BREEDING POTATOES NOWADAYS: an overview of the current situation

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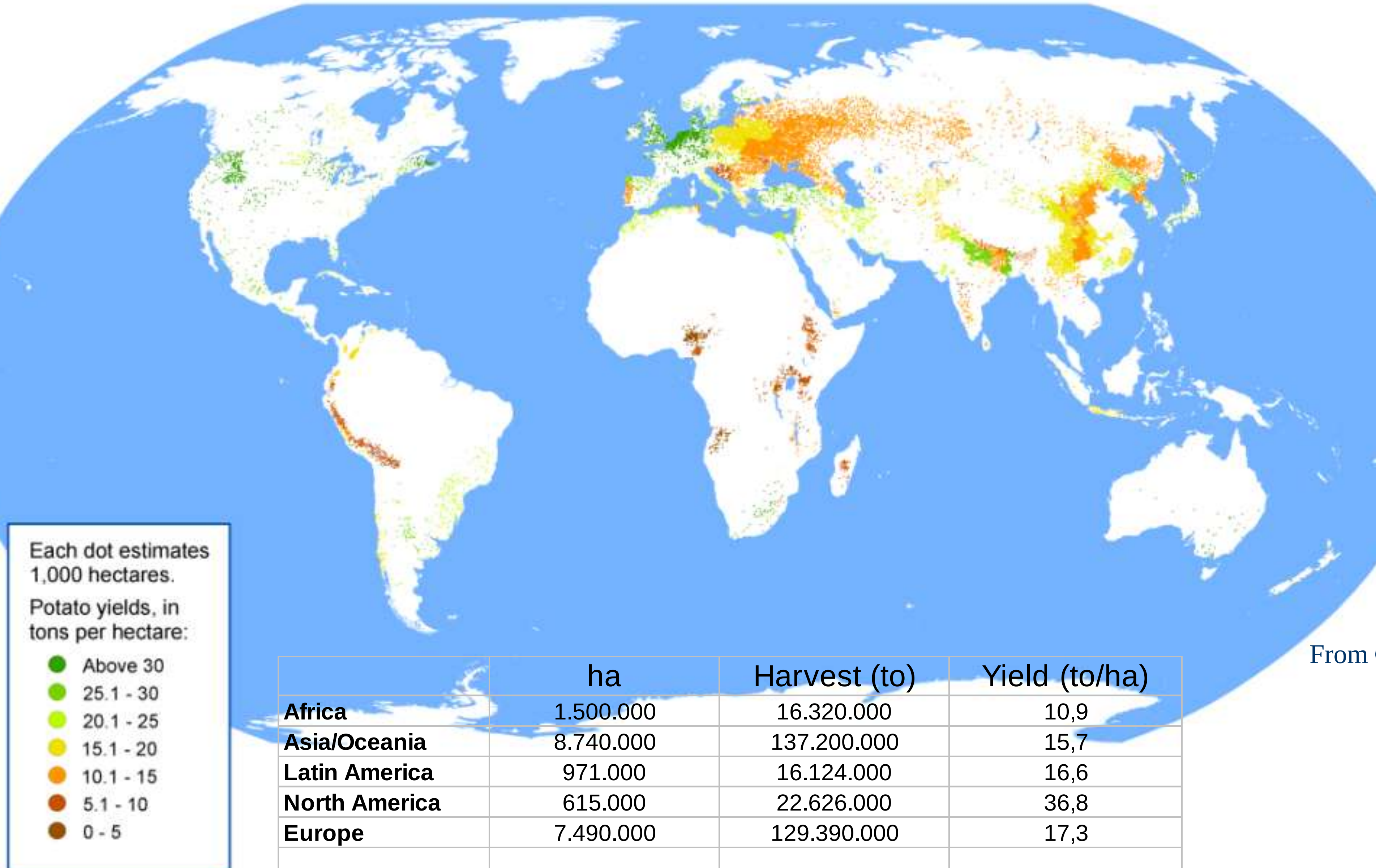
Potato Production

Areas of Cultivation and Average Yields

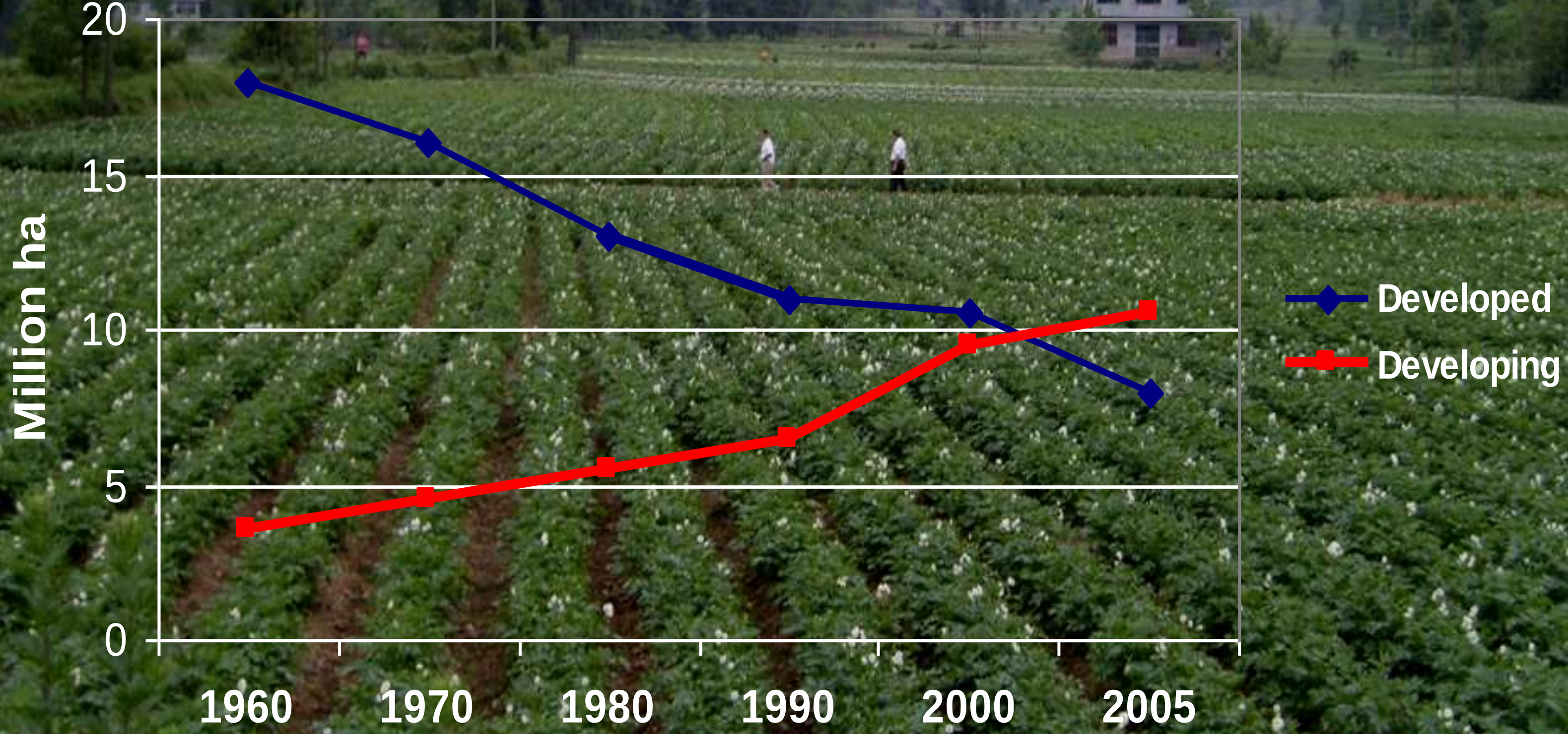


	ha	Harvest (to)	Yield (to/ha)
Africa	1.500.000	16.320.000	10,9
Asia/Oceania	8.740.000	137.200.000	15,7
Latin America	971.000	16.124.000	16,6
North America	615.000	22.626.000	36,8
Europe	7.490.000	129.390.000	17,3
	19.316.000	**321.660.000**	**16,7**

From C

FAOSTAT 2007

Potato area evolution in developed and developing countries



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BREEDING OBJECTIVES

Global objective:

- ✓ produce and market new varieties better suited than the old ones under the conditions in which they are used.

More specific but still general:

- ✓ better yield
- ✓ better quality use
- ✓ better resistance against diseases and pests
- ✓ less sensitive to the environment
- ✓ good nutritional characteristics

BREEDING OBJECTIVES

Adapted to the environment and markets constraints :

✓ **robust varieties in less developed countries**:

- late blight resistance
- viruses resistance
- storage diseases resistance
- better agri-chemical use efficiency

✓ **well adapted on the markets requirements in developed countries**:

- fresh market:
  - tuber visual aspect (shape, eyes depth, skin colour, flesh colour…),
  - cooking behavior
- processing market:
  - tuber chemical composition (dry matter, reducing sugars,…)
- both: antioxydants, potassium, Vitamin C, glycemic index,…

BREEDING OBJECTIVES

Regional aspects :

- ✓ **warmer and drier regions**:
  - tolerance to heat and drought stresses
- ✓ **cooler and more wet regions**:
  - tolerance to late blight
- ✓ **Africa:**
  - tolerance to tuber moth,
  - Brown rot disease (Central Africa)
- ✓ **Regions of intensive cropping (i.e West Europe):**
  - resistance to pectynolitic bacteria (Dickeya sp.)
  - nematode resistance
- ✓ **Regions with two or more cropping seasons (Africa, Asia):**
  - short dormancy period

BREEDING OBJECTIVES: conclusions

Bacterial diseases

Heat, drought

Shape

Viruses

Skin colour

Tuber moth

Eyes Depth

Nematodes

Dry matter

Late blight

Reducing sugars

…etc…

Huge need for genetic ressources

POTATO BREEDING: bottelnecks

Narrow genetic base.

✓ european cultivated *Solanum tuberosum*

✓ originated from few specimens introduced in Europe in the 16th century, then severe inbreeding by self pollination leading to the long days adapted european potato

✓ broadening of the genetic base in the begining of 20th century: introgression of new alleles from wild species

Multiple ploidy levels in the tuber-bearing Solanum species:

✓ from diploids (2n=2x=24) to hexaploids (2n=6x=72)

✓ incompatibility barriers between different ploidy levels

POTATO BREEDING: bottelnecks

Tetraploidy level of the european cultivated potato.

- ✓ 2n=4X=48 (four pairs of 12 chromosomes)
- ✓ four alleles possibly different for one locus
- ✓ high heterozygosity level leading, by crossing two tetra-allelic parents, to a lot of genotypes in the hybrid progeny
- ✓ Quality traits are usually controlled by polygenes
- ✓ Genotype x environment interaction

⇒ **With traditional breeding, selecting a desirable genotype is a time-consuming process**

POTATO BREEDING: technologies to overcome the traditional breeding bottlenecks

Reduction of the ploidy level.

✓ **Reduction of the tetraploid level to the diploid one allows:**

- to cross the cultivated potato more easily with the wild species (most of them are diploids),
- to manage more easily the heterozygosity (2 allelic forms in place of 4)

✓ **Techniques: production of dihaploids from tetraploids**:

- using anther or pollen culture
- using « diploids inducers » like some *Solanum phureja*

✓ **Dihaploids x Diploids, then selected progenies are redoubled by chemical treatment = more chance to produce genotypes with a higher level of homozygosity.**

⇒ **Introducing new genes and increasing the gene pool of the cultivated tetraploid potato is easier but still time consuming**

POTATO BREEDING: technologies to overcome the traditional breeding bottelnecks

Biotechnologies development last 2 decades.

✓ ***In vitro* potato micropropagation**:

- Safe in laboratory maintenance and fast multiplication of the selected clones,
- Opened the ways for:
  - somaclonal variation techniques
  - protoplast fusion
  - ploidy reduction by anther/microspore culture
  - genetic modification by artificial insertion of particular genes into the potato genome

POTATO BREEDING: technologies to overcome the traditional breeding bottelnecks

Biotechnologies development last 2 decades

✓ **Molecular markers assisted selection (MAS)**:

- fragments of DNA sequence associated with a specific part of the genome, i.e a part coding for qualitative or/and quantitative trait
- early selection of individuals with superior alleles using these markers reduces considerably the breeder’s work: avoids resistance tests, field assays,…
- numerous quantitative and qualitative traits already mapped on the potato genome: late blight, root cyst nematode, viruses, wart, plant maturity, tuber starch content,…

= « precision breeding »

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POTATO BREEDING: technologies to overcome the traditional breeding bottelnecks

Biotechnologies development last 2 decades

✓ **Genes cloning and insertion: artificial genetic modifications**

- Once sequences of genes of interest known
- Cloning them
- introducing them in the genome using « Agrobacterium tumefaciens » as insertion vector
- Many examples:
  - The « Durable resistance to Phytophthora » dutch program (DuRPh)

POTATO BREEDING: technologies to overcome the traditional breeding bottlenecks

Biotechnologies development last 2 decades

✓ **Genes cloning and insertion: artificial genetic modifications**

- The « Durable resistance to *Phytophthora* » dutch program (DuRPh):
  - using only genes of interest from the crop itself and/or from crossable species: cys-genes and not trans-genes
  - identification of usefull R genes in wild species, isolation, and cloning
  - insertion in well known potato cultivars
  - pyramiding technique: several genes are inserted together in the genome (less chance to select resistant *Phytophthora* isolates)
  - dynamic resistance management: various combinations of R genes inserted in the same known varieties

POTATO BREEDING: technologies to overcome the traditional breeding bottelnecks

Biotechnologies development last 2 decades

✓ **Regulation of target genes by over expression or silencing**

- Examples:
  - the BASF potato *Amflora* which is the known variety *Prevalent* in which the gene coding for **amylose** production is silenced: the production of the desired **amylopectine** is then enhanced
  - over expression of the genes StSN1 and StSN2 producing antimicrobial peptides for the control of bacterial diseases.

POTATO BREEDING: technologies to overcome the traditional breeding bottelnecks

Biotechnologies development last 2 decades

✓ **Potato genome sequencing achieved in 2009/2010**

- Potato Genome Sequencing Consortium (PGSC)
- Following step = the understanding of the « blue print » genome map (relations between regions of interest…)

THE COLLABORATIVE POTATO BREEDING PROGRAM BETWEEN BRASOV (Ro) and LIBRAMONT (B)

- ✓ **Initiated in 2003, intensified since 2005**
- ✓ **Bilateral cooperation program between Romania and the Walloon Region in Belgium (2008-2010)**

- ✓ **Financial support is limited but appreciated**
- ✓ **Not a huge program**
- ✓ **Traditional breeding**
- ✓ **Main objectives:**
  - late blight resistance
  - good yield
  - good quality use (fresh market and processing market)

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THE COLLABORATIVE POTATO BREEDING PROGRAM BETWEEN BRASOV (Ro) and LIBRAMONT (B)

✓ How does it work?

- choice of parents is carried out jointly,
- priority to late blight resistant genotypes (GASORE, BIONICA, SARPO MIRA, R clones,…)
- crossings made at Brasov Institute
- first years evaluation made in Libramont
- selected clones are evaluated in Barsov from the fourth year
- in case of succes, the new obtentions will be shared

✓Preliminary results

- in the period 2005-2010, 60 crossings
- 375 clones from 31 crossings being evaluated at the moment

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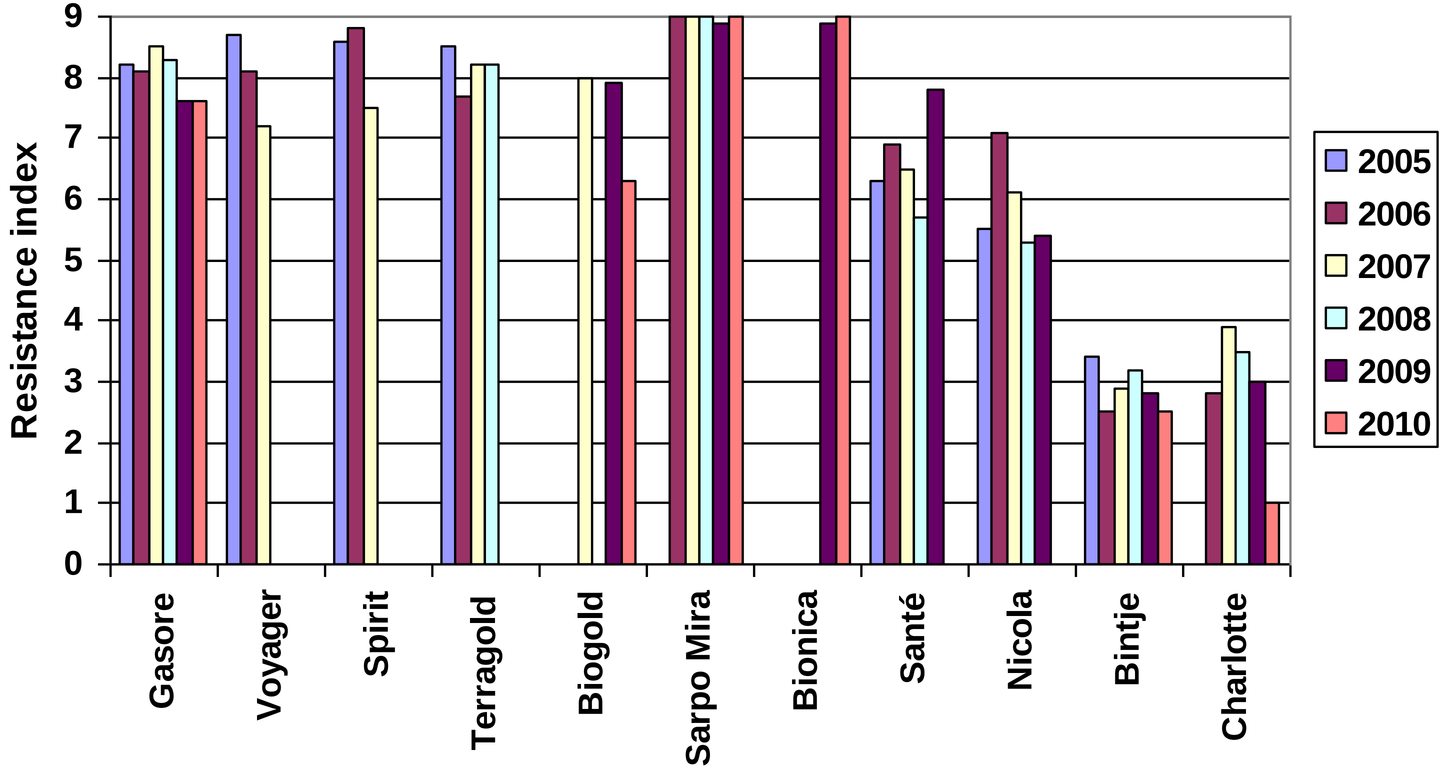
THE COLLABORATIVE POTATO BREEDING PROGRAM BETWEEN BRASOV (Ro) and LIBRAMONT (B)

✓ **Preliminary results with GASORE as parent.**

- GASORE is a variety from Libramont (registred in 1996)
- robust: late blight, immune PVY, low susceptibility to bacterial diseases
- production of « babies » in France for the processing market
- crossed in the joint program with Laura, Impala, Victoria, Desiree
- at the moment, 14 advanced clones from 4 crossings



GASORE Late Blight Resistance Level compared to other varieties (Period 2005-2010)



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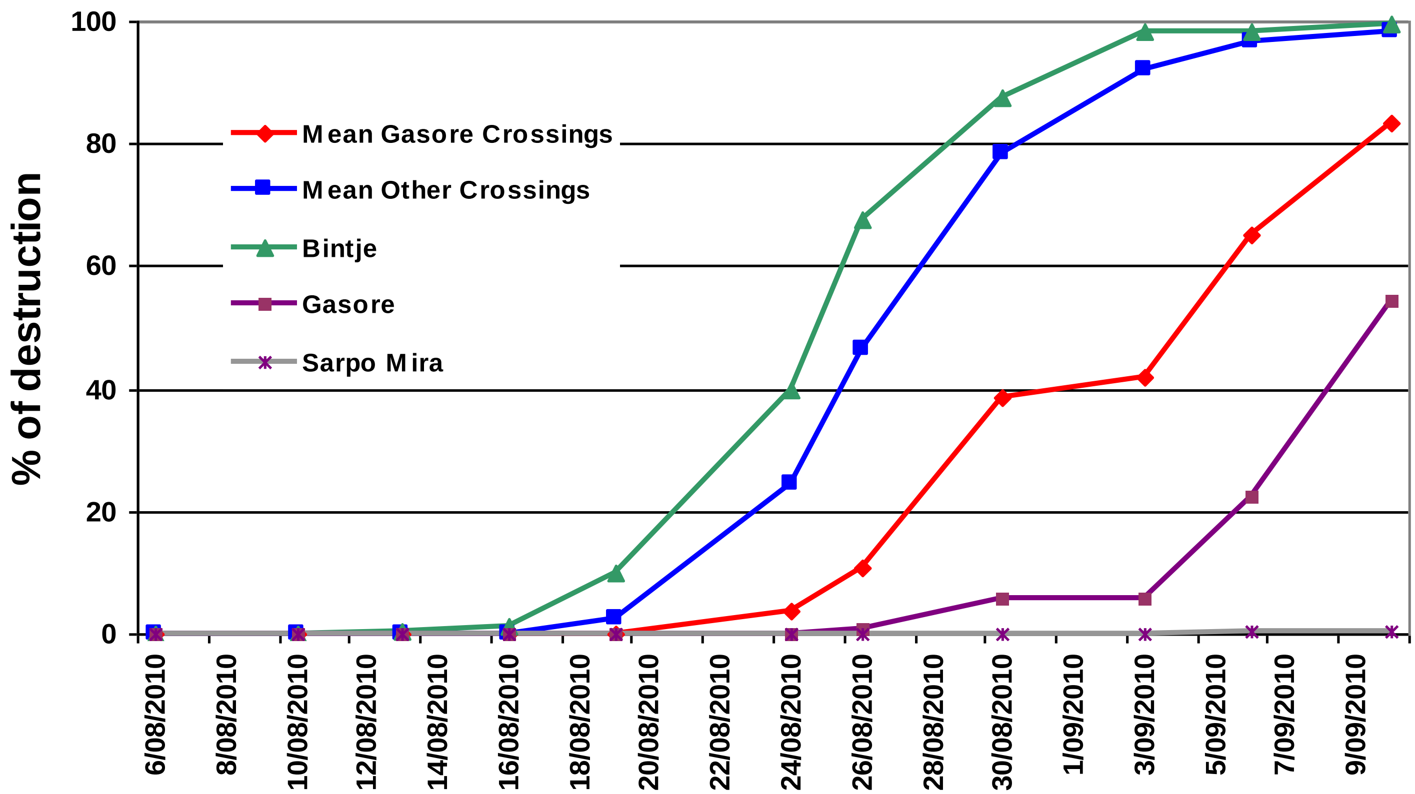
Haulm destruction during vegetation period by natural infection



- Gasore crossings: average behavior for 14 advanced clones from 4 crossings
- Other crossings: average behavior for 26 advanced clones from 12 crossings

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