THE ROLE OF AMERINDIAN CULTIVATORS IN MAINTAINING GENETIC, MORPHOLOGICAL AND BIOCHEMICAL DIVERSITY: THE CASE OF MANIOC

Anne DUPUTIÉ, Marianne ÉLIAS, Benoit PUYOL, Marc DELÊTRE, Caroline ROULLIER, Jane BRADbury & Doyle MCKEY

Centre d'Écologie Fonctionnelle et Évolutive, Montpellier, France
WHY DOES DIVERSITY MATTER?

• Genetic diversity: fuel for adaptation to different environments
  – Spatial and temporal heterogeneity
  – Resilience
  – Repository

• Crops: Morphological, biochemical diversity
  – Diversity of uses
  – Niche complementarity
A BRIEF INTRODUCTION TO MANIOC

Sinnamary, French Guiana

©thekebun.wordpress.com
A BRIEF INTRODUCTION TO MANILOC

- A South American species with a single origin

single ancestor (*M. e. ssp. flabellifolia*)
single origin, >5600 BP

Duputie et al. Societe Francaise de Biologie, Montpellier, October 17, 2012

Olsen & Schaal, 1999; Olsen, 2004; Léotard et al. 2009
A BRIEF INTRODUCTION TO MANIOC

- A South American species with a single origin
- Now cultivated throughout the tropics
A BRIEF INTRODUCTION TO MANIOC
A BRIEF INTRODUCTION TO MANIOC

- A South American species with a single origin
- Now cultivated throughout the tropics
- Highly diverse
- Some varieties are toxic

[Chemical diagram showing the breakdown of Linamarin (and lotaustralin) by β-D-glucosidase to form Glucose and HCN.]

Duputié et al. Société Française de Biologie, Montpellier, October 17, 2012
A BRIEF INTRODUCTION TO MANIOC

Wayâpi women grinding manioc

Soaking and squeezing
Why clonal propagation?
  - Varieties breed true to type
    (no unwanted gene flow)
Why clonal propagation?
- Varieties breed true to type (no unwanted gene flow)
- Easy (faster growth, higher yield)
Why clonal propagation?
- Varieties breed true to type (no unwanted gene flow)
- Easy (faster growth, higher yield)

Why NOT clonal propagation?
- Clonal attrition

Duputié et al. Société Française de Biologie, Montpellier, October 17, 2012
Why clonal propagation?
- Varieties breed true to type (no unwanted gene flow)
- Easy (faster growth, higher yield)

Why NOT clonal propagation?
- Clonal attrition
- Mutation accumulation
Why clonal propagation?
- Varieties breed true to type
  (no unwanted gene flow)
- Easy (faster growth, higher yield)

Why NOT clonal propagation?
- Clonal attrition
- Mutation accumulation
- Pathogen accumulation
CLONAL/SEXUAL SYSTEMS

Time

Clonal propagation

Sexual recombination

Duputié et al. Société Française de Biologie, Montpellier, October 17, 2012
CLONAL/SEXUAL SYSTEMS

Unwanted genotypes:
- Inbred
- Outbred
- Poor agronomic quality
- Intermediate bitterness
- ...

Time

Clonal propagation

Sexual recombination

Duputié et al. Société Française de Biologie, Montpellier, October 17, 2012
Different landraces in a Wayãpi field
CLONAL/SEXUAL SYSTEMS

Inbreeding depression

Outbreeding depression

Duputie et al. Societe Francaise de Biologie, Montpellier, October 17, 2012
CLONAL/SEXUAL SYSTEMS

Unwanted genotypes:
- Inbred
- Outbred
- Poor agronomic quality
- Intermediate bitterness
...

Clonal propagation
Sexual recombination
CLONAL/SEXUAL SYSTEMS: MANIOC
CLONAL/SEXUAL SYSTEMS: MANIOC

Duputié et al. Société Française de Biologie, Montpellier, October 17, 2012
CLONAL/SEXUAL SYSTEMS: MANIOC

Duputié et al. Société Française de Biologie, Montpellier, October 17, 2012
CLONAL/SEXUAL SYSTEMS: MANIOC

1. weeding
2. competition
3. harvest
4. Interclonal selection

Duputié et al. Société Française de Biologie, Montpellier, October 17, 2012
IN SITU SELECTION: REMOVING INBRED PLANTS

1. More homozygous (also the smallest) seedlings removed by weeding
IN SITU SELECTION: REMOVING INBRED PLANTS

- 2. More heterozygous seedlings are better competitors
IN SITU SELECTION: REMOVING INBRED PLANTS

3. Seedlings chosen for incorporation are more heterozygous on average

- 1. Weeding
- 2. Competition
- 3. Conscious selection at harvest

Duputié et al. Société Française de Biologie, Montpellier, October 17, 2012
IN SITU SELECTION: REMOVING INBRED PLANTS

- 4. Long-lived landraces are even more heterozygous
**IN SITU SELECTION: REMOVING OUTBRED PLANTS**

- Ideotypic selection (counter-selection of off-types) prevents from incorporating « too outbred landraces »

- Intra-landrace relatedness increases through time

<table>
<thead>
<tr>
<th></th>
<th>Intra-landrace relatedness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long established clones</td>
<td>0.37 ± 0.28</td>
</tr>
<tr>
<td>Seedlings</td>
<td>0.05 ± 0.23</td>
</tr>
<tr>
<td>Clones of seedlings</td>
<td>0.22 ± 0.32</td>
</tr>
</tbody>
</table>

Duputié et al. Société Française de Biologie, Montpellier, October 17, 2012
WRAP-UP: IN SITU GENERATION AND SELECTION OF USEFUL DIVERSITY

• Constant generation of diversity

• An efficient selection process
  – Against inbred plants
  – Against outbred and unwanted phenotypes (e.g. half-bitter)

• Soil seed bank = long-term preservation of genotypes.
  – After catastrophic events, new clones are found in the seed bank
  – Diversity can be even higher than before the catastrophe

• What about introduction zones?

Duputié et al. Société Française de Biologie, Montpellier, October 17, 2012
TRAVELLING CROPS – NOT NECESSARILY TRAVELLING KNOWLEDGE

Duputié et al. Société Française de Biologie, Montpellier, October 17, 2012
TRAVELLING CROPS – NOT NECESSARILY TRAVELLING KNOWLEDGE

Slide courtesy of M Delètre
TRAVELLING CROPS – NOT NECESSARILY TRAVELLING KNOWLEDGE

19th-20th

17th-18th

18th-19th

Duputié et al. Société Française de Biologie, Montpellier, October 17, 2012

Slide courtesy of M Delèle
Exclusively sweet cassava grown

Mostly sweet

Both

Mostly bitter

TRAVELLING CROPS – NOT NECESSARILY TRAVELLING KNOWLEDGE

Duputié et al. Société Française de Biologie, Montpellier, October 17, 2012

Slide courtesy of M Delêtre
Exclusively sweet cassava grown

Mostly sweet

Both

Mostly bitter

South America
Bitter ≠ Sweet

West Africa
Bitter ~ Sweet

Pacific
Sweet

Duputié et al. Société Française de Biologie, Montpellier, October 17, 2012

Bradbury et al. subm
GENERATION & MAINTENANCE OF DIVERSITY IN SPACE & TIME
GENERATION & MAINTENANCE OF DIVERSITY IN SPACE & TIME

Space

Time

Duputié et al. Société Française de Biologie, Montpellier, October 17, 2012
In situ crop management

Environment  
Crop biology

In situ reproduction and selection

Farmer’s perception of constraints  
Social networks
Institution network

Flow of genetic material
NETSEED PROJECT: HUMAN NETWORKS, PLANT NETWORKS

Social status
Social structure
Geographic distance

Structure and dynamics of exchanges

Structure and dynamics of crops diversity

19 researchers, 10 countries, 81 villages, >100 cultivated plants
• Exchanges of genetic material may lead to:
  – Increased local diversity
  – Increased agroecosystem resilience
  – Introduction of maladapted material
  – Pathogen introduction

• Global change (climate + land use), intensive cultivation

• Loss of indigenous knowledge
  – (e.g. fallow shortening, knowledge about seedlings)

  -> need to understand how (managed plants) diversity is constructed and maintained *in situ*
THANKS TO ...

Doyle McKey

Caroline Roullier

E. Jane Brabury

Marianne Elias

Benoît Pujol

Marc Delêtre

Luiz Carvalho

Contrat plan état région Guyane

& you!
... AND CLONALLY PROPAGATED

Why clonal propagation?
- Varieties breed true to type (no unwanted gene flow)
- Easy (faster growth, higher yield)

-> Mixed clonal/sexual systems

Why NOT clonal propagation?
- Clonal attrition
- Mutation accumulation
- Pathogen accumulation