UNIVERSITY OF HOHENHEIM

History of Plant Genetic Resources

3502-470 Plant Genetic Resources

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Learning goals

1. Understand the historical connections in PGR conservations
2. Know the key arguments in the discussion regarding *ex situ* and *in situ* conservation
3. Recognize that the current gene bank and PGR conservation system is the result of a complex political process

Introduction

Key events in the context of plant genetic resources

- Internationalization of agriculture (Since 1492)
- Green Revolution (Since 1940's)
- International Agricultural system (Since 1940s)
- Convention of biological diversity (1992)

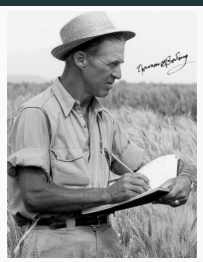
Internationalization of agriculture

Sebastiano del Piombo

Christopher Columbus (1451-1506)

- Age of discoverers
- Driven by greed and capitalism
- Globalization of trade

Green Revolution



Norman Borlaug (1914-2009)

- Globalization of plant breeding

International Agriculture

- Consultative Group of International Agricultural Research (CGIAR)
- Research institutes with a mandate for a particular crop or agroecosystem
- Promote research and develop new varieties using modern technologies

Convention of biological diversity

- Assign task of presevering and taking stewardship of genetic resources to each country
- Regulation of exchange of PGR by International Treaty on Plant Genetic Resources

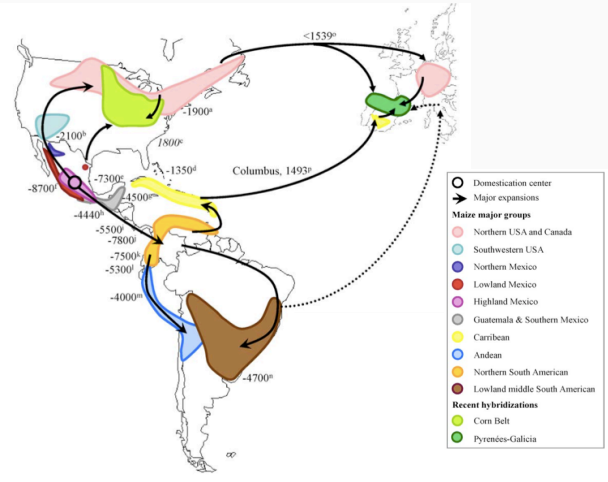
Plants that changed the world

- Since domestication, some plants expanded their range and became very important
- Examples: Wheat, barley, maize and rice

Columbian Exchange

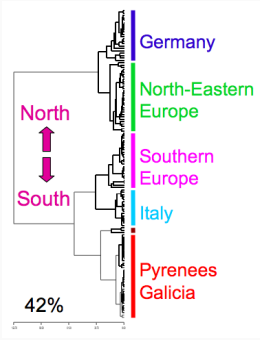
- Term coined by historian Alfred Crosby in 1972
- A small number of plants that transformed world agriculture
- Important effects of animals and diseases
- Rapid distribution of few plants throughout the world
- Initially, plants were not improved by breeding

Maize introduction into Europe



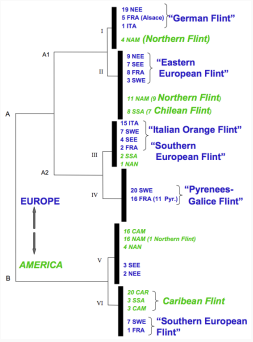
Tenaillon and Charcosset (2011)

Relationship of European maize



Rebourg et al. 2001

Relationship of European maize with American material

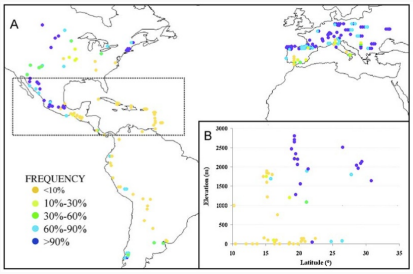


- Compare 139 European accessions and 89 American populations with 29 RFLP (≈ SNP) markers
- Identify similarities
- Southern Spain and Caribbean material, consistent with the first introductions by Columbus
- Northern European material and American Northern Flints, also with material from South Chile
- Italian and South American material
- Original group in the Pyrenees without similarity to American material

Rebourg et al. (2003)

Frequency of a marker for early flowering

Frequency of a MITE transposable element linked with early flowering at the *Vgt1* locus.



Tenaillon and Charcosset (2011)

The situation in the 19th century

- Plantations established in tropical countries
- Colonialism to protect (among other things) plantations
- Mid-1800's: Steam engine, capitalism
- Late 1800's: Globalization

Unprecented wealth of rubber barons

Movie 'Fitzcarraldo' by Werner Herzog

Beginning of plant breeding

- End of 19th century
- Main method: mass selection, also extraction of individual elite varieties from populations
- Early example: Ferdinand von Lochow with rye varieties
- But main improvements by plant cultivation, and not breeding
- It was realized that some "modern" varieties were not better than old landraces ⇒ The importance of land races was recognized

Agricultural conference in Vienna, 1890

von Proskowetz and Franz Schindler: *'What is the relationship in value between land races of agricultural crops and the so-called breeding lines?'*

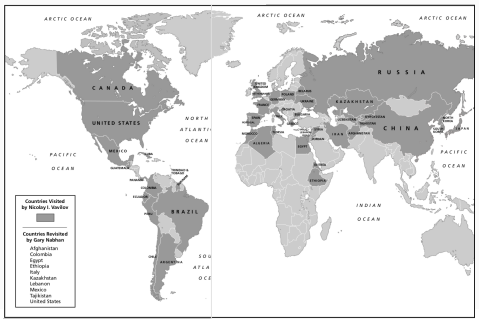
Plant breeding after the rediscovery of Mendelian rules

- Mendelian genetics became an important concept in breeding
- Example: Creation of the 'Panzerweizen' by Hermann Nilsson-Ehle in Sweden (1907):

High-yielding english Squarehead
$\times$
Cold and frost tolerant Swedish land wheat
$\Downarrow$
Panzerweizen: Combination of both traits

Countries visited by Vavilov

Beginning of 20th century: Vavilov started collection triops



Collections by Heinz Brücher

- 1915-1991
- Studied biology in Tübingen
- Was soldier during early years of war
- Was then professor of botany in Jena
- Was hired by SS-Ahnenerbe

Robbery of PGR by Germans

[redacted]

Nur für den Dienstgebrauch!

Übersetzung von:

N. J. Vavilov

Theoretische Grundlagen der Pflanzenzüchtung

Band I

Allgemeine Pflanzenzüchtung

Kap. 2

Botanisch-geographische Grundlagen der Pflanzenzüchtung

von N. J. Vavilov

Forschungsdienst

Reichsarbeitsgemeinschaften der Landbauwissenschaft

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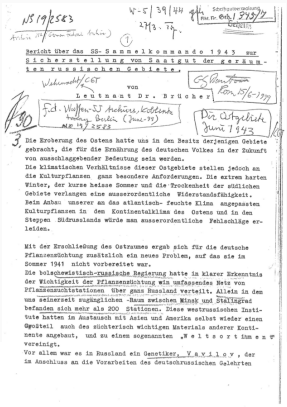

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Bericht über das SS-Sammelkommando 1943 zur Sicherstellung von Saatgut der geräumten russischen Gebiete.

von

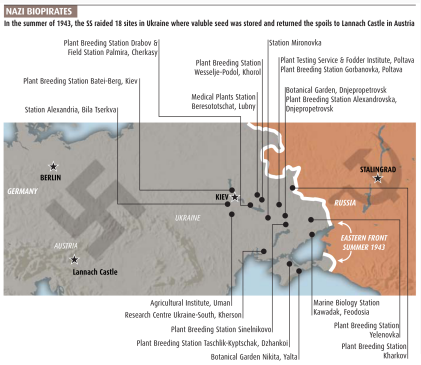
Leutnant Dr. Brücher

Die Eroberung des Ostens hatte uns in den Besitz derjenigen Gebiete gebracht, die für die Ernährung des deutschen Volkes in der Zukunft von ausschlaggebender Bedeutung sein werden.
Die klimatischen Verhältnisse dieser Gebiete stellen jedoch an die Kulturpflanzen ganz besondere Anforderungen. Die extrem harten Winter, der kurze heiße Sommer und die Trockenheit der südlichen Gebiete verlangen eine ausserordentliche Widerstandsfähigkeit. Beim Anbau unserer an das atlantisch- feuchte Klima angepassten Kulturpflanzen in den Kontinentalklima des Ostens und in den Steppen Südrusslands würde man ausserordentliche Fehlschläge erleiden.

Mit der Erschließung des Ostraumes ergab sich für die deutsche Pflanzenzüchtung praktisch ein neues Problem, auf das sie im Sommer 1941 nicht vorbereitet war.
Die bolschewistisch-russische Regierung hatte in klarer Erkenntnis der Wichtigkeit der Pflanzenzüchtung ein umfassendes Netz von Pflanzenzuchtstationen über ganz Russland verteilt. Allein in dem uns seinerzeit zugänglichen -Raum zwischen Minsk und Stalingrad befanden sich mehr als 200 Stationen. Diese westrussischen Institute hatten in Austausch mit Asien und Amerika selbst wieder einen Grossteil auch des sichterlich wichtigen Materials anderer Kontinente angebaut, und so einen sogenannten „Weltsortimente" vereinigt.
Vor allem war es in Russland ein Genetiker, Vavilov, der im Anschluss an die Vorarbeiten des deutschrussischen Gelehrten

Report by Brücher

Acquisition of Vavilov's collection



History of German crop science institutes

- The crop scientists worked at the KWI institutes in Berlin-Dahlem and KWI institute in Müncheberg early in their careers
- KWI of Crop Research was funded close to Vienna in 1943
- KWI of Genetics in Dahlem
  → MPI of Molecular Genetics, Berlin
- KWI of Plant Breeding, Müncheberg
  → MPI of Plant Breeding Research, Cologne
- KWI of Crop Research, near Vienna
  → Leibniz Institute of Plant Genetics and Crop Research (IPK), Gatersleben

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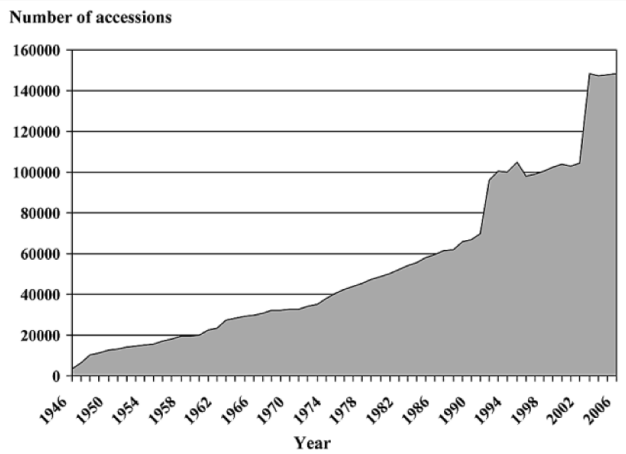
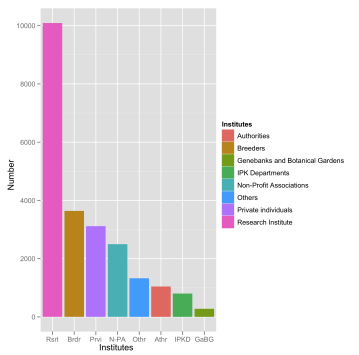
IPK collection activities

Period	Number of expeditions	Number of samples collected	Main regions
Before 1950	9	4307	Austria, Hindukush, Tibet, Balkan
1950–1959	4	1227	China, Iran, Italy
1960–1969	5	664	Mongolia, Cuba, Soviet Union (Amur region)
1970–1979	9	2424	Czechoslovakia, Poland, Spain
1980–1989	57	8520	Italy, Georgia, Austria, Libya, Cuba, Iraq, North Korea, Ethiopia
1990–1999	54	8083	Albania, Tunisia, Romania, Italy, Iran, Uzbekistan, Turkmenistan, Croatia, Bulgaria
2000–2006	15	1506	Uzbekistan, Georgia, Armenia, France, Ireland, Czech Republic, Germany (Bavarian Alps)
Total	153	26 731	

Genbank increase



IPK sendouts



Successful use of IPK accessions in varieties

Crop	No. of varieties
Spring barley	30
Winter barley	3
Spring wheat	1
Winter wheat	12
Dry soup pea	2
Fodder pea	3
Lettuce	1
Vegetable pea	4
Total	56

Table 1: Varieties registered from 1973 to 1990 that were developed by including material from the genebank in Gatersleben (Hammer 1991).

International developments 1941 - 1959

- 1941: Henry Wallace, the founder of Pioneer Hi-Bred Company (success with marketing of hybrid maize) met with Raymond Fosdick, the president of the Rockefeller Foundation.
- They decided on an international program that became famous as the Green Revolution
- 1943: Breeding researchers were sent to Mexico to establish the Office of Special Studies, the precursor of the International Maize and Wheat Improvement Centre (CIMMYT).
- Similar institutes were established in other countries. Funding was largely provided by the Rockefeller Foundation.

International developments 1941 - 1959

- Internationalization of seed trade became a problem (no clear regulations)
- The world was partitioned into developed and underdeveloped countries
- 16 September 1945: Food and Agriculture Organisation (FAO) was founded
- FAO initiated the international distribution of seeds
- Then, the loss of native varieties and the narrow genetic basis of modern seeds was recognized → Focus on conservation
- 1959: Initiate systematic conservation of plants

Task of the FAO

..to do everything possible (...) especially in coordinating plans for plant exploration, in order that collections should be efficiently organized and service, and the proceeds shared equitably among interested parties.

Positions agreed upon in the 1967 FAO conference

"Dogma" of PGR

- Highest priority is given to the collecting and preservation of the widely endangered landraces.
- Generalist instead of mission-oriented collecting strategy.effort for a particular crop which had to be improved in its particular range of adaptation.
- Representativeness through a large size of collections.
- Evaluation is essential for utilization.
- Preservation by long-term storage.

Establishing a system of gene banks

- Goal: establish a neutral organization under the umbrella of an international organization
- Should not be FAO: Too bureaucratic and inefficent
- Therefore: establish an independent system of international genebanks

Perceived disadvantages of *ex situ* collections

- Deterioration of collections (loss of germination ability)
- Genetic drift and enrichment of deleterious mutations
- Difficulties in the evaluation of large collections
- Lack of use
- Poor funding
- Political problems because of a centralized *ex situ* storage

Results of the conference

- Genetic erosion was recognized and publicized as a problem in breeding
- It was recognized that modern plant breeding requires a steady flow of new germ plasm
- A generalist approach was considered to be more successful to prevent genetic erosion
- Genetic variation should be predominately conserved *ex situ* in gene banks
- The *ex situ* versus *in situ* conservation debate was not resolved: Are they complementary or alternative strategies?

The international network of gene banks (1972)

1. A coordinating centre: IBPGR (later to become IPGRI and now Bioversity in Rome)
2. Establish genebanks in four existing international agricultural research centers: IRRI, CIMMYT, CIAT, and IITA
3. Establish genebanks in new international centres: CIP, WARDA, ICRISAT already existed and joined the network. ILCA and ICARDA were later included.
4. Establish new 'regional' centres in Vavilovian centres of crop diversity

Summary

- The movement of to preserve plant genetic resources is closely tied to the desire to protect genetic resources.
- In Germany, very early a system of public institutes to collect and utilize plant genetic resources were created.
- The Genebank in Gatersleben has become one of the largest gene banks in the world, thanks to the effort of many collection expeditions.
- After the second world war, the conservation of genetic resources has become an international effort. Because of the internationalization of seed companies and the emerging North-South conflict, the arena has become highly politiced.
- The Convention on Biological Diversity and the GATT treatment regulate the collection, exchange of genetic resources and any intellectual property derived from them.

Further reading

- Pistorius (1997) A good and concise summary of historical and political aspects of the genetic resources movement is by Robin Pistorius, *Scientists, plants and politics - A History of the Plant Genetic Resources Movement.* (1997) [ILIAS]

Review questions

- What were the key international developments and events in the plant genetic resource movement?
- Which organisations and institutions originated from these developments, and what is their task?

References i

Pistorius R (1997) Scientists, Plants and Politics A history of the Plant Genetic Resources Movement. Tech. rep., International Plant Genetic Resources Institute, Rome, Italy