# The Banana

**Are we going bananas, or where are bananas going?**
**The domestication and future of our most-loved fruit**

**Pat Heslop-Harrison** www.biobanana.com

Bioversity International

Generation
Cultivating Plant Diversity for the Resource-Poor

PROMUSA
A Global Programme for Musa Improvement

University of Leicester

Zingiberales Order Bed, National Botanic Garden of Wales, 2006

# What is a banana?

## Monocotyledon - giant herb not a tree!



# What are bananas?

# What is in banana DNA?

# What is the future for banana?

# What is the future for diet and farmers?

Generation
Cultivating Plant Diversity for the Resource-Poor

PROMUSA
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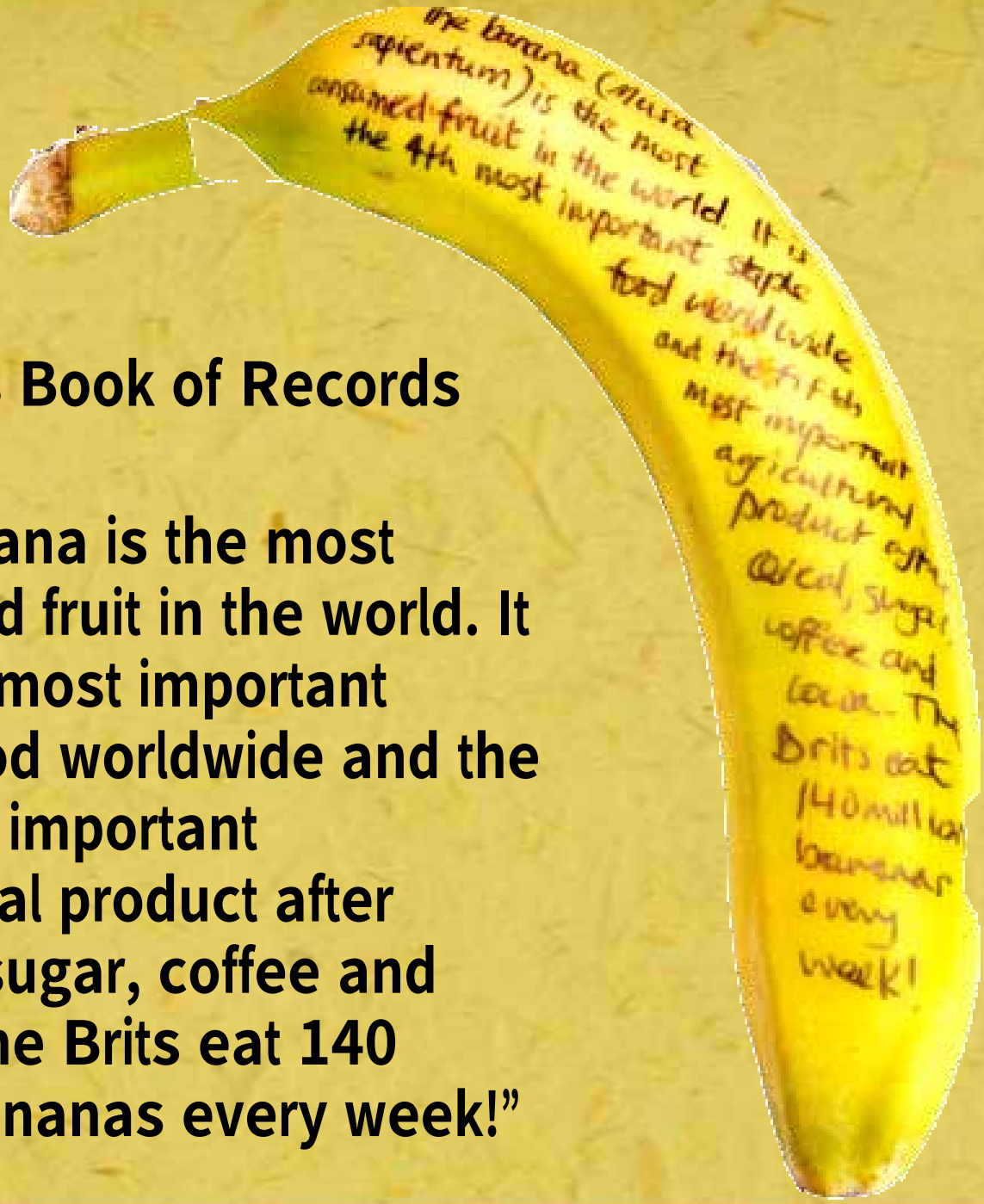



- Guinness Book of Records 2007
- "The banana is the most consumed fruit in the world. It is the 4th most important staple food worldwide and the fifth most important agricultural product after cereals, sugar, coffee and cocoa. The Brits eat 140 million bananas every week!"

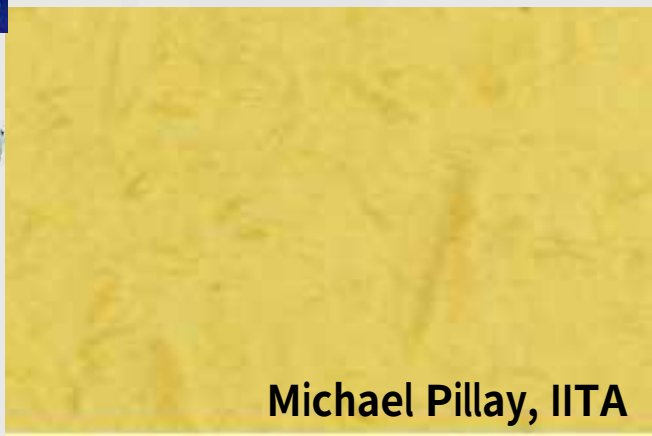

Dried sweet banana
chips


Dried green banana
chips


banana crisps


nana Starch


anana flour


Michael Pillay, IITA

# Uganda

- 400 kg/person/year annual consumption
- Matoke of steamed bananas then mashed

From www.synesthete.com

# Banana Evolution

- Center of origin: South-east Asia
- Grown throughout the humid tropics: Asia, Americas, Africa

# Cultivated banana

- Origin from two species:
- *Musa acuminata* (the A genome) and *Musa balbisiana* (B genome)

axonomic Advisory Group for Musa: :: Index - Microsoft Internet Explorer

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http://tag.inibap.org/index.php?sid=c98db81e8b9ac69b7445074be9faece9

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# Taxonomic Advisory Group for Musa:

Expert discussion forum on taxonomic and conservation issues

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The time now is Thu Mar 15, 2007 8:16 am
**Taxonomic Advisory Group for Musa: Forum Index**

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| Forum | Topics | Posts | Last Post |
|---|---|---|---|
| **General discussion** | | | |
| **How to use this forum** | 1 | 1 | Thu Jul 06, 2006 5:53 pm tvidal |
| **General discussion**<br>This area is for bringing up general points about the conservation strategy for *Musa* and for topics not covered in the 5 thematic discussion groups below | 1 | 6 | Sat Feb 24, 2007 10:10 am edmond |
| **News - Announcements and news from TAG members**<br>Moderators elizabeth, charlotte | 4 | 8 | Sat Dec 09, 2006 9:23 pm ngeza |
| **Task discussion** | | | |
| **MGIS and Musalogue**<br>To develop information tools for accessing accurate characterization data at the accession and variety level to aid the selection and use of *Musa* diversity | 4 | 22 | Wed Dec 06, 2006 7:34 pm elizabeth |

Internet

Taxonomic Advisory Group for Musa: :: Index - Microsoft Inte

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Address http://tag.inibap.org/index.php?sid=c98db81e8b9ac69b7445074be

Google Go

covered in the 5 thematic discussion groups below

**News - Announcements and news from TAG members**
Moderators elizabeth, charlotte

**Task discussion**

**MGIS and Musalogue**
To develop information tools for accessing accurate characterization data at the accession and variety level to aid the selection and use of *Musa* diversity
Moderators elizabeth, jean-pierre

**Wild species and threatened cultivars**
To evaluate the status of wild species and landraces (i.e localized or lesser-known traditional cultivars) with the aim of ensuring that genetic diversity is conserved for present and future use
Moderators charlotte, uma

**Improving characterization**
To improve the characterization of *Musa* (initially up to the subgroup level) through the comparative study and documentation of a set of reference varieties
Moderators jeff, nicolas

**Rationalizing collections**
To agree and implement a procedure for rationalizing the collections within the ITC
Moderators charlotte, ines

**Nomenclature and synonymy**
To develop an accepted nomenclature and glossary of terms by which the *Musa* research community and beyond may communicate and understand one another
Moderators elizabeth, edmond

**Discussion summary**

**Discussion summary**
Moderator elizabeth

Internet

http://bananas.bioversityinternational.org/content/view/58/90/lang,fr/

start Microsoft P... PROMUSA ... GMGC - Glo... Microsoft ... Welcome t... INIBAP -- -... Taxonomic ... Taxonomic ... Adobe Pho...

# Banana Plantains *Musa*

1-7 year plantation
Vegetatively propagated
(exclusively)

85% used as local staple

20-30kg fruit bunch
>100Mt /yr

2n=3x=33

# Banana Evolution

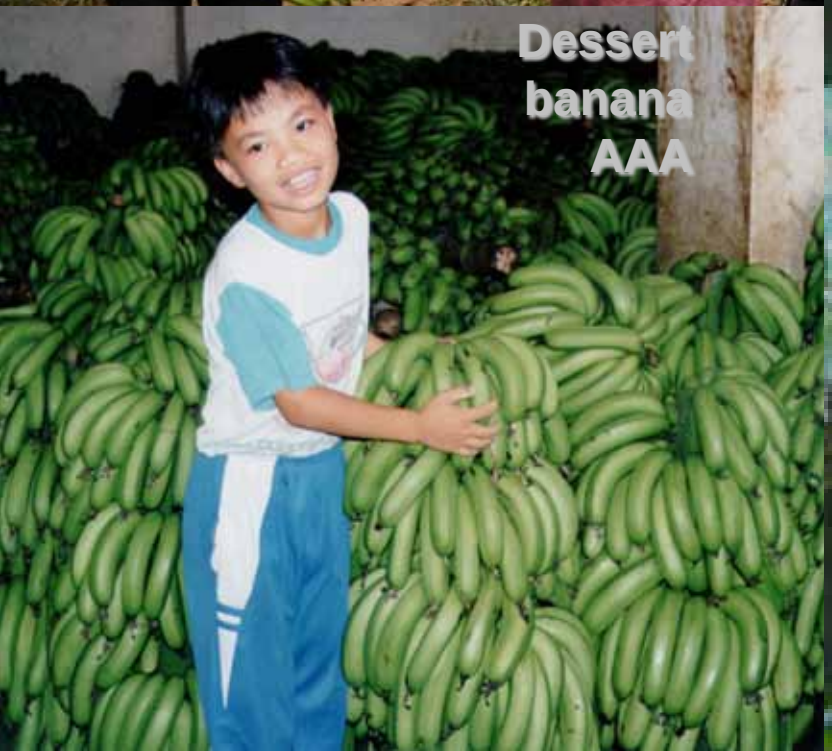
- Cultivars: sterile, parthenocarpic clones
- Very unusual for a fruit to be produced without a seed
- Only in last decade for oranges & grapefruit (coming now for lemons and limes)

- Subsistence agriculture
- Smallholder farms
- Cash crop
- Commercial
- Year-round production
- Eaten by all ages of people

Plantain AAB

Highland banana AAA

# Diversity

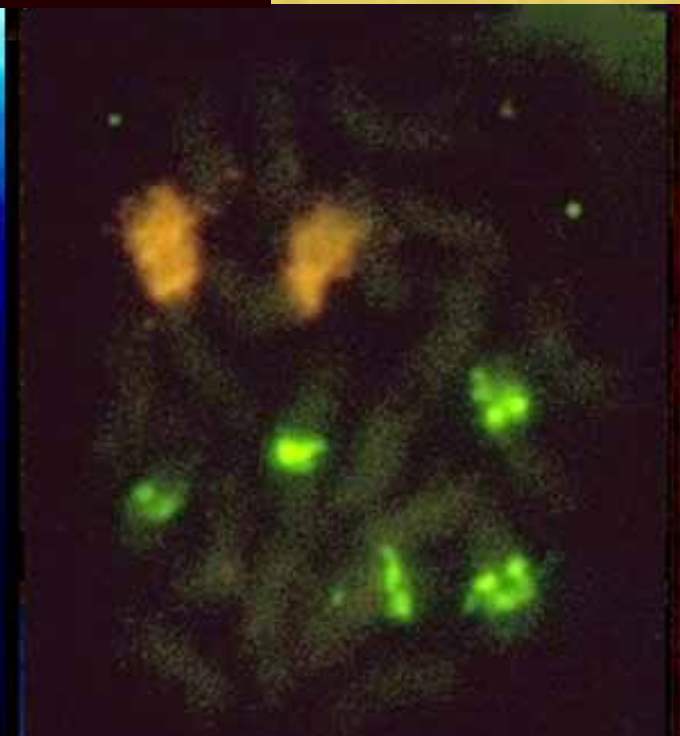


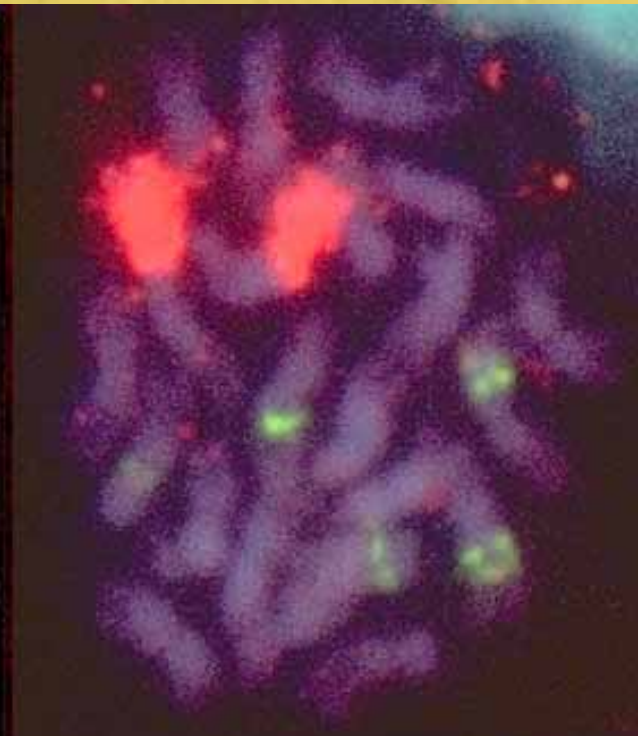
Dessert banana AAA

Cooking banana ABB

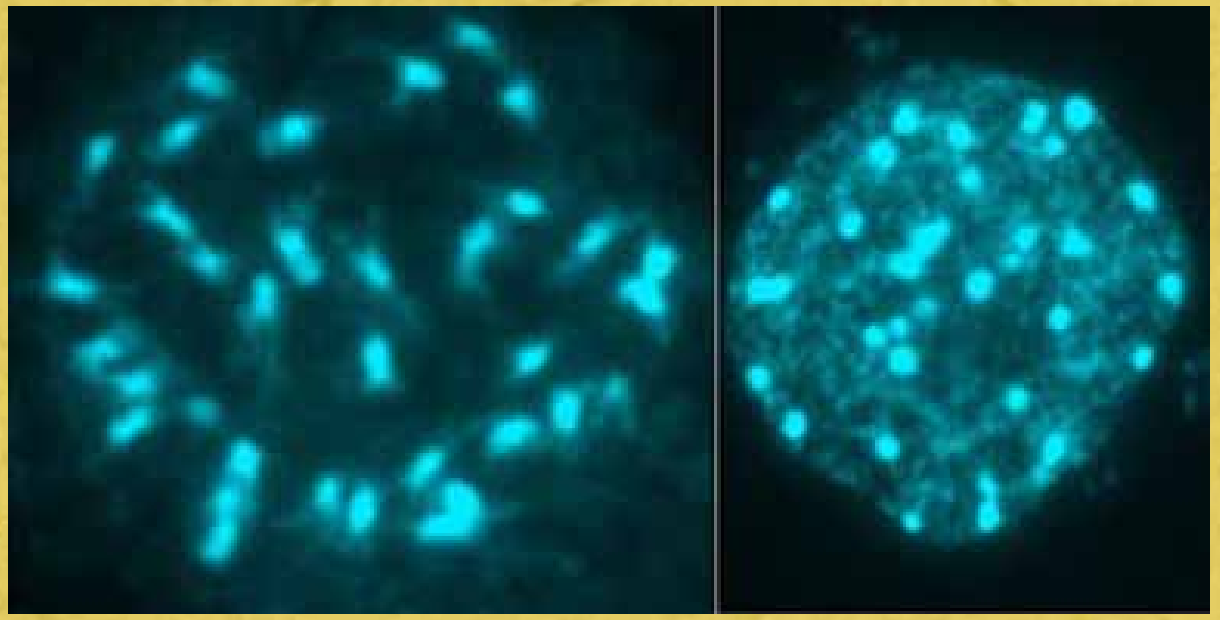
Michael Pilay
IITA

*Musa acuminata* ‘Calcutta 4’
AA genomes, 2n=2x=22
One genome and 11 chromosomes from mother
Other genome and 11 chromosomes from father





# The banana genome - DNA and Chromosomes



- **Haploid genome size:**
- **500 to 600 Mbp DNA**
  **(Rice: 440 Mbp; Human: 3200 Mbp; Wheat: 17000 Mbp)**

# Variety Cavendish

- 15% of banana production worldwide
- The vast majority of export banana to temperate countries
- Controllable ripening but very sensitive to conditions
- First collected in China in 1826 (Telfair), Sold to Duke of Devonshire, Chatsworth
- Distributed worldwide from 1836
- Became dominant variety in 1960s
- Has various variants: Williams, Dwarf C, Giant C, Grand Naine, Robusta, Poyo …


VARIABILITY IN BANANA

L to R:
Red - AAA
Palayam codan AAB (two bunch yellow, one green)
Peyan ABB (green cooking banana),
Njalipoovan AB (yellow)
Robusta AAA (green ripe)
Nendran AAB
Poovan AAB (one yellow bunch)
Red AAA
Peyan

Varkala, Kerala, India

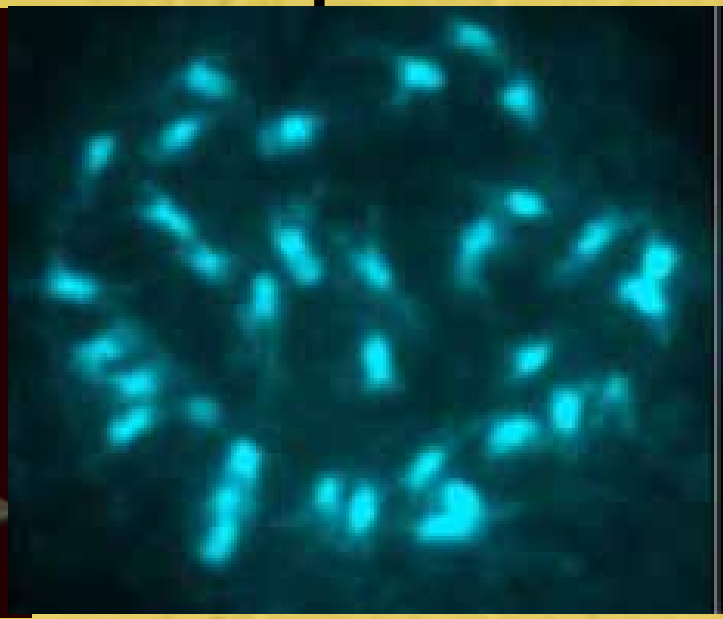
# Measuring diversity

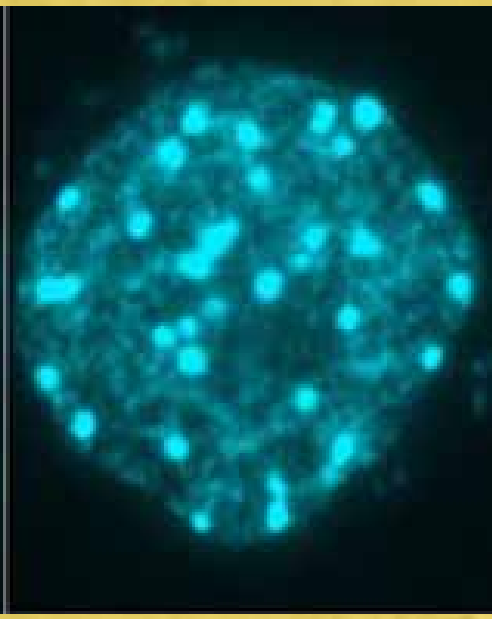
# Where does diversity come from?

- The DNA
- Single nucleotide changes
  - Cellulose synthase
- Deletions/insertions in genes
- Duplications
  - Modifies expression
  - Important as gives something for evolution to work on
- Regulatory elements

# What is a genome?

- In bananas and plantains, about 500 million base pairs of DNA





```
ta clone MuG9, genomic, 73268bp
aaatccaatcaatccagatcaatattgatcgg
gacgaagcagtcaaactgatcactaaaattca
gagtgctgatttcagaaacttaatcccttctg
caacttacactaattagtcttaaaactcatta
ataaatgtcatattacccttccaggtcataaa
atgctgaagctattggcattacacttagtctt
tttaacgatatgacaatcaataatgagatagg
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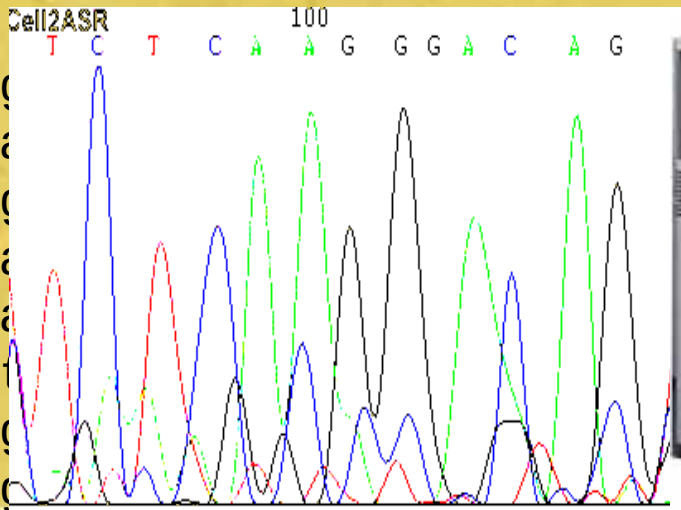
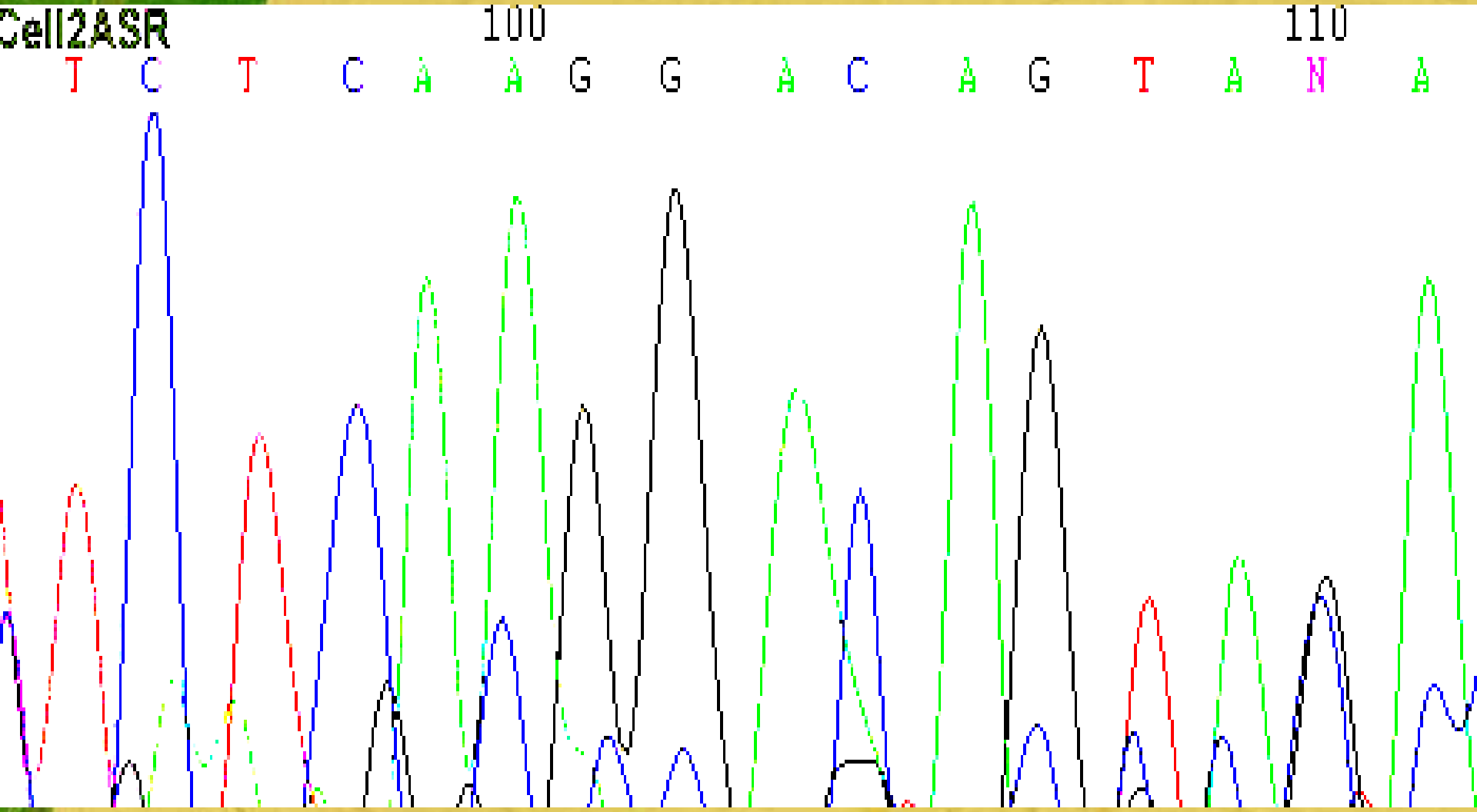
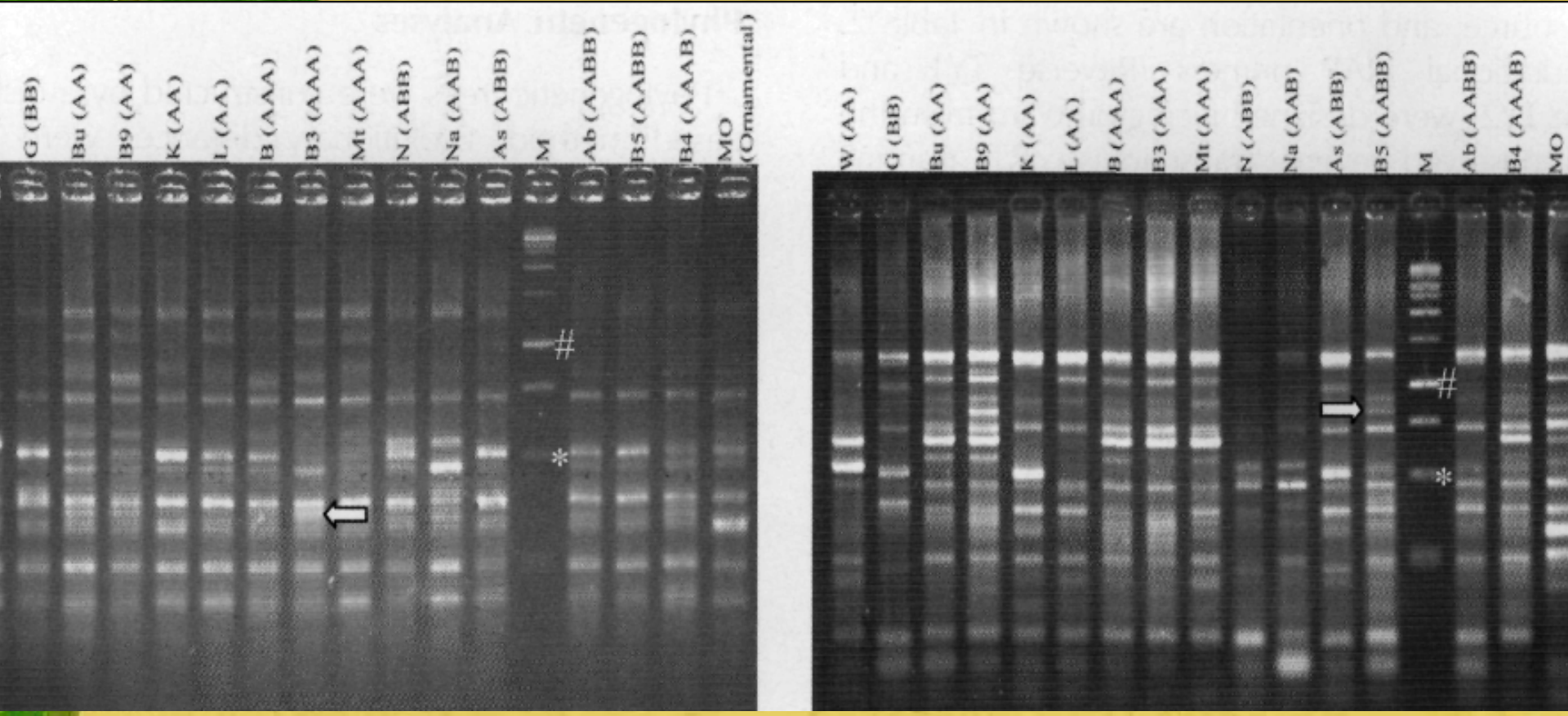


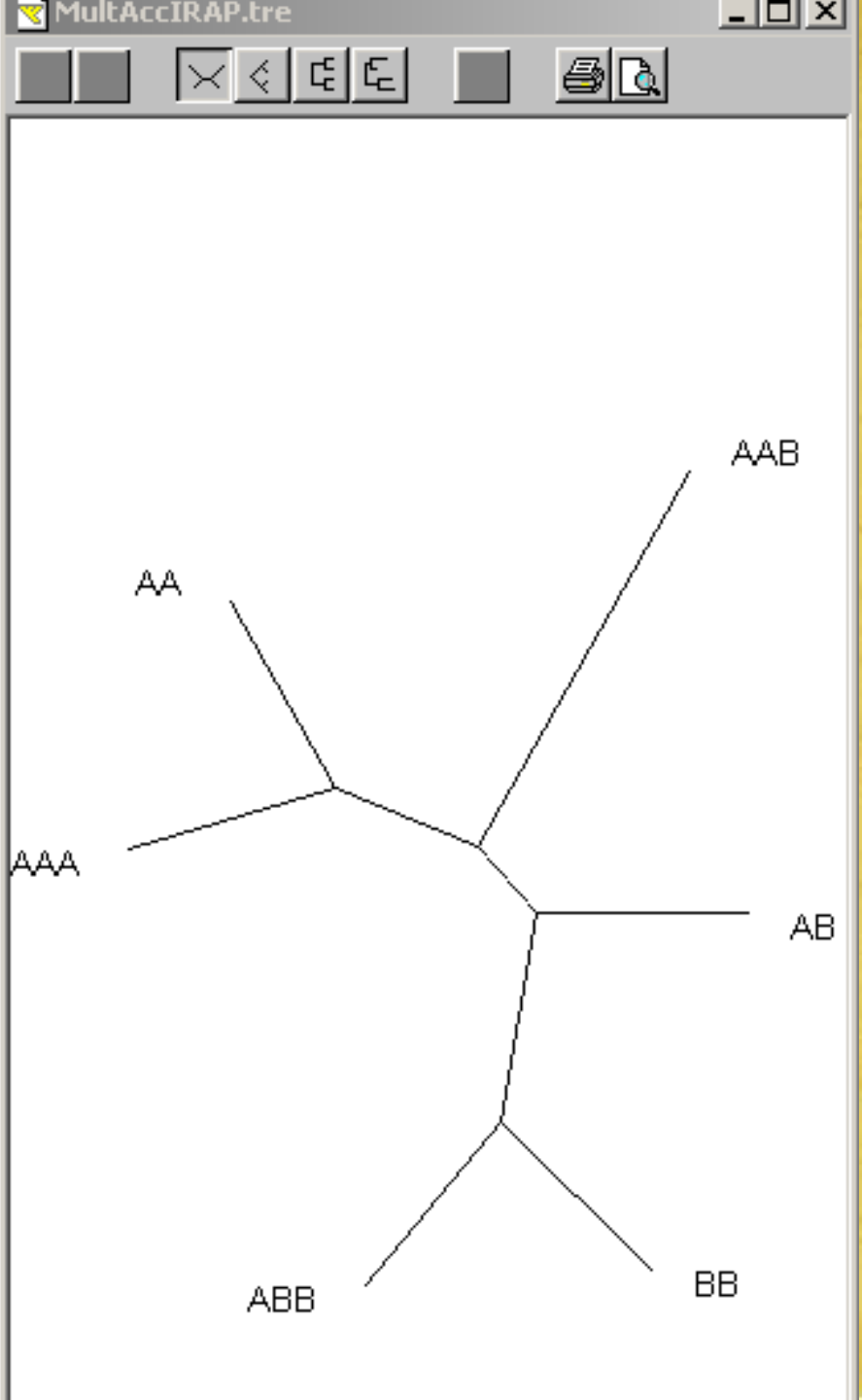

# Cellulose Synthase
# Single Nucleotide Polymorphism SNP



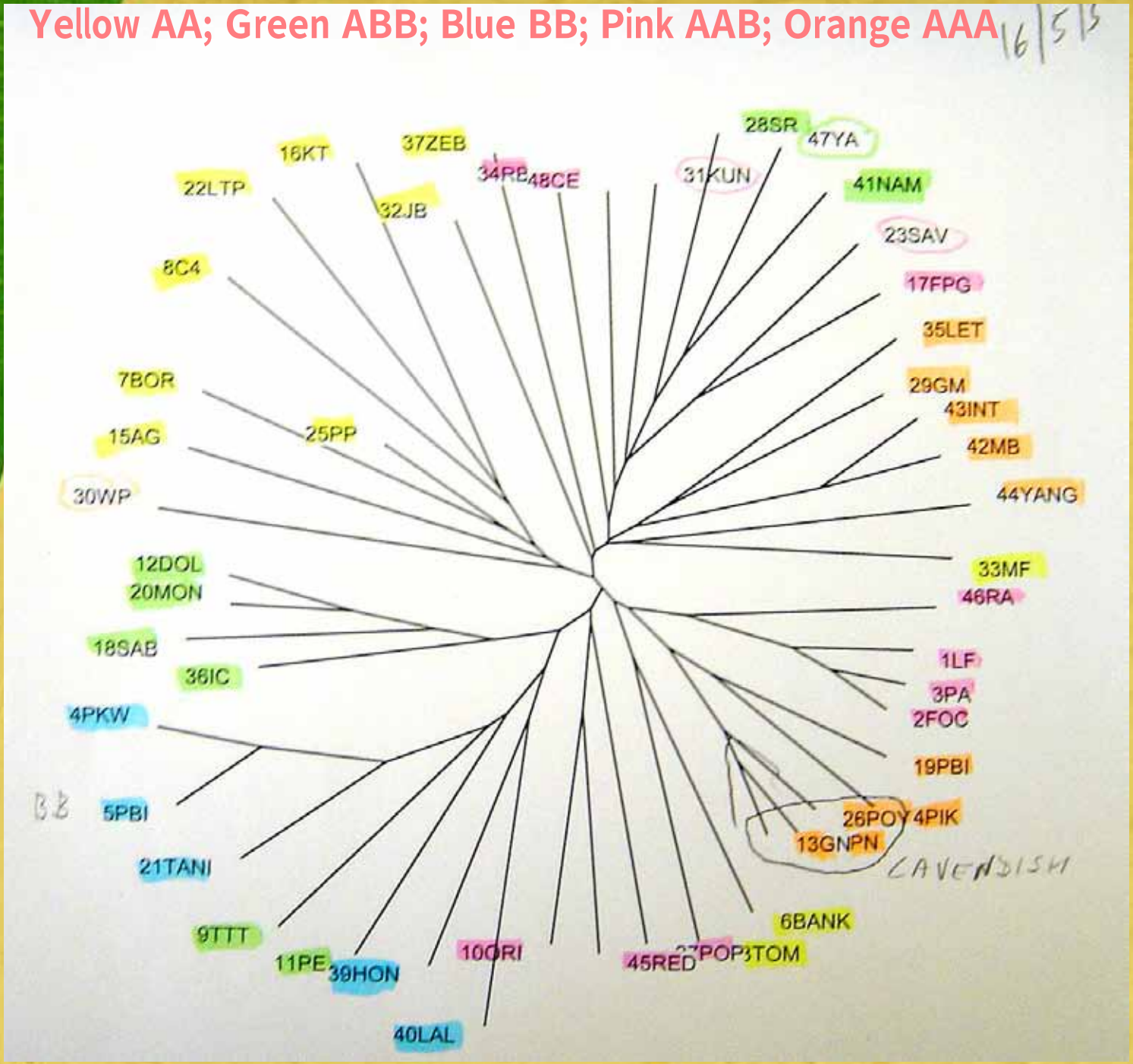
# IRAP diversity in Musa




Teo, Tan, Ho, Faridah, Othman, HH, Kalendar, Schulman 2005 *J Plant Biol*
Nair, Teo, Schwarzacher, HH 2006 Euphytica
Desai, Maha…, HH et al. in prep.


MultAccIRAP.tre
AAB
AA
AAA
AB
ABB
BB

- Yellow AA; Green ABB; Blue BB; Pink AAB; Orange AAA




AICRP(TF)
COLLECTION, CONSERVATION AND
EVALUATION OF BANANA GERMPLASM
No. OF ACCESSIONS - 256.
No. OF PLANTS/ACCESSION - 5.
SPACING - 2 x 2.5m.
DATE OF PLANTING - 23.10.2006.

GMGC Global Musa Genomics Consortium



Site map

pharmison

GMGC is an initiative of Bioversity International



# Genetic Diversity

A genebank holding more than 90% of the existing diversity of cultivated bananas and a representative sample of the wild species of Musa is maintained by Bioversity International at the International Musa genebank in Leuven, Belgium. The collection has been tested for bacteria and viruses and all varieties that tested negative are available for distribution.

There is a very good knowledge of the structure of the Musa species complex based on morphological descriptors as well as molecular markers for the chloroplastic, mitochondrial and nuclear genome. Studies have revealed a great diversity in Musa, providing a good model for the study of gene regulation.

**Ploidy and genome size and constitution**

- Analysis of nuclear genome size in *Musa* and *Ensete* (IEB)
- Evaluation of genome identity and constitution of Philippine Musa Cultivars (especially the Balbisiana group) through flow cytometry (USM)


BANANA
GERMPLASM

# The Genepool

- **Why do we need it?**

# Plant breeding

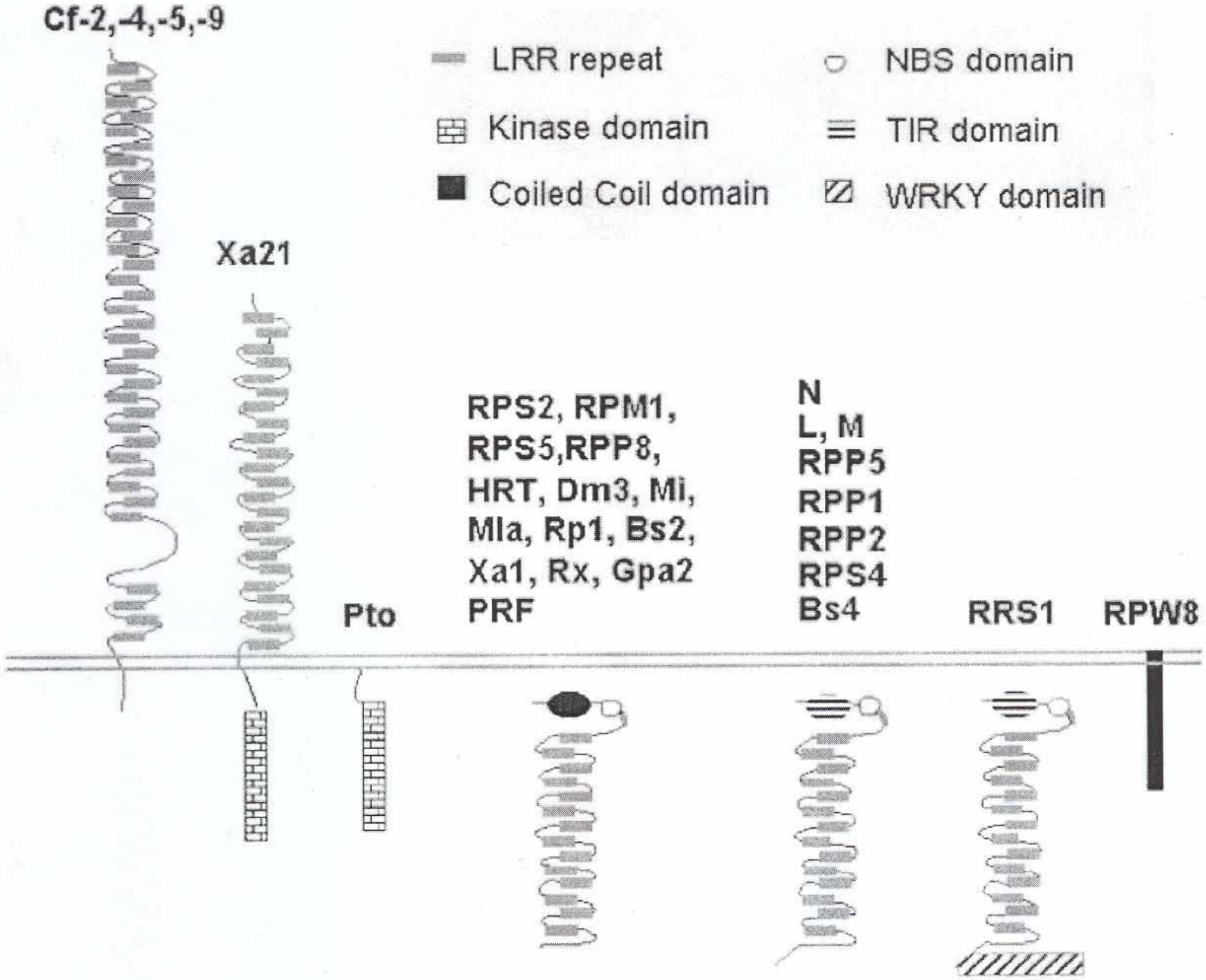
- Keeping up with changes
- Biotic stress
  - New disease races are continuously appearing and spreading
  - Fungi, viruses, bacteria
  - Insects, nematodes, weeds …
- Abiotic stresses
  - Drought/flooding/salt, cold …
- Socio-economic changes
  - More people to feed on less land
  - Urbanization of population

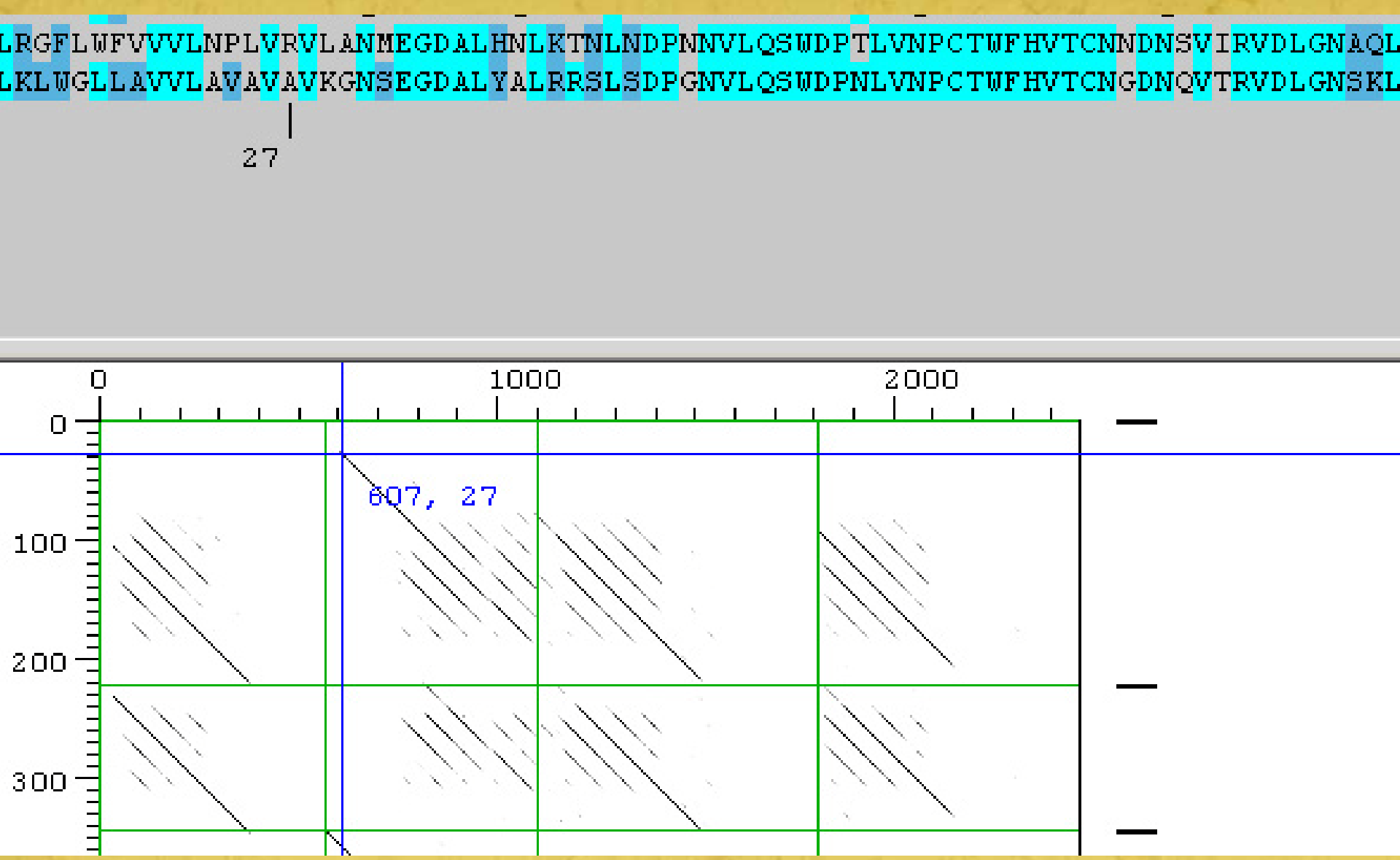

- **Gros Michel in Fusarium (Panama disease) trial in Malaysia**

# 4.4 Future – Pollution and land use

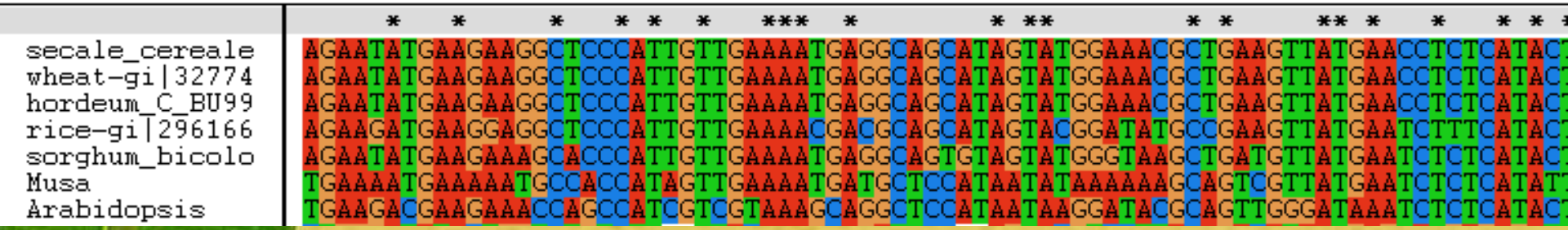
# Daily Telegraph 23 May 2006

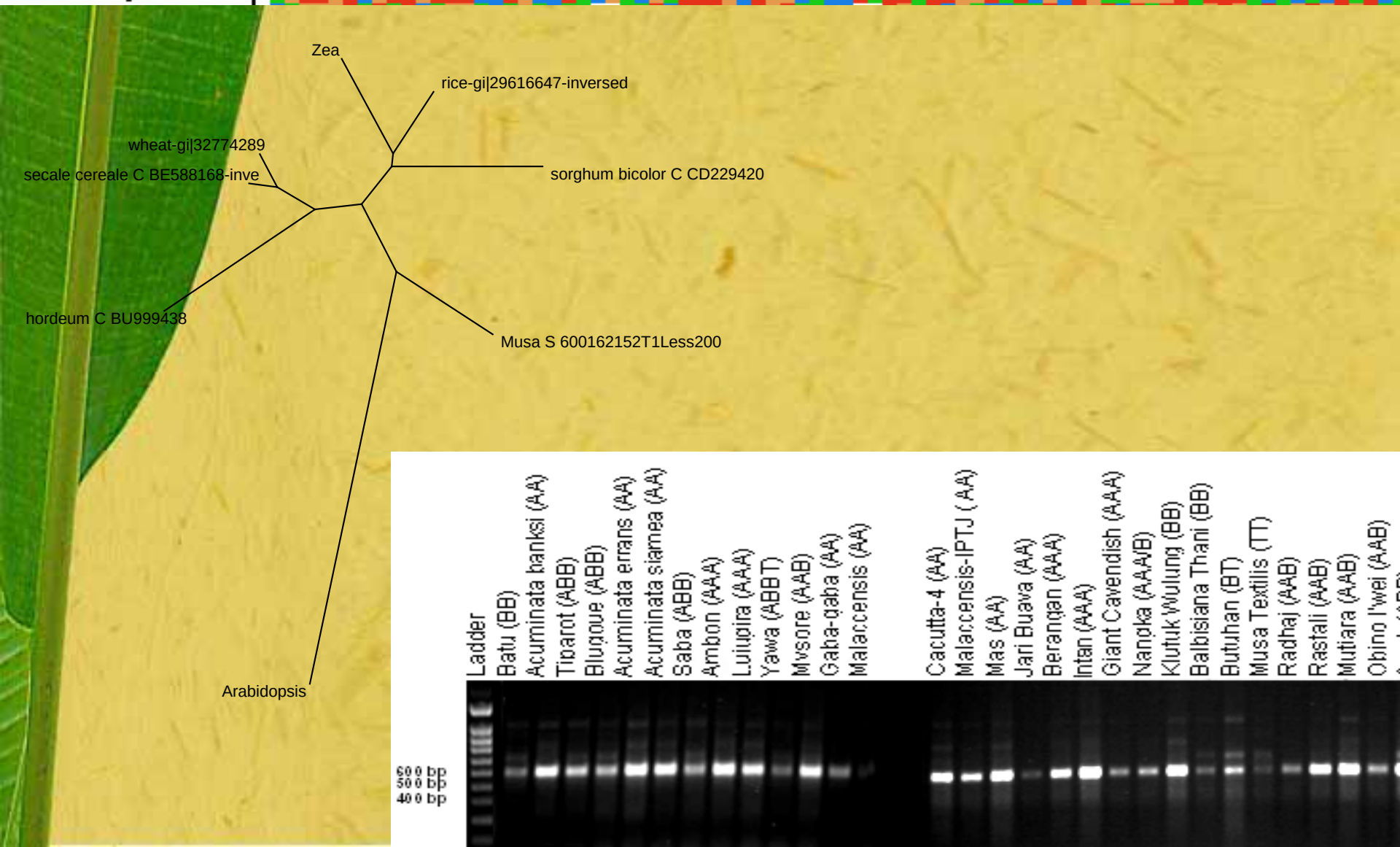
- **No 1 banana could face extinction**
  **By Roger Highfield, Science Editor**
- The most popular type of banana, the Cavendish, is under threat from disease. In the 1950s, Britons ate a different banana, the Gros Michel but it was wiped out by Panama disease.
- Now the Cavendish could follow suit as a new strain of the fungus to which it was supposed to be immune has begun to attack the plants. So far, the new, more aggressive variant of Panama disease - TR4 - has not reached the main exporting countries in Latin America or Africa but it is spreading widely through Cavendish plantations in Asia - Indonesia, Taiwan, southern provinces of China and Malaysia.
- In the humid conditions of traditional banana plantations in Central America, the black Sigatoka fungus which attacks leaves, also thrives and the plants must be protected by weekly sprays of fungicides. Although the Cavendish could disappear, experts are confident that a bunch of alternative bananas could fill the void. The caveat is that the taste and texture will be changed forever and there is likely to be a rise in price.


Cf-2,-4,-5,-9
LRR repeat
NBS domain
Kinase domain
TIR domain
Coiled Coil domain
WRKY domain
Xa21
RPS2, RPM1,
RPS5,RPP8,
HRT, Dm3, Mi,
Mla, Rp1, Bs2,
Xa1, Rx, Gpa2
PRF
N
L, M
RPP5
RPP1
RPP2
RPS4
Bs4
Pto
RRS1
RPW8

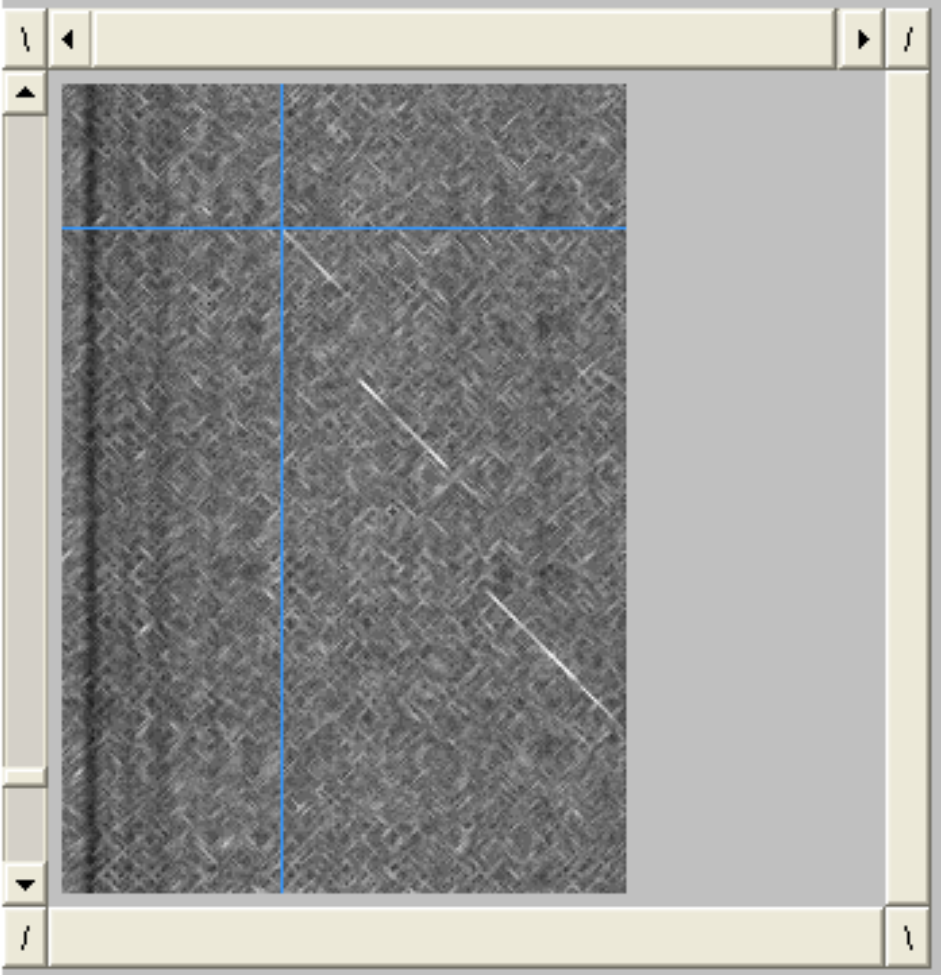



- **LRRs in Musa compared to reference Rice**

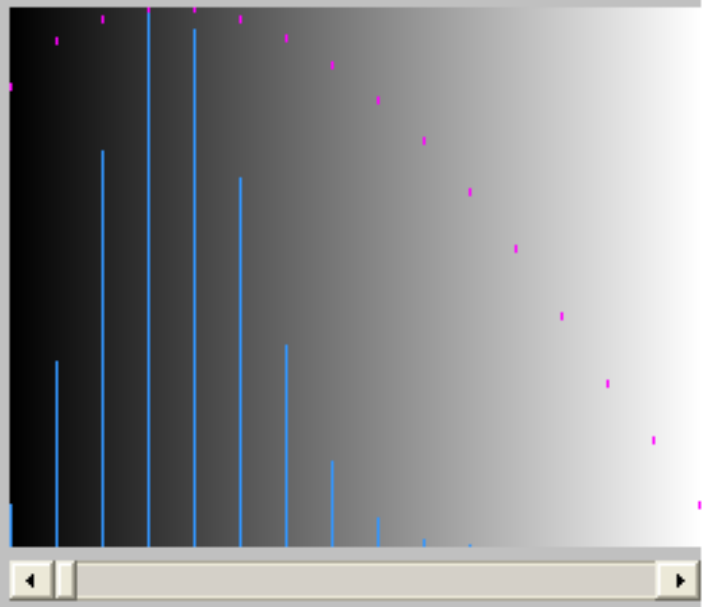

secale_cereale
wheat-gi|32774
hordeum_C_BU99
rice-gi|296166
sorghum_bicolo
Musa
Arabidopsis


Zea
rice-gi|29616647-inversed
wheat-gi|32774289
secale cereale C BE588168-inve
sorghum bicolor C CD229420
hordeum C BU999438
Musa S 600162152T1Less200
Arabidopsis


Ladder
Batu (BB)
Acuminata banksi (A,A)
Tiparot (ABB)
Bluqoue (ABB)
Acuminata errans (AA)
Acuminata siamea (A,A)
Saba (ABB)
Ambon (AAA)
Luiuqira (A,A,A)
Yawa (ABBT)
Mvsore (A,AB)
Gaba-qaba (AA)
Malaccensis (AA)
Cacutta-4 (AA)
Malaccensis-IPTJ ( A,A)
Mas (A,A)
Jari Buava (A,A)
Berangan (AAA)
Intan (AAA)
Giant Cavendish (A,A,A)
Nanqka (A,A,A/B)
Klutuk Wulung (BB)
Balbisiana Thani (BB)
Butuhan (BT)
Musa Textilis (TT)
Radhaj (AAB)
Rastali (AAB)
Mutiara (AAB)
Ohino I'wei (AAB)
600 bp
500 bp
400 bp



horizontal: musa
vertical: rice BAC
matrix: Identity
sliding window: 15
zoom: 1:3
score range: 0 to 15
gray scale: 0% - 100%



musa | 250

CTTCGACAGGCGTAGAGAGGCTCAGGTTCGACTTTTCTTTGAATCCAATTGTCCTTGGCCCAAACATGTCCATCTGTGTCCACCACATGCAAGC
GAATTTTAACTTTAGAATTCTCCAAAAGTGTTAAAATAAACTAACCAGTTTTGCTTGGACCATTCACATCCTTCGGTATCAATTACATGTAAGC

rice BAC | 109289
musa (revcomp'd) | 250

AGCTTGCATGTGGTGGACACAGATGGACATGTTTGGGCCAAGGACAATTGGATTCAAAGAAAAGTCGAACCTGAGCCTCTCTACGCCTGTCGAA
GAATTTTAACTTTAGAATTCTCCAAAAGTGTTAAAATAAACTAACCAGTTTTGCTTGGACCATTCACATCCTTCGGTATCAATTACATGTAAGC

rice BAC | 109289

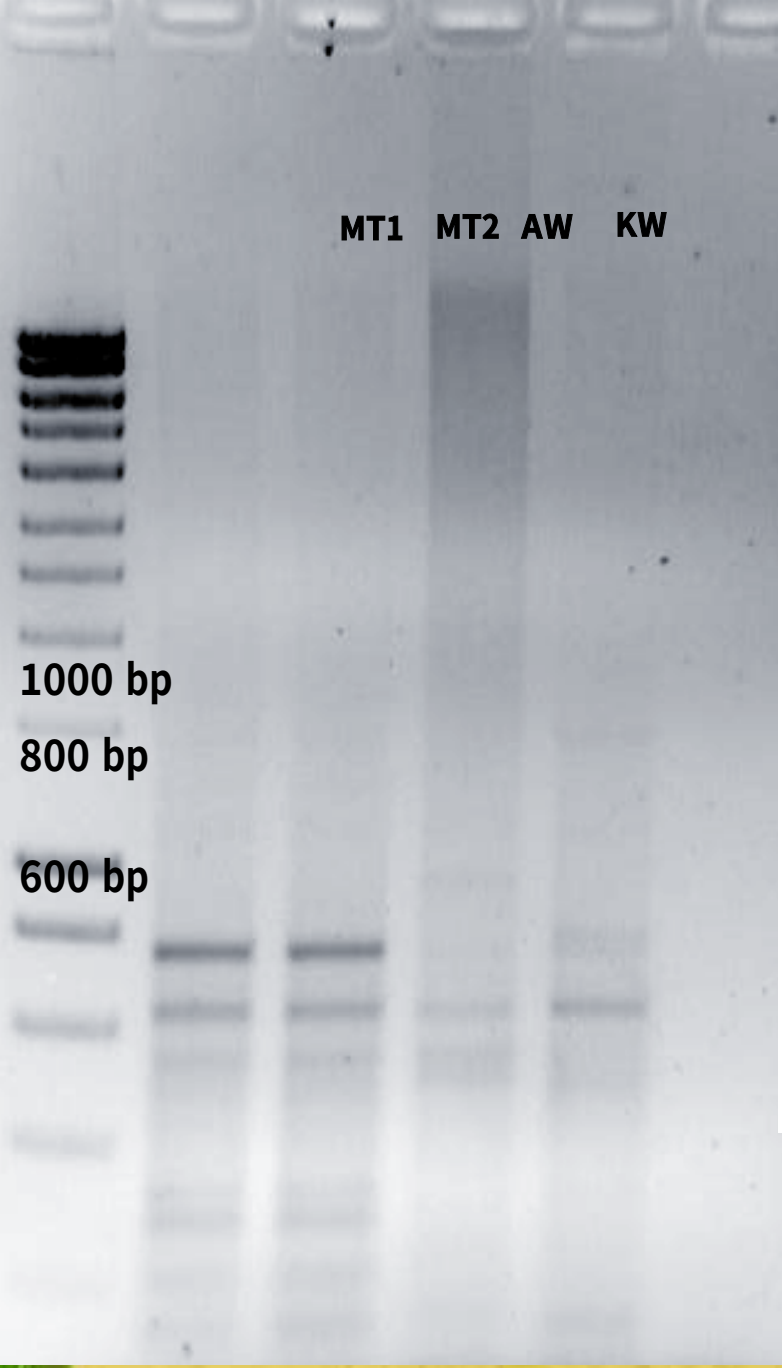



Table 9 Response of some banana cultivars to *Fusarium oxysporum* f. sp. *cubense* (FOC)

| Cultivars | Genome | Disease Reaction | |
|---|---|---|---|
| | | FOC Race 1 | FOC Race 4 |
| Pisang Mas | AA | T | S |
| Pisang Lemak Manis | AA | T | T |
| Pisang Jari Buaya | AA | R | R |
| Pisang Berangan | AAA | S | VS |
| Pisang Embun | AAA | VS | VS |
| Pisang Udang | AAA | S | S |
| Grand Naine | AAA | R | S |
| GCTCV215-1 | AAA | R | T (?) |
| Pisang Serendah | AAA | R | T |
| Pisang Rastali | AAB | VS | VS |
| Mutiara (selected P. Rastali) | AAB | T | T |
| Pisang Seribu | AAB | S | S |
| Pisang Raja | AAB | S | S |
| Pisang Relong | AAB | S | S |
| Pisang Nangka | AAB | S | S |
| Pisang Awak | ABB | T | S |
| Pisang Tanduk | ABB | S | S |
| Pisang Abu Keling | ABB | T | T |
| Pisang Abu Nipah | ABBB | S | S |
| Gold Finger | AAAB | R | T |

R, resistant; T, tolerant; S, susceptible; VS, very susceptible.

**Primers : MLRR1-F and MLRR2-R**

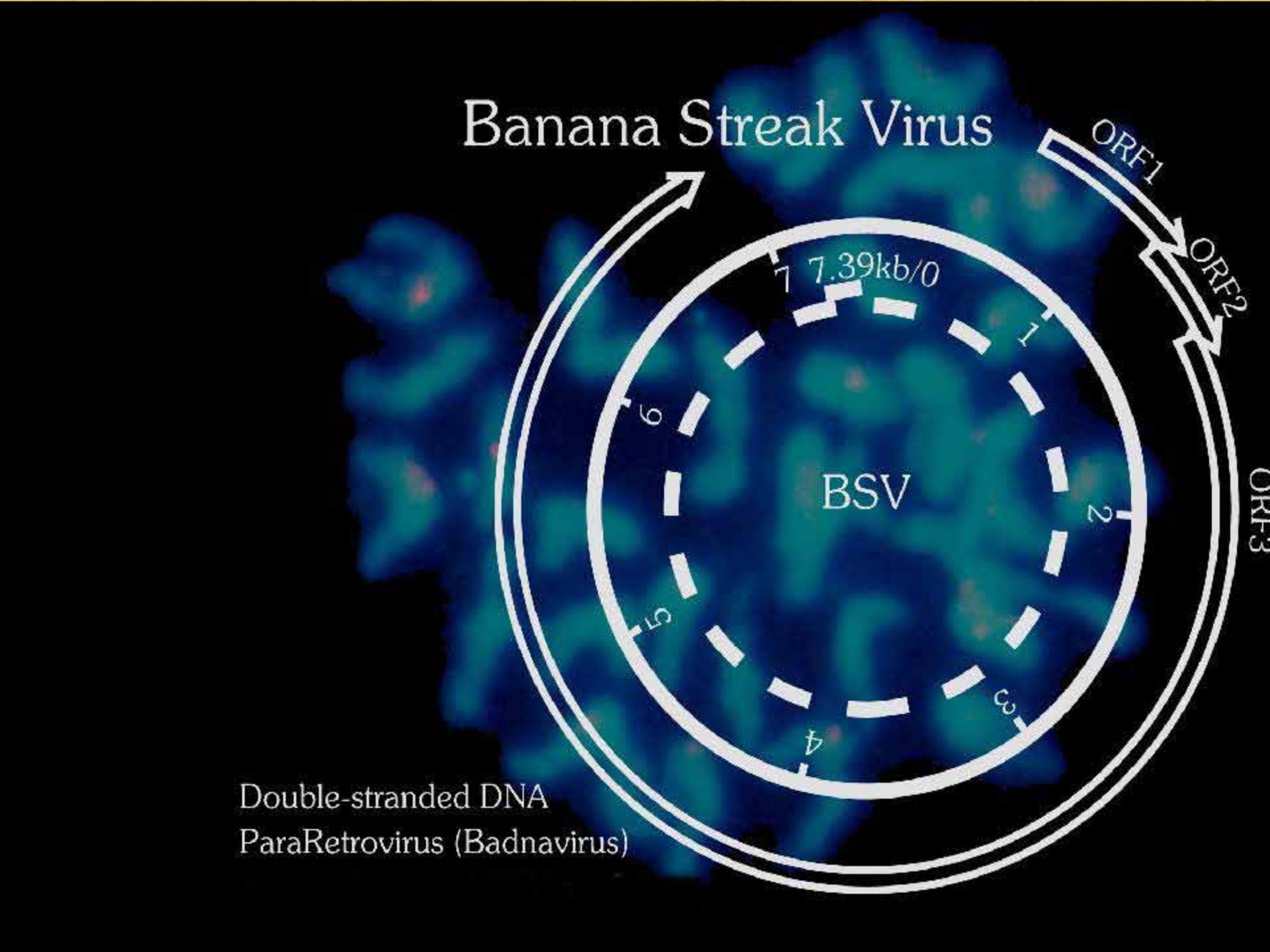
**MT1 and MT2 - Mutiara tolerance to FOC**
**AW - Pisang Awak**
**KW - Klutuk Wulung**

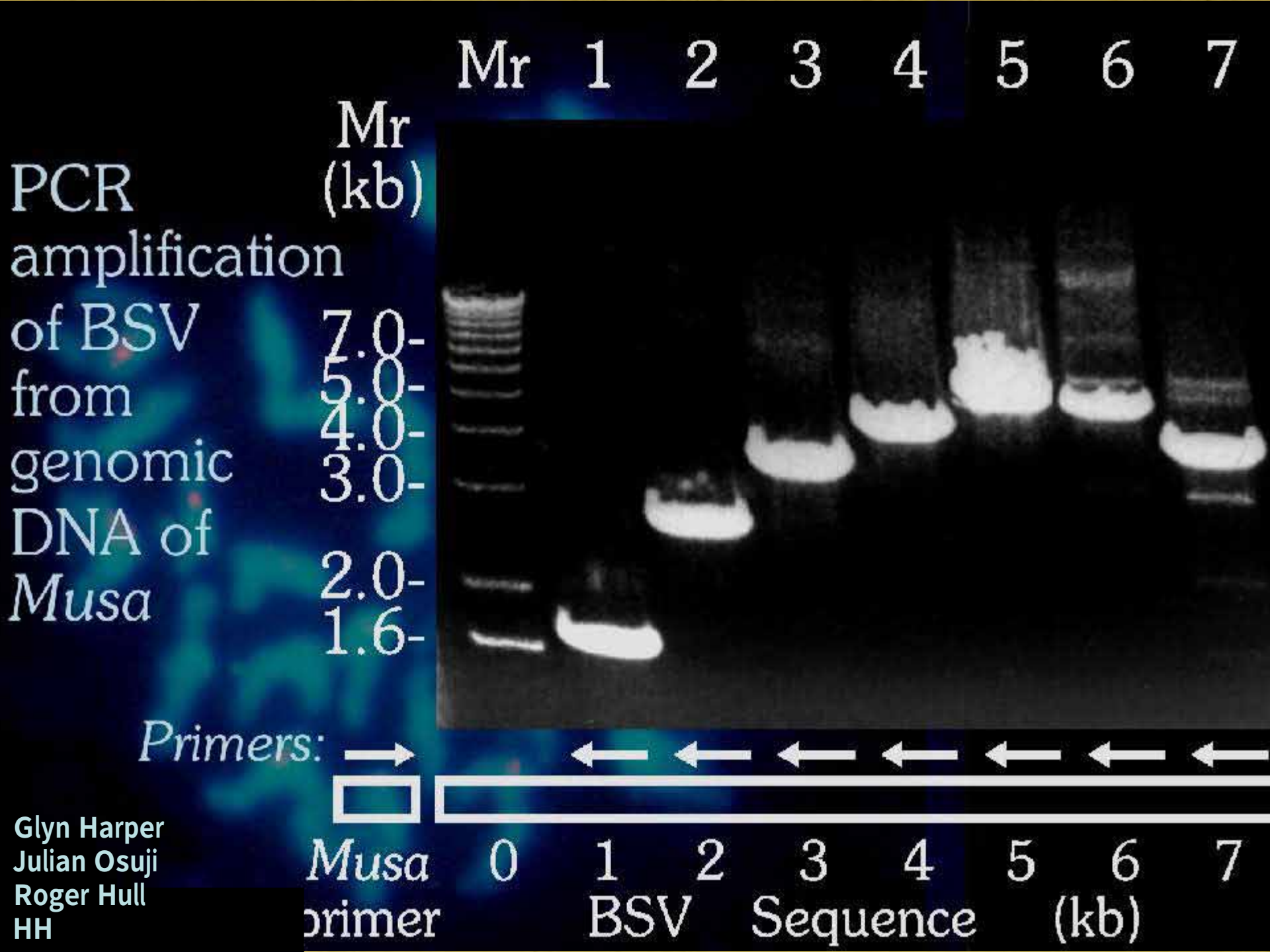
**Azhar Mohamad & HH 2007**

# Banana Streak ParaRetrovirus (BSV)

- Double stranded DNA is infective
- Insect vector
- Unexpected epidemiology
  - Appearance after cold or tissue culture

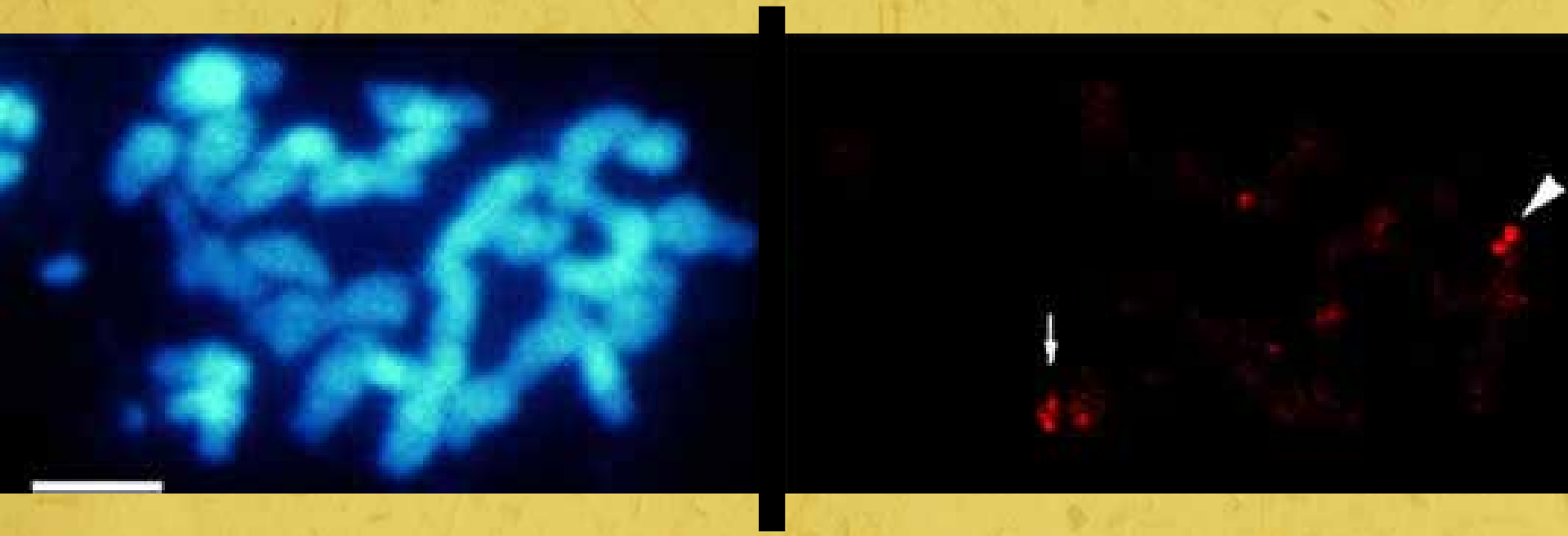
- Glyn Harper, Roger Hull, IITA,
- Ben Lockhart, Andrew Geering
- Trude Schwarzacher & HH Leicester


Banana Streak Virus
ORF1
ORF2
ORF3
7 7.39kb/0
1
2
3
4
5
6
BSV
Double-stranded DNA
ParaRetrovirus (Badnavirus)




Glyn Harper
Julian Osuji
Roger Hull
HH

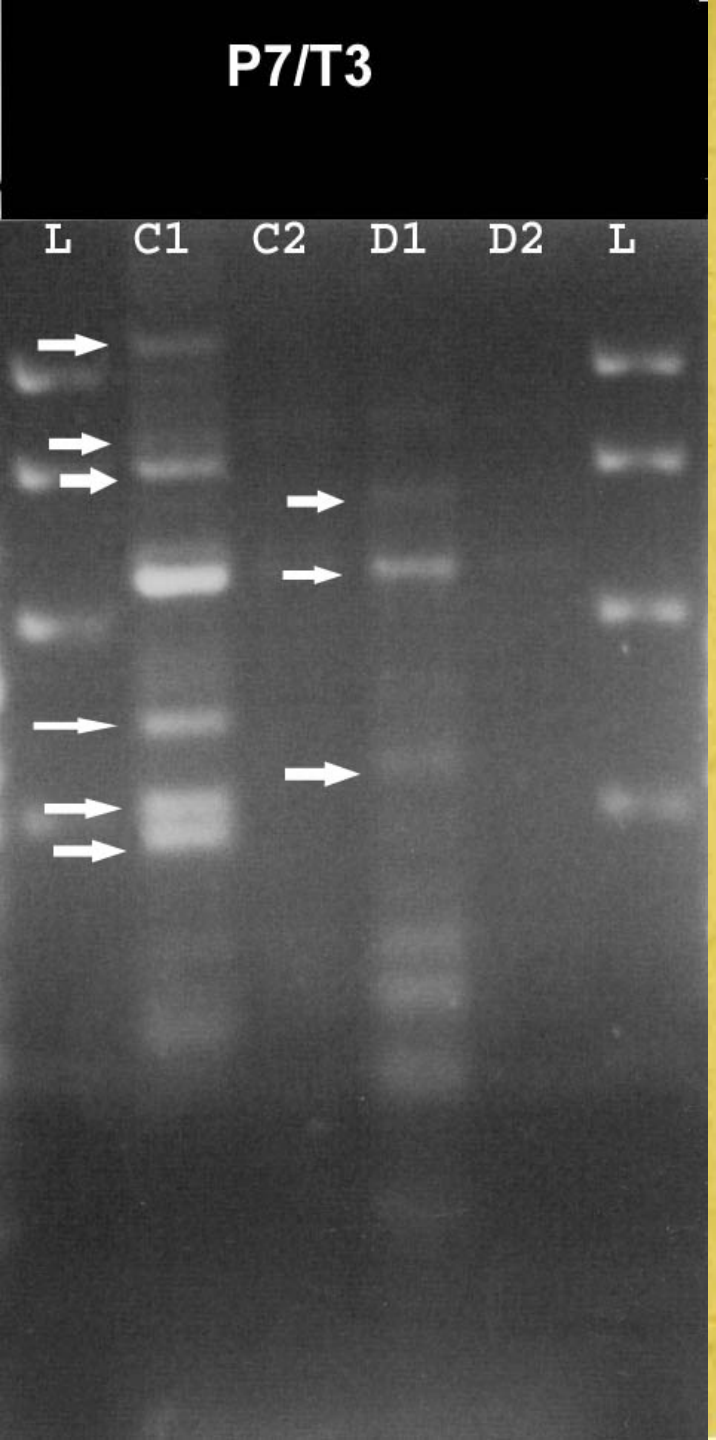
# Nuclear Copies of BSV in Banana



# Drought Responsive Genes

- Differential display of genes being expressed from droughted and watered *Musa* lines

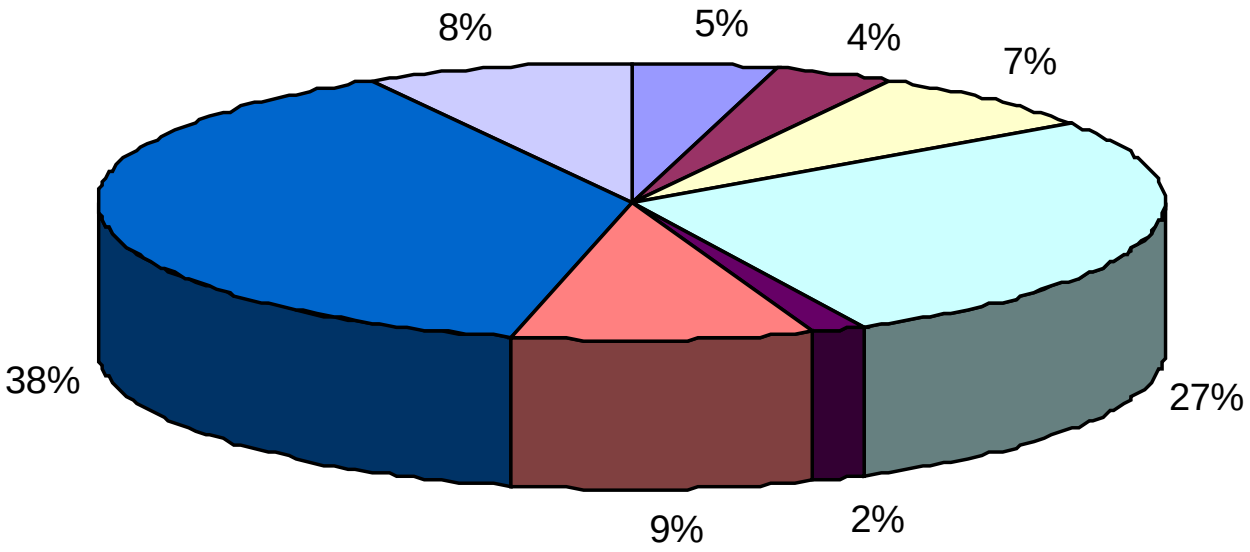
# Drought Responsive Genes




# Differential Display

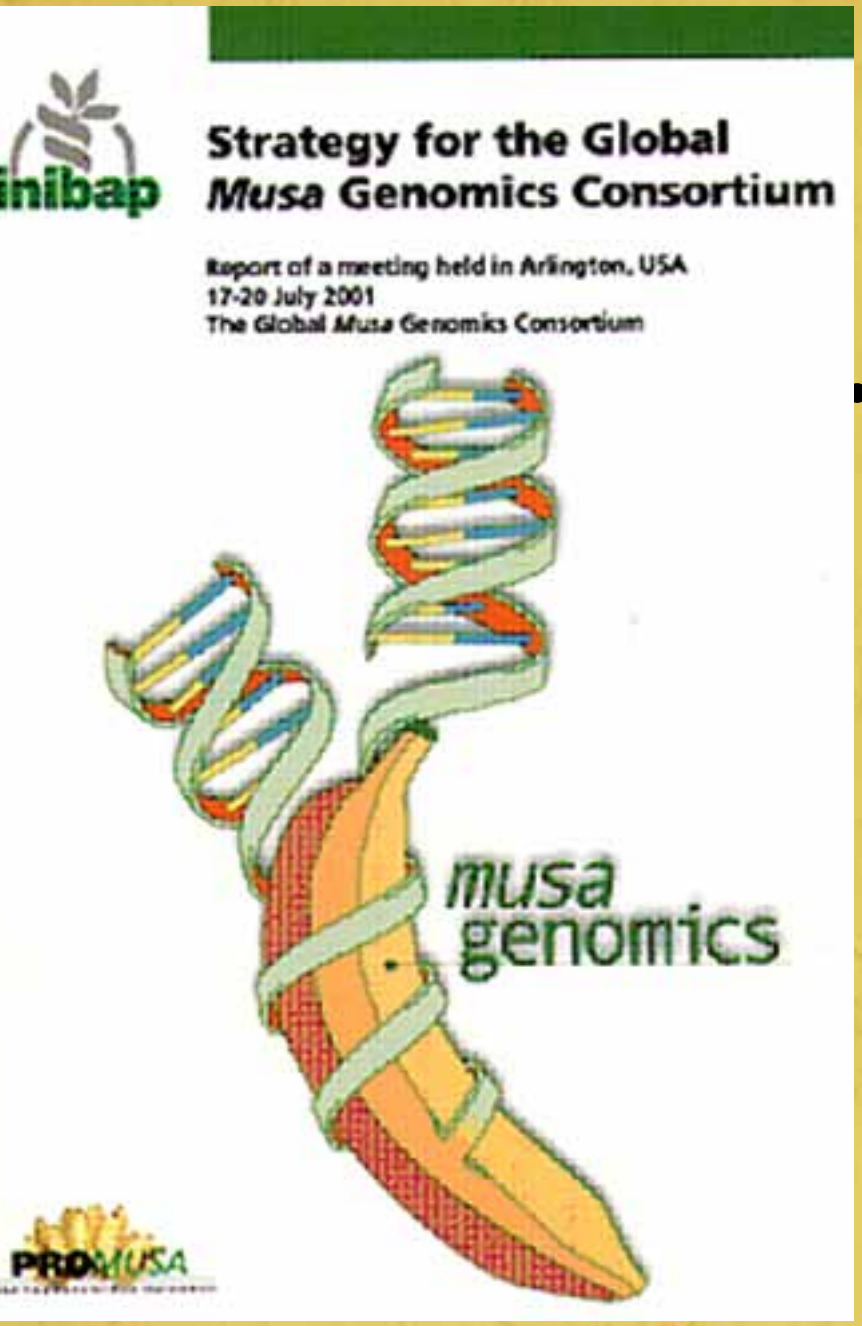
14 DD-PCR reactions using different arbitrary and Oligo dT primer combinations, a total of 22 differentially expressed bands (MDRG)

# Expression Analysis




- transcription factors
- cell division and growth
- protein synthesis
- novel genes
- other
- metabolism
- abiotic stress related
- cellular communication and signal transduction

**Preliminary data; Dhairyasheel Desai, HH *et al.* in prep 2007**




# The Global Musa Genomics Consortium

- To assure the sustainability of banana as a staple food crop by developing an integrated genetic and genomic understanding, allowing targeted breeding, transformation and more efficient use of Musa biodiversity

# Super-domestication: The future of banana crops

- Biotic stresses
- Abiotic stresses
- Socioeconomic factors

- … all mean current cultivars do not meet future needs

# Super-domestication: The future of banana crops

- The genepool has the diversity there which can meet these challenges
- Breeders need to get better and faster
- Banana, has extra challenges
  - Staple food
  - Major income source in many communities
  - Sterile plant

# How farmers make money

- Stop farming

- Sell something else
- Sell the same for more money
- Sell more quantity
- Reduce costs

# What have farmers done?

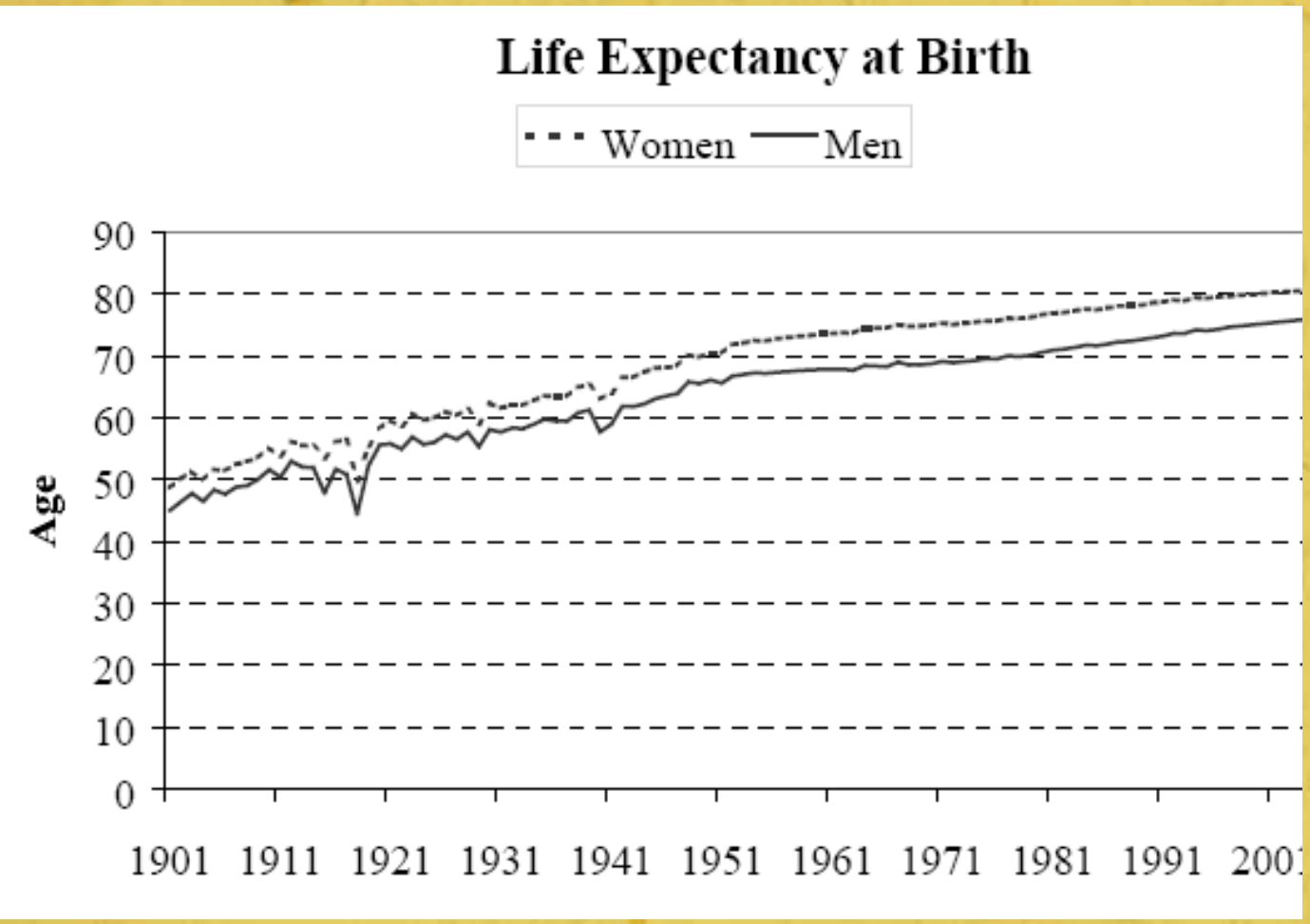
- Over the 100 years 1906-2006,

- 1.5% reduction in production costs per year
- similar across cereals, fruits, milk, meat, coal, iron
- With increased quality and security, supporting a longer-lived (3 months/year later that they were born in UK), larger population

- Remarkable total of 10-fold reduction in costs

# What have farmers done?

- **Increased quality and security, supporting a longer-lived, larger population**




**A Century of Change: Trends in UK statistics since 1900**
**UK House of Commons**

# How farmers make money

- (stop farming)

- Sell something else
- Sell the same for more money
- Sell more quantity for the same amount
- Reduce costs

# Are there many candidates?

- 250,000 plants
- 4,629 mammals
- 9,200 birds
- 10,000,000 insects

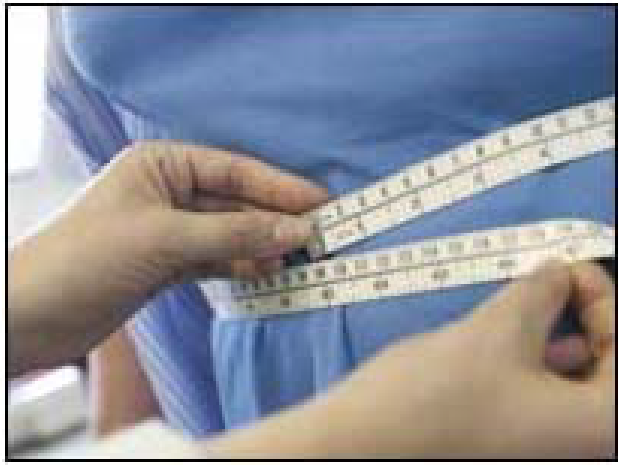
- But only 200 plants, 15 mammals, 5 birds and 2 insects are domesticated!

Last Updated: Tuesday, 15 August 2006, 09:06 GMT 10:06 UK

E-mail this to a friend  Printable version

# Overweight 'top world's hungry'

**There are now more overweight people across the world than hungry ones, according to experts.**



The number of people overweight has topped 1bn across the world

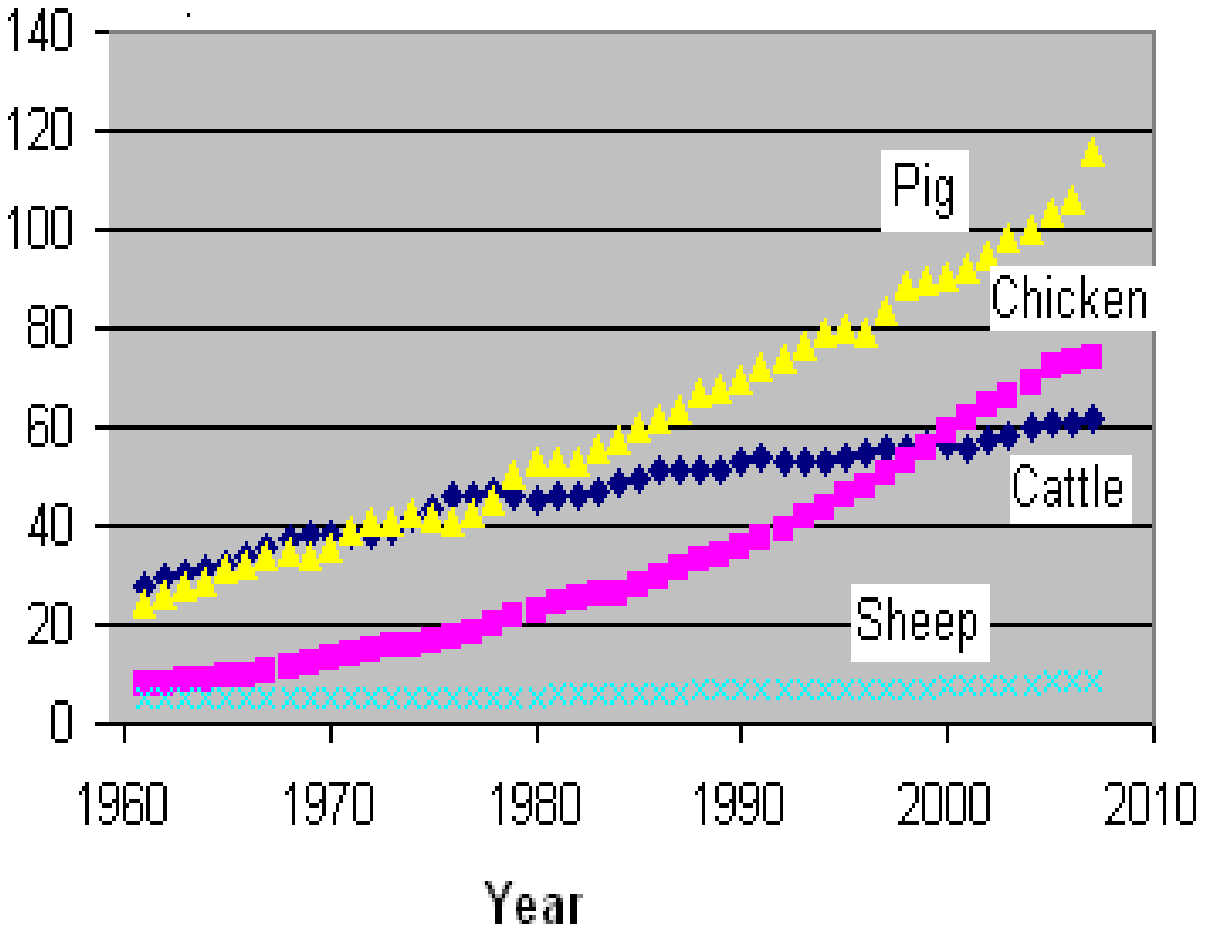
US professor Barry Popkin said all countries - both rich and poor - had failed to address the obesity boom.

He told the International Association of Agricultural Economists the number of overweight people had topped 1bn, compared with 800m undernourished.

Speaking at an Australian conference, he said changing diets and people doing less physical exercise was the cause.

Professor Popkin, from the University of North Carolina, said that the change had happened quickly as obesity was rapidly spreading, while hunger was slowly declining among the world's 6.5bn population.

# Meat Production



| | year (millions) |
|---|---|
| item | 2007 |
| People | 6,602 |
| Maize | 785 |
| Rice, paddy | 652 |
| Wheat | 607 |
| Potatoes | 322 |
| Sugar beet | 248 |
| Cassava | 228 |
| Soybeans | 216 |
| Oil palm fruit | 192 |
| Barley | 136 |
| Sweet potatoes | 126 |
| Tomatoes | 126 |
| Watermelons | 93 |
| Bananas | 81 |
| Seed cotton | 73 |
| Cabbages and other bra | 69 |
| Grapes | 66 |
| Sorghum | 65 |
| Onions, dry | 64 |
| Apples | 64 |
| Oranges | 64 |
| Coconuts | 55 |
| Yams | 52 |
| Rapeseed | 49 |
| Cucumbers and gherkin | 45 |
| Groundnuts, with shell | 35 |
| Plantains | 34 |
| Mangoes, mangosteens | 33 |
| Eggplants (aubergines) | 32 |
| Millet | 32 |

FAO Statistics 2007

All plant crops with >30M tons annual production

excluding sugar cane and ‘other vegetables’

People: WHO

Calories are pretty important - ‘let them eat micronutrients’ is not the message!

| | year (millions) | |
|---|---|---|
| item | 1961 | 2007 |
| People | 3,090 | 6,602 |
| Maize | 205 | 785 |
| Rice, paddy | 216 | 652 |
| Wheat | 222 | 607 |
| Potatoes | 271 | 322 |
| Sugar beet | 161 | 248 |
| Cassava | 71 | 228 |
| Soybeans | 27 | 216 |
| Oil palm fruit | 14 | 192 |
| Barley | 72 | 136 |
| Sweet potatoes | 98 | 126 |
| Tomatoes | 28 | 126 |
| Watermelons | 18 | 93 |
| Bananas | 21 | 81 |
| Seed cotton | 27 | 73 |
| Cabbages and other bra | 23 | 69 |
| Grapes | 43 | 66 |
| Sorghum | 41 | 65 |
| Onions, dry | 14 | 64 |
| Apples | 17 | 64 |
| Oranges | 16 | 64 |
| Coconuts | 24 | 55 |
| Yams | 8 | 52 |
| Rapeseed | 4 | 49 |
| Cucumbers and gherkin | 10 | 45 |
| Groundnuts, with shell | 14 | 35 |
| Plantains | 13 | 34 |
| Mangoes, mangosteens | 11 | 33 |
| Eggplants (aubergines) | 7 | 32 |
| Millet | 26 | 32 |

| | year (millions) | | |
|---|---|---|---|
| item | 1961 | 2007 | 2007/1961 |
| People | 3,090 | 6,602 | 2.1 |
| Maize | 205 | 785 | 3.8 |
| Rice, paddy | 216 | 652 | 3.0 |
| Wheat | 222 | 607 | 2.7 |
| Potatoes | 271 | 322 | 1.2 |
| Sugar beet | 161 | 248 | 1.5 |
| Cassava | 71 | 228 | 3.2 |
| Soybeans | 27 | 216 | 8.0 |
| Oil palm fruit | 14 | 192 | 13.7 |
| Barley | 72 | 136 | 1.9 |
| Sweet potatoes | 98 | 126 | 1.3 |
| Tomatoes | 28 | 126 | 4.5 |
| Watermelons | 18 | 93 | 5.2 |
| Bananas | 21 | 81 | 3.9 |
| Seed cotton | 27 | 73 | 2.7 |
| Cabbages and other bra | 23 | 69 | 3.0 |
| Grapes | 43 | 66 | 1.5 |
| Sorghum | 41 | 65 | 1.6 |
| Onions, dry | 14 | 64 | 4.6 |
| Apples | 17 | 64 | 3.8 |
| Oranges | 16 | 64 | 4.0 |
| Coconuts | 24 | 55 | 2.3 |
| Yams | 8 | 52 | 6.5 |
| Rapeseed | 4 | 49 | 12.3 |
| Cucumbers and gherkin | 10 | 45 | 4.5 |
| Groundnuts, with shell | 14 | 35 | 2.5 |
| Plantains | 13 | 34 | 2.6 |
| Mangoes, mangosteens | 11 | 33 | 3.0 |
| Eggplants (aubergines) | 7 | 32 | 4.6 |
| Millet | 26 | 32 | 1.2 |

| | year (millions) | | |
|---|---|---|---|
| item | 1961 | 2007 | 2007/1961 |
| Oil palm fruit | 14 | 192 | 13.7 |
| Rapeseed | 4 | 49 | 12.3 |
| Soybeans | 27 | 216 | 8.0 |
| Yams | 8 | 52 | 6.5 |
| Watermelons | 18 | 93 | 5.2 |
| Onions, dry | 14 | 64 | 4.6 |
| Eggplants (aubergines) | 7 | 32 | 4.6 |
| Tomatoes | 28 | 126 | 4.5 |
| Cucumbers and gherkin | 10 | 45 | 4.5 |
| Oranges | 16 | 64 | 4.0 |
| Bananas | 21 | 81 | 3.9 |
| Maize | 205 | 785 | 3.8 |
| Apples | 17 | 64 | 3.8 |
| Cassava | 71 | 228 | 3.2 |
| Rice, paddy | 216 | 652 | 3.0 |
| Cabbages and other bra | 23 | 69 | 3.0 |
| Mangoes, mangosteens | 11 | 33 | 3.0 |
| Wheat | 222 | 607 | 2.7 |
| Seed cotton | 27 | 73 | 2.7 |
| Plantains | 13 | 34 | 2.6 |
| Groundnuts, with shell | 14 | 35 | 2.5 |
| Coconuts | 24 | 55 | 2.3 |
| People | 3,090 | 6,602 | 2.1 |
| Barley | 72 | 136 | 1.9 |
| Sorghum | 41 | 65 | 1.6 |
| Sugar beet | 161 | 248 | 1.5 |
| Grapes | 43 | 66 | 1.5 |
| Sweet potatoes | 98 | 126 | 1.3 |
| Millet | 26 | 32 | 1.2 |
| Potatoes | 271 | 322 | 1.2 |

- What are bananas?
- What is in banana DNA?
- What is the future for banana?
- What is the future for diet and farmers?

L to R:
Red - AAA
Palayam codan AAB (two bunch yellow, one green)
Peyan ABB (green cooking banana),
Njalipoovan AB (yellow)
Robusta AAA (green ripe)
Nendran AAB
Poovan AAB (one yellow bunch)
Red AAA
Peyan

Varkala, Kerala, India, 2007

# United Nations Millennium Development Goals

- **Goal 1 - Eradicate extreme poverty and hunger**
- **Goal 2 – Achieve universal primary education**
- **Goal 3 - Promote gender equity and empower women**
- **Goal 4 - Reduce child mortality**
- **Goal 5 - Improve maternal health**
- **Goal 6- Combat HIV/AIDS, malaria and other diseases**
- **Goal 7 - Ensure environmental sustainability**
- **Goal 8 - Develop a global partnership for development**

**Convention on Biodiversity** ("Rio Convention"): inventory the worlds diversity

# The Banana

**Pat Heslop-Harrison**

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