the new analyses include all available measures of national food supplies (calories, protein, fat, and food weight) and three pertinent measures of national production systems (production quantity, harvested area, and production value), and reveal change over the past 50 years. The results indicate for each country the level to which international collaboration to access plant genetic resources is critical to their food systems, based upon their degree of utilization of crops whose genetic diversity originates largely beyond their borders.

Countries depend on crops whose genetic diversity originates largely outside their borders (see Figure 2). This is the case both for their food supplies (65.8% dependence for calories, 66.6% for protein, 73.7% for fat, and 68.7% for food weight as an average across countries worldwide) and in their production systems (71.0% for production quantity, 64.0% for harvested area, and 72.9% for production value). The global average of the degree of countries' dependence on crops that originated in other regions is 68.7% across food supply variables, 69.3% across production variables, and 69.0% across all variables for all countries.

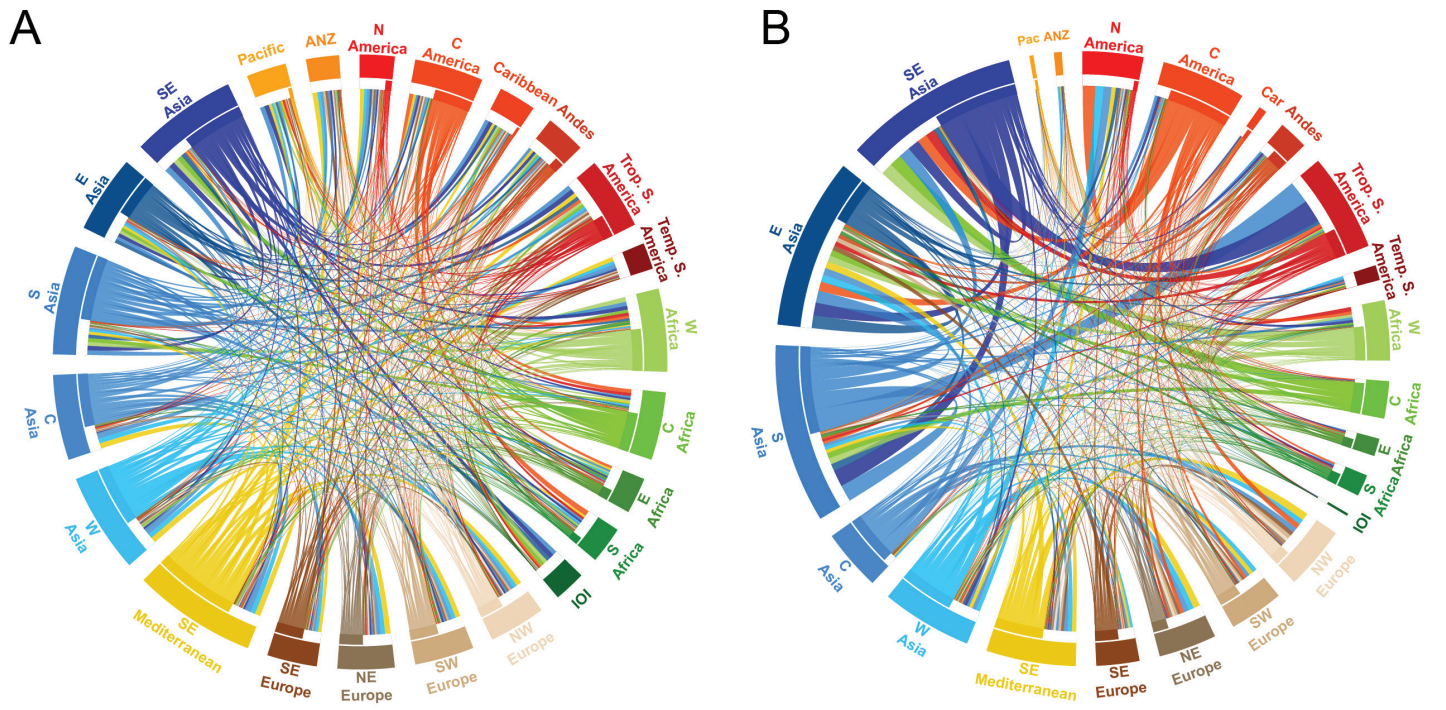

Figure 2. Countries are highly interdependent in regard to the primary regions of diversity of crops that are important in their food systems. These circles link the primary regions of diversity of crops comprising (**A**) calories in national food supplies and (**B**) production quantity in national production systems, shown at the regional level. The direction of the contribution is indicated by both the origin region's colour and a gap between the connecting line and the destination region's segment. The magnitude of contribution is indicated by the width of the connecting line. As an example, (**B**) clearly displays the high importance in tropical South America of crops – namely sugarcane, rice, and bananas & plantains – whose primary regions of diversity are in South and Southeast Asia.

Dependence on "foreign" crops in national food supplies and production systems is highest in countries that are geographically isolated from and/or located at great distance from the primary regions of diversity of major staple crops (see Figure 3). These countries are generally in temperate climates, although tropical islands and some continental tropical regions, such as Central Africa, also demonstrate very high levels of dependence for most variables. Conversely, dependence is lowest in countries located within the primary regions of diversity of major crops and where traditional staples are still cultivated and consumed. The lowest levels of dependence are found in countries whose food systems are dominated by a limited number of traditional staples, such as rice, wheat, yams, sorghum, and millets.

Dependence on crops whose genetic diversity originates outside national borders has increased over the past 50 years in concert with economic and agricultural development and the globalization of food systems, leading to more homogeneous global food supplies. Even countries located within the most ancient and richest primary regions of diversity (e.g., West Asia) now exhibit considerable dependence on crops that originated in other regions, both in their food supplies and production systems.

Increased utilization of "foreign" crops is correlated with greater diversity in national food supplies and production systems, although high dependence also occurs in numerous countries exhibiting low diversity. Very few countries, on the other hand, show high diversity in their food systems and at the same time low dependence on crops whose genetic diversity originates outside their borders. Dependence on "foreign" crops is also positively associated with Gross Domestic Product (GDP), although with considerable variation worldwide.

As countries diversify their diets and increase their GDP in order to enhance food, nutrition, and economic security, dependence on crops whose genetic diversity originates largely outside their borders in food supplies and production systems is also likely to further increase. Moreover, greater emphasis on nutritional quality as well as resilience in the face of climate change and natural resource limitations will heighten the need for diverse genetic materials in crop breeding, further increasing global interdependence in plant genetic resources.

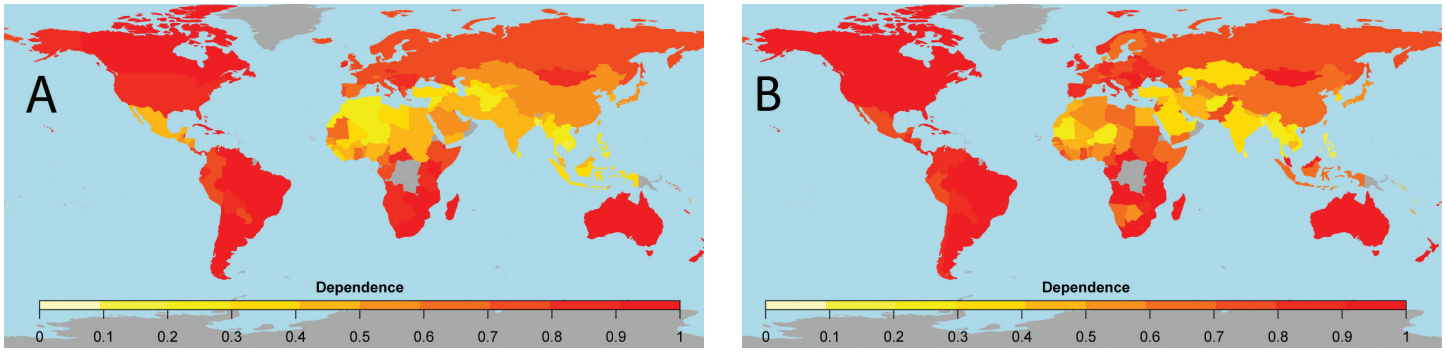

Figure 3. Degree of dependence per country on crops **whose genetic diversity originates outside their borders** with regard to (**A**) calories in national food supplies and (**B**) production quantity in national production systems. Dependence scale is degree of dependence (1=completely dependent). As examples, (**A**) demonstrates that Canada (dark red) is very highly dependent on "foreign" crops in terms of their contribution to calories in national food supplies (estimated value is 92.5%), and (**B**) shows that Australia (dark red) is very highly dependent on "foreign" crops measured in tonnes of food produced nationally (estimated value is 99.9%).

Policy recommendations

After a century of genetic erosion in the wake of economic development and globalization, what remains of crop genetic diversity in the wild, farmers' fields, and genebanks represents the global food system's raw material for further crop improvement and its genetic safety net against hunger. Conserving remnant crop and wild relative diversity *in situ*, collecting for storage in genebanks *ex situ*, ensuring that germplasm repositories are equipped to conserve and distribute these plant genetic resources over the long term, and enabling access to this diversity constitute critically important steps in maximizing the potential contribution of plant genetic resources to national and global food security. The window of opportunity for securing the world's agricultural diversity threatened *in situ* and in underfunded genebanks will not remain open indefinitely.

Global interdependence in plant genetic resources provides a strong rationale for proactively conserving and facilitating access to this diversity worldwide. The results particularly support the argument for more comprehensive participation of countries in the Multilateral System of Access and Benefit Sharing of the ITPGRFA, and for widening international cooperation and a multilateral approach to the exchange of plant genetic diversity in order to consider all crops of present and future international importance. As food systems continue to evolve due both to dietary change and to novel production challenges, a broadly inclusive and adaptable effort to conserve and provide access to plant genetic resources globally is at the very least prudent.

Further reading

Khoury CK; Achicanoy HA; Bjorkman AD; Navarro-Racines C; Guarino L; Flores-Palacios X; Engels JMM; Wiersema JH; Dempewolf H; Ramírez-Villegas J; Castañeda-Álvarez NP; Fowler C; Jarvis A, Rieseberg LH; Struik PC. 2015. Estimation of countries' interdependence in plant genetic resources provisioning national food supplies and production systems. International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), Research Study 8. Rome: Food and Agriculture Organization of the United Nations (FAO). Available online at: http://www.planttreaty.org/content/research-paper-8

This new research provides plant genetic resources interdependence metrics for calories, protein, fat, and food weight in national food supplies, and production quantity, harvested area, and production value in national production systems, for 177 countries covering 98.5% of the world's population. The study also includes an assessment of change in the past 50 years in countries' interdependence in these food supply and production metrics, and an analysis of the relationship between interdependence and diversity in national food systems, as well as GDP.

Correct citation

Khoury CK; Achicanoy HA; Bjorkman AD; Navarro-Racines C; Guarino L; Flores-Palacios X; Engels JMM; Wiersema JH; Dempewolf H; Ramírez-Villegas J; Castañeda-Álvarez NP; Fowler C; Jarvis A; Rieseberg LH; Struik PC. 2015. Where our food crops come from: A new estimation of countries' interdependence in plant genetic resources. CIAT Policy Brief No. 25. Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia. 4 p.

Acknowledgements

Financial support came from the "Adapting agriculture to climate change: Collecting, protecting and preparing crop wild relatives" project, which is supported by the Government of Norway, managed by the Global Crop Diversity Trust with the Millennium Seed Bank of the Royal Botanic Gardens, Kew, UK, and implemented in partnership with national and international genebanks and plant breeding institutes around the world. For further information, see http://www.cwrdiversity.org/

About the authors

Colin K. Khoury, Harold A. Achicanoy, Carlos Navarro-Racines, Julian Ramírez-Villegas, Nora P. Castañeda-Álvarez, and Andy Jarvis – International Center for Tropical Agriculture (CIAT), Cali, Colombia.
Colin K. Khoury and Paul C. Struik, Centre for Crop Systems Analysis, Wageningen University, Wageningen, The Netherlands.
Anne D. Bjorkman, German Centre for Integrative Biodiversity Research, Leipzig, Germany.
Carlos Navarro-Racines, Julian Ramírez-Villegas, and Andy Jarvis, CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), Cali, Colombia.
Luigi Guarino, Hannes Dempewolf, and Cary Fowler, Global Crop Diversity Trust, Bonn, Germany.
Ximena Flores-Palacios, Auckland University of Technology, Auckland, New Zealand.
Johannes M. M. Engels, Bioversity International, Maccarese, Italy.
John H. Wiersema, United States Department of Agriculture, Agricultural Research Service (USDA-ARS), National Germplasm Research Laboratory, Beltsville, MD, USA.
Julian Ramírez-Villegas, School of Earth and Environment, University of Leeds, Leeds, UK.
Nora P. Castañeda-Álvarez, School of Biosciences, University of Birmingham, Edgbaston, Birmingham, UK.
Loren H. Rieseberg, The Biodiversity Research Centre, University of British Columbia, Vancouver, BC, Canada; Department of Botany, University of British Columbia, Vancouver, BC, Canada; and Department of Biology, Indiana University, Bloomington, IN, USA.

Corresponding author

Colin K. Khoury – c.khoury@cgiar.org

Any opinions stated herein are those of the authors and do not necessarily reflect those of the organizations they represent.

CIAT
International Center for Tropical Agriculture
Since 1967 Science to cultivate change

CROP TRUST
SECURING OUR FOOD, FOREVER

CGIAR
RESEARCH PROGRAM ON
Climate Change, Agriculture and Food Security
CCAFS