EAPR Pathology & Pests

Reducing Pesticide Use while Preserving Potato Productivity and Profitability

Neuchatel, September 3rd 2019

Doretta Boomsma
Which would you rather fight: 1 horse-sized duck or 100 duck-sized horses
EAPR Pathology & Pests
Reducing Pesticide use while Preserving Potato Productivity and Profitability

+ Quality

Resistance Breeding

Neuchatel, September 3rd 2019

Doretta Boomsma
Programleader Plant Pathology & Cell Biology
• Annual production: ~ 388 mln tonnes
• Acreage: ~ 20 mln ha
• Strong variety dominance

Potato Facts

Production per country (Top 10, in mln tonnes)
disease control

Source: WUR, Francine Govers
“HZPC is the innovative global market leader in potato breeding, seed potato trade and product concept development”
Vision
“We drive the development of responsible food for the world population.”

Mission
“We inspire the potato value chain worldwide by delivering innovative products and services.”
HZPC materiality matrix

Community involvement was renamed into Social impact

HZPC

Develop new varieties maximizing/Securing yield with reduced input
Growers with sustainability program
Local for local
Stakeholder dialogue & transparency
Create healthier varieties
Child labor
Optimize transport
Building Human Capital
Genetic resources
More varieties to more countries
Energy use (facilities)
Travel efficiency
Sustainable sourcing (packaging)
Paper use

Impact on HZPC

moderate

significant

major
Market Trends

Healthy seed potatoes, certification systems (now) True seed (as well) Distribution channels Knowledge via apps Convenience …

(A)biotic tolerances Climate extremes Production at marginal soils Handling in the value chain Low input Salinity Easy storage …

No waste Low foot print Value to price Honest product …

Availability Safety Less meat Nutrition rich and dense Taste is the carrier …
Our Breeding Program serves all the Actors of the Value Chain

1. RESEARCH & DEVELOPMENT
2. SEED GROWER
3. PROCESSOR
4. CONSUMER

Product Profiles
Breeding

GROWER

SUPERMARKET

LOCAL MARKET

QSR
- List of requirements translated into Product Profiles
- Each actor in value chain has different Product Profiles consisting of different traits
- A new variety has to be significantly better and/or has to contain new (combination of) traits
- About 50 ‘Must Haves’ traits per variety!
Resistance Breeding
Genotyping (MAB)
Cooperation Academic-Companies
Diploid Breeding
Stacking R-genes
Explore and exploit wild species for R genes
Resistant varieties
Big Data Analysis
Phenotyping
(in development)

PMTV
Benefits of molecular markers

1. Which crosses give the highest probability to result in progeny combining many traits from the product profile.

2. Allows us to select within 5 week after sowing for several traits.

Years after sowing of marker result

At this moment mainly markers for dominant monogenic resistances:

PCN, PVY, LB, MCH, WD
Diploid Breeding

- 160 wild diploid species
- Quality and resistance traits used in diploid gene pool
- Introgression traits into 4x potato via 2n gametes

**Haploid Tuberous / Andigena**

(2n=2x=24)
* Female fertility/adaptation
  * Ps/ps (or) ps/ps

**Cultivated/wild species**

(2n=2x=24)
* New genes/alleles
  * ps/ps

**Agronomic superior cultivar**

(2n=4x=48)
* Unrelated to haploid

**Haploid-species hybrid**

(2n=2x=24)
* ps/ps

**2n-pollen**

**Diploid tetraploid hybrid**

(2n=4x=48)
* Heterosis/allelic diversity
  * Desirable combination of traits
Late blight resistance

Explore and exploit R genes
Mapping Populations
Stacking R genes

R genes
- Rpi-ber, Rpi-chc1
- Rpi-edn2
- Rpi-vnt1
- RB, Rpi-sto1
- Rpi-blb2
- R1
- R2, Rpi-blb3
- Rpi-amr3

Sources:
- S. edinense
- S. berthaultii
cv Bintje

Cooperation
Academic-Companies

Source: WUR, Geert Kessel & Jack Vossen
The Fields for potato breeding
**Late Blight**
Based on one R gene
(R8, Blb2, venturi en berthaulti)

**PVY (foliage)**
e.g. Sagitta, Delia Red en Camelia

**PCN (Gro-ABC & Gpa-DE)**
e.g. Allison, Alcander, Primabella

**WART (fysio 1, 2, 6, 18)**
e.g. Althea, Cardyma

**In about 5 years time:**
New candidate varieties with combination of
PCN, PVY, Wart (1) and Late blight resistance

<table>
<thead>
<tr>
<th>LB Res.Variety</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alouette</td>
<td>Bio Select/Agrico</td>
</tr>
<tr>
<td>Levante</td>
<td>Bio Select/Agrico</td>
</tr>
<tr>
<td>Carolus</td>
<td>Bio Select/Agrico</td>
</tr>
<tr>
<td>Twinner</td>
<td>Bio Select/Agrico</td>
</tr>
<tr>
<td>Twister</td>
<td>Bio Select/Agrico</td>
</tr>
<tr>
<td>Acoustic</td>
<td>C. Meijer b.v.</td>
</tr>
<tr>
<td>Cammeo</td>
<td>Caithness Potatoes B.V.</td>
</tr>
<tr>
<td>Passion</td>
<td>Caithness Potatoes B.V.</td>
</tr>
<tr>
<td>Tentation</td>
<td>Caithness Potatoes B.V.</td>
</tr>
<tr>
<td>Sarpo Mira</td>
<td>Danespo</td>
</tr>
<tr>
<td>Connect</td>
<td>Den Hartigh</td>
</tr>
<tr>
<td>Otolia</td>
<td>Europlant</td>
</tr>
<tr>
<td>Alanis</td>
<td>Interseed Holland B.V.</td>
</tr>
<tr>
<td>Bionica</td>
<td>N. Vos</td>
</tr>
<tr>
<td>Sevilla</td>
<td>N. Vos</td>
</tr>
<tr>
<td>Cephora</td>
<td>Plantera B.V.</td>
</tr>
<tr>
<td>Vitabella</td>
<td>Plantera B.V.</td>
</tr>
</tbody>
</table>
Resistance Breeding

Combining all traits of interest

Phenotyping & Genotyping quantitative/polygenic traits

Time consuming (phenotyping, seed multiplication rate)

Yield, Quality, Resistances
Time-consuming

<table>
<thead>
<tr>
<th>Year</th>
<th>Generation</th>
<th>Breeding</th>
<th>Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cross parents</td>
<td></td>
<td>Procure initial variation</td>
</tr>
<tr>
<td>2</td>
<td>Pot seedlings</td>
<td></td>
<td>Test of experimental varieties</td>
</tr>
<tr>
<td>3</td>
<td>Field seedlings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>A clones</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>B clones</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>C clones</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>D clones</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-9</td>
<td>Official testing</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 10-12| Positioning    |          |                             |
| 13   | Commercial     |          |                             |
Potato is autotetraploid: 4 sets of 39,000 genes randomly reassorted in each generation

- Highly heterozygous: awful lot of genetic variation
- Complex genetics
- Difficult to manage and predict
- Hardly any genetic gain
- Majority of high impact traits are polygenic & more difficult to phenotype

“Numbers Game”

Start selection (500 individuals)
- After 3 years of selection 2% is left
- Probability is very small that they all have these traits

Conclusion: New variety will be a compromise
Resistance Breeding

Hybrid potato - TPS

Unravel genetics plant-pathogen interaction

New Technologies (Cis-genesis, GMO, Gene-editing)

Genomic selection

Market trends – sustainable agriculture
Clonal vs Hybrid Breeding

Clonal 2n = 4x

- Fix traits of interest in homozygous lines
- Stack & combine specific traits in hybrids

Control & time gain!

TPS 2n = 2x & 4x

Diploid F₁ hybrid breeding

- diploid potato germplasm
  - crossings, selfings and selections
  - Young inbred lines
    - elite line
    - elite line
    - elite line
    - elite line
  - experimental hybrids
    - selection on combining ability
    - female parent
    - male parent
  - commercial hybrid cultivar

Potential: 120 tons/ha
Achievement: >100 tons/ha, 90% marketable

Potential: unknown
Achievement: improving on marketable yield!
1-R-gene transgenic Desiree differential set in the field

Disease progress 48 d after start LB epidemic (2016)

% infested leaf area

R genes (s)

Source: WUR, Geert Kessel & Jack Vossen
Resistance Breeding

Regulation Gene editing & GMO

Resistance breakdown (e.g. Pi)

Adaptation of pathogens

Climate change

Increased global trade

Market demands

HZPC
Growing with our potatoes
Market demands

- Market demands can change fast – traditional breeding is slow
- Market penetration of novel varieties is very slow
- Competition of free varieties
- Yield&Quality vs Resistances

Potato varieties in NL

<table>
<thead>
<tr>
<th>Variety</th>
<th>Registration (year)*</th>
<th>Seed prod 2016 NL (% of total)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bintje</td>
<td>1910</td>
<td>2</td>
</tr>
<tr>
<td>Desiree</td>
<td>1962</td>
<td>2</td>
</tr>
<tr>
<td>Spunta</td>
<td>1968</td>
<td>15</td>
</tr>
<tr>
<td>Agria</td>
<td>1985</td>
<td>4</td>
</tr>
<tr>
<td>Innovator</td>
<td>1998</td>
<td>4</td>
</tr>
<tr>
<td>Fontane</td>
<td>1999</td>
<td>8</td>
</tr>
<tr>
<td>Sarpo Mira</td>
<td>&lt;2003</td>
<td>0,009</td>
</tr>
<tr>
<td>Toluca</td>
<td>2006</td>
<td>0</td>
</tr>
<tr>
<td>Carolus</td>
<td>2012</td>
<td>0,09</td>
</tr>
<tr>
<td>Avito</td>
<td>2013</td>
<td>0,03</td>
</tr>
<tr>
<td>Alouette</td>
<td>2014</td>
<td>0,02</td>
</tr>
</tbody>
</table>

*Source: http://10.73.177.202/potatopedigree/
**Source: https://www.nak.nl/
Adaptation of pathogens

Resistance breakdown (e.g. Pi)

*Rpi-blb2* breaking in 2008

Stacking vs non-stacking

<table>
<thead>
<tr>
<th>Host diversity</th>
<th>Pathogen population diversity</th>
<th>Potato destroyed in landscape</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% R0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50% R0 + 50% R1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50% R0 + 50% R12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50% R0 + 50% R123</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: WUR, Geert Kessel & Jack Vossen
New challenges

- Climate Change
- Increased global trade

Bacterial Wilt

Zebra Chip

Colorado Beetle

White Fly

TSWV
Conclusion

Use

Improve

Exploit

Mitigate

RESISTANT VARIETIES
Integrated Crop Management - 2030

Agro-ecology with high-tech support: IPM (resistant varieties, monitoring, biocontrol, low input...) Crop Diversification, DSS, Digital Farming, Drones....

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Together we can win the fight!!