



Innate[®] Potatoes: Development, Event Detection, and Regulatory Challenges

Gary Rudgers, PhD

AEIC, April 2022



Headquartered in Boise, Idaho



Simplot

A family-owned, international food and agriculture company with more than 13,000 employees at major operations in 6 countries. The Company distributes products to more than 100 countries around the world.

- Phosphate mining
- Fertilizer manufacturing and distribution
- Farming
- Ranching
- Food processing and distribution
- Food brands
- Animal nutrition
- Life sciences

We Are Simplot Plant Sciences



Started in year 2000

With a simple goal of improving the potato. 22 years, multiple pioneering biotech potato platforms later, we've evolved the Vision: **To become the global knowledge leader in potato.**

85 employees; ethnically diverse

Employees from 11 countries with an average age of 35 and 23 PhDs. Located 3 miles from Simplot's headquarters in downtown Boise.

Startup functions all under one roof

Responsible for R&D, regulatory approvals, compliance, stewardship and new market development.

Innate[®]: A Better Potato



Wild and
Cultivated Potatoes



Desired
Potato DNA



A NEW TYPE OF BIOTECH

No foreign genes
Consumer health benefits
Reduced waste

Four Popular Varieties

Russet Burbank, Ranger Russet,
Atlantic and Snowden.

Commercial Products


Gen1 - 2015
Gen2 - 2017
Gen3 - Coming soon

Non-Browning/Reduced Black Spot

Benefits: Reduced Waste

Polyphenol Oxidase (PPO)

Innate[®] **Control**




↓ RNAi

Slows conversion of *o*-diphenols to *o*-quinones

Lower Reducing Sugars

Benefits: Improved storage & fry color



Innate[®] **Control**

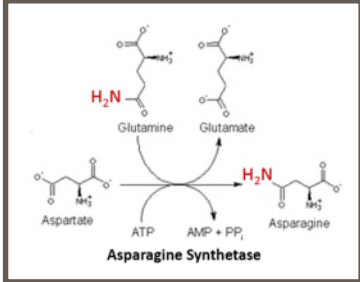
Water Dikinase Phosphorylase L

↓ RNAi

Slows conversion of starch to reducing sugars

Reduced Free Asparagine

Benefits: Lower acrylamide (50%-80%)



Asparagine Synthetase

↓ RNAi

Slows conversion of Aspartate to Asparagine



innate
by Simplot




Innate[®]: Gen2 – All traits of Gen1 plus a few more

Non-Browning/Reduced Black Spot
Benefits: Reduced Waste

Polyphenol Oxidase (PPO)


Innate[®] **Control**



↓ RNAi

Slows conversion of σ -diphenols to σ -quinones

Lower Reducing Sugars
Benefits: Improved storage & fry color



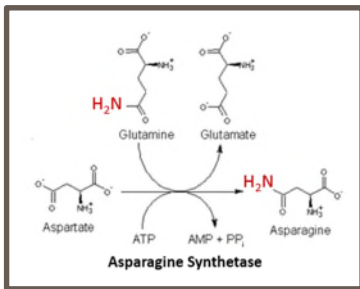
Innate[®] **Control**

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Asparagine Synthetase

↓ RNAi

Slows conversion of Aspartate to Asparagine


Resistance Gene (R gene)
Benefits: Late Blight Production

VNT1 protein induces a hypersensitive response



Innate[®]
Control

Further Lower Reducing Sugars
Benefits: Improved storage & fry color

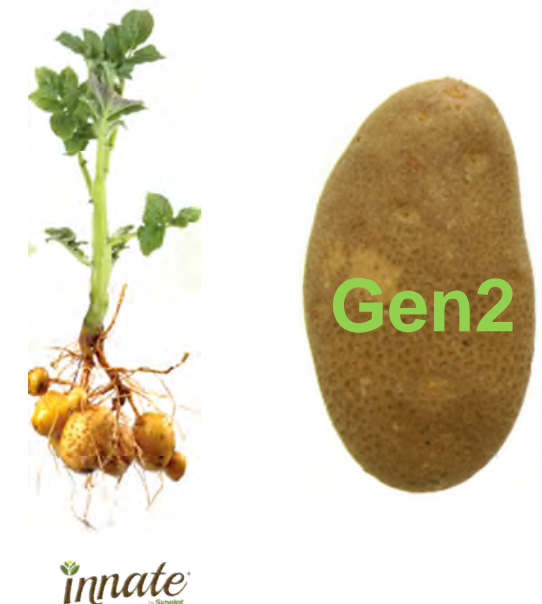


Innate[®] **Control**

Vacuolar Invertase

↓ RNAi

Slows conversion of sucrose to reducing sugars



What do you get when you cross a potato with a potato?

Breeding using True Seed

- ❑ Autopolyploids (Tetraploid genome)
- ❑ Highly heterozygous
- ❑ Subject to inbreeding depression

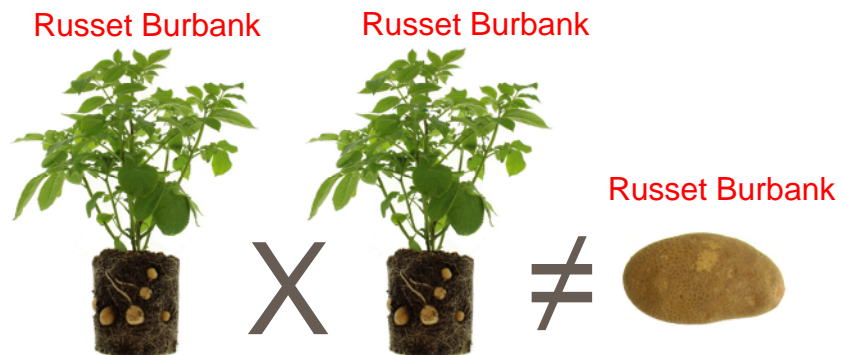


Photo: Jansky Lab - [Jansky Lab | Potato Germplasm Enhancement \(wisc.edu\)](https://www.wisc.edu/jansky-lab/potato-germplasm-enhancement)
Tuber diversity in an F2 population

What Happens when you cross a potato with a potato?

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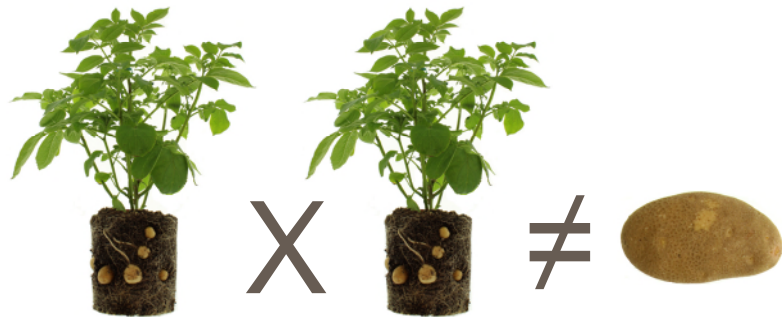
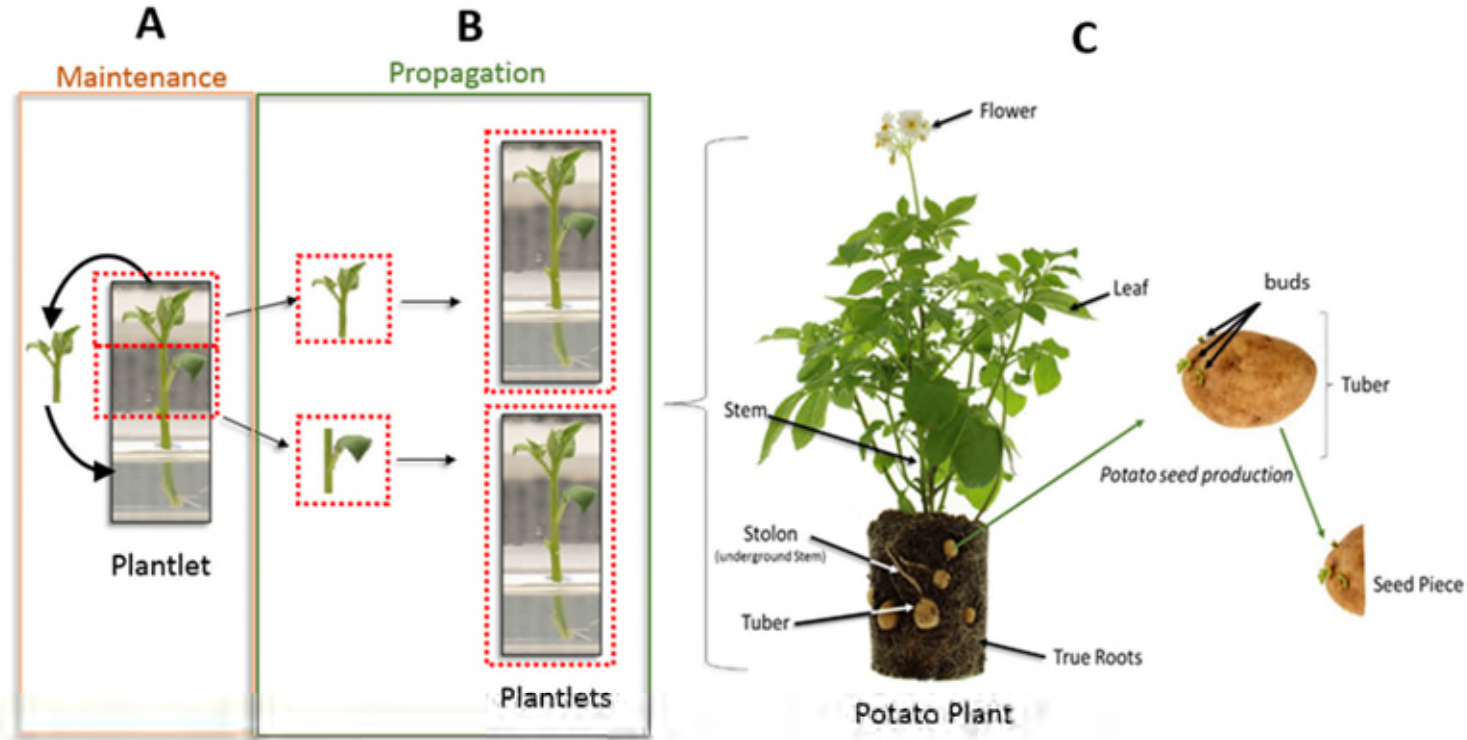


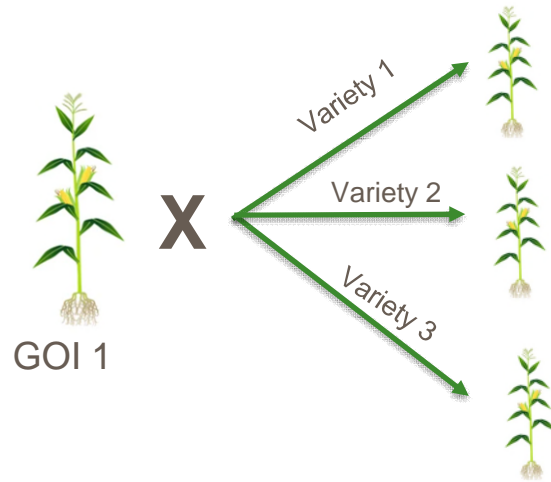
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Tuber diversity in an F2 population

Vegetatively/Clonally Propagation

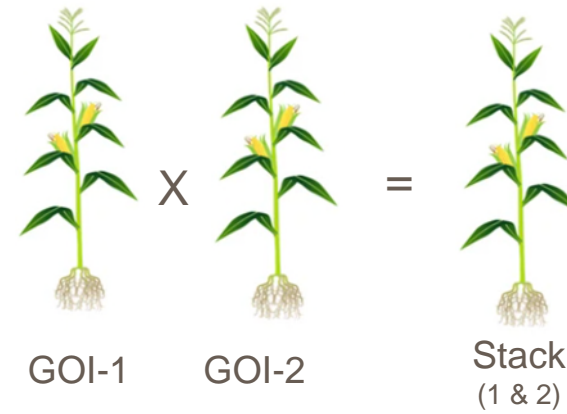


Each Innate[®] Potato Variety Must be Independently Developed

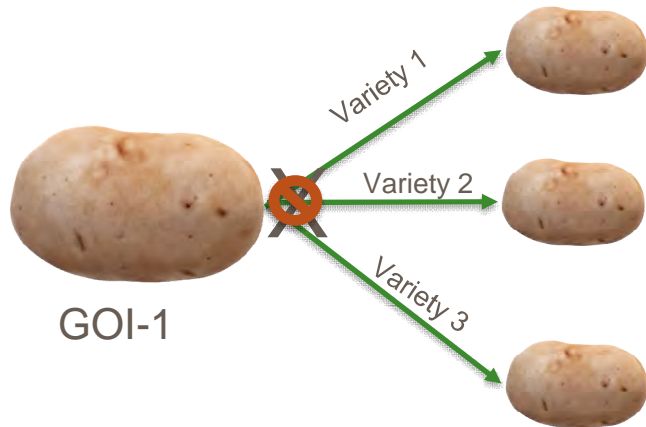
Traditional Bred Crops



OR



Potato

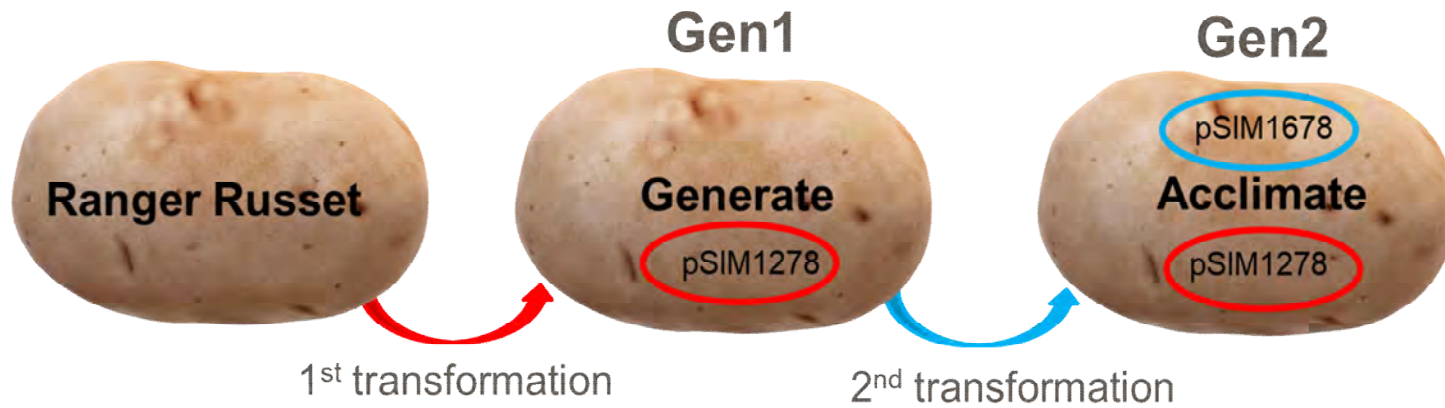


OR



GOI = Gene of Interest

Each Innate[®] Potato Variety Must be Independently Developed



Black spot bruise,
Lower reducing sugars, Reduced
free asparagine

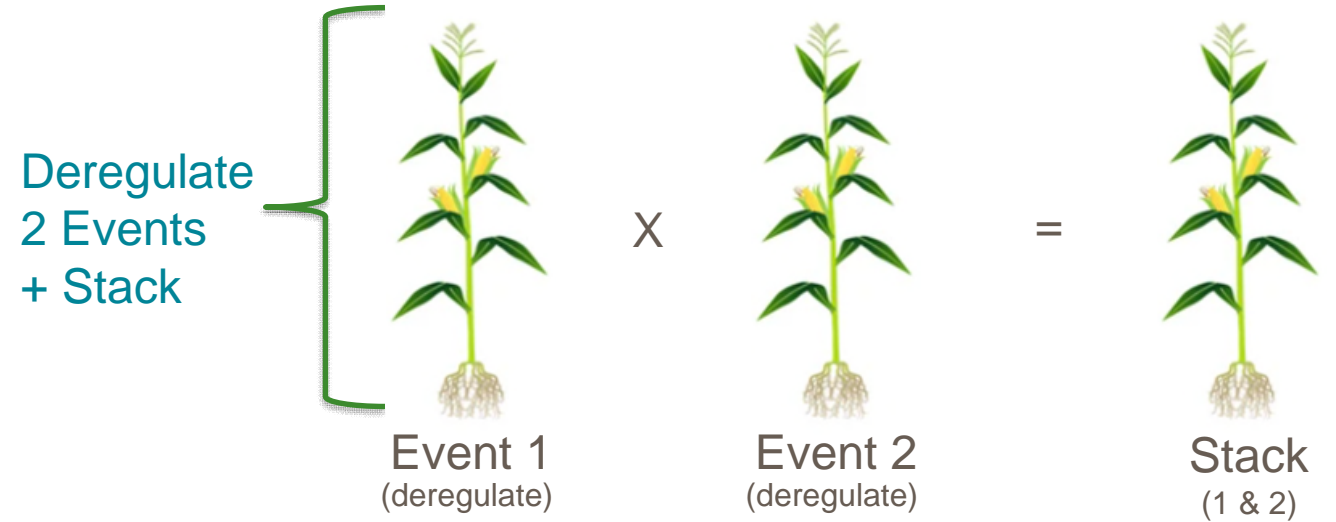
Further lowered reducing
sugars and late blight
resistance

Conventional	Gen1 Innate [®]	Gen2 Innate [®]
Burbank	Cultivate	-
Ranger	Generate	Acclimate
Atlantic	Accelerate	Hibernate
Snowden	Invigorate	Elevate
Total	4	3

Each Innate[®] Potato Variety Must be Independently Developed and Deregulated

☐ Traditional Bred Crops

- Each event is approved/deregulated in various geographies
- Approved events can be bred with other varieties with no further regulatory review
- Events can be stacked and, depending on geography, may or may not need further regulatory review



Each Innate[®] Potato Variety Must be Independently Developed and Deregulated

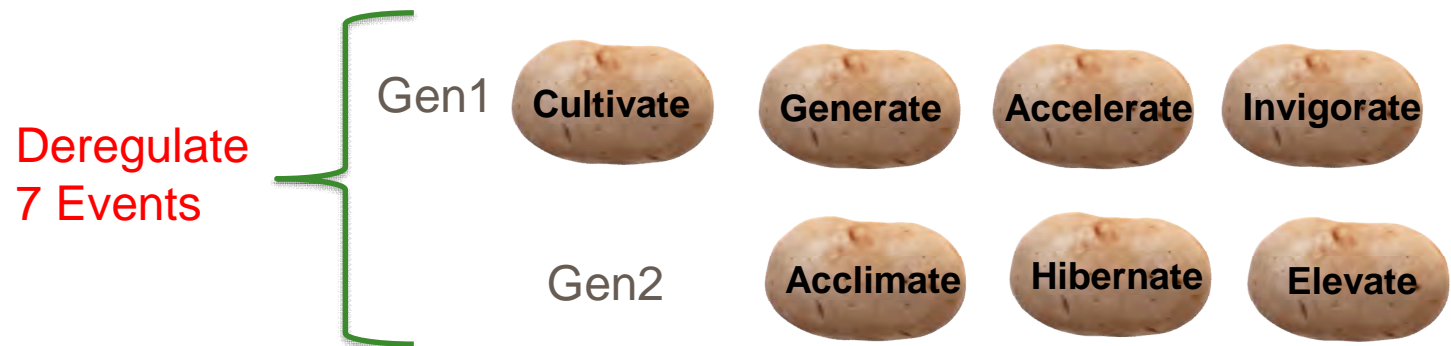
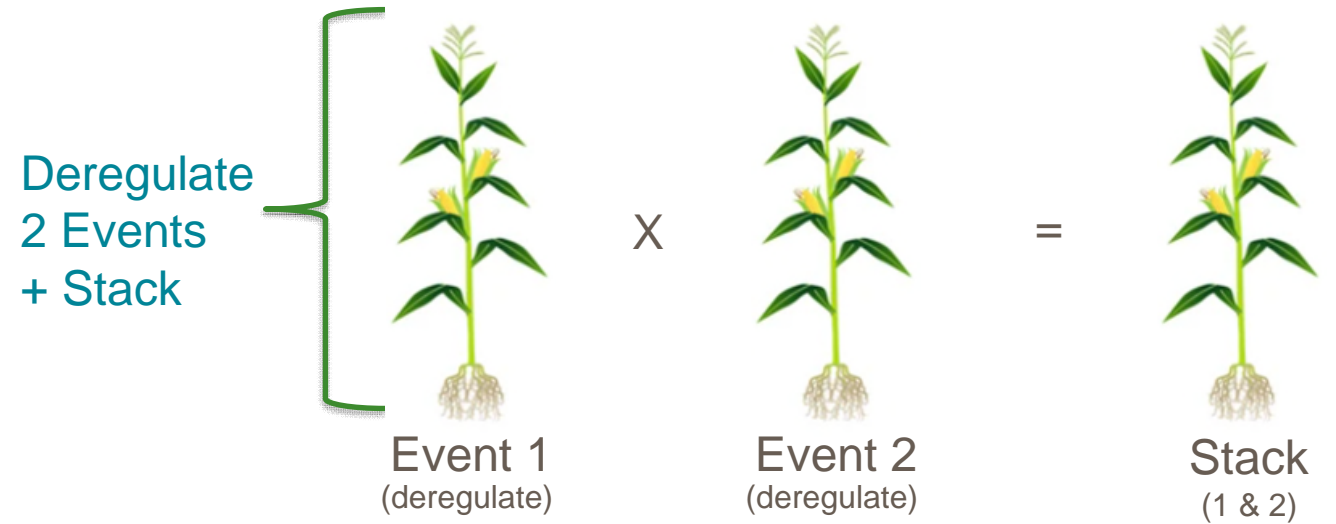
❑ Traditional Bred Crops

- Each event is approved/deregulated in various geographies
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❑ Most countries regulate events

- Events have slightly different insert sequences due to the transformation process, rearrangements, etc..
- Events have inserts at different genomic locations

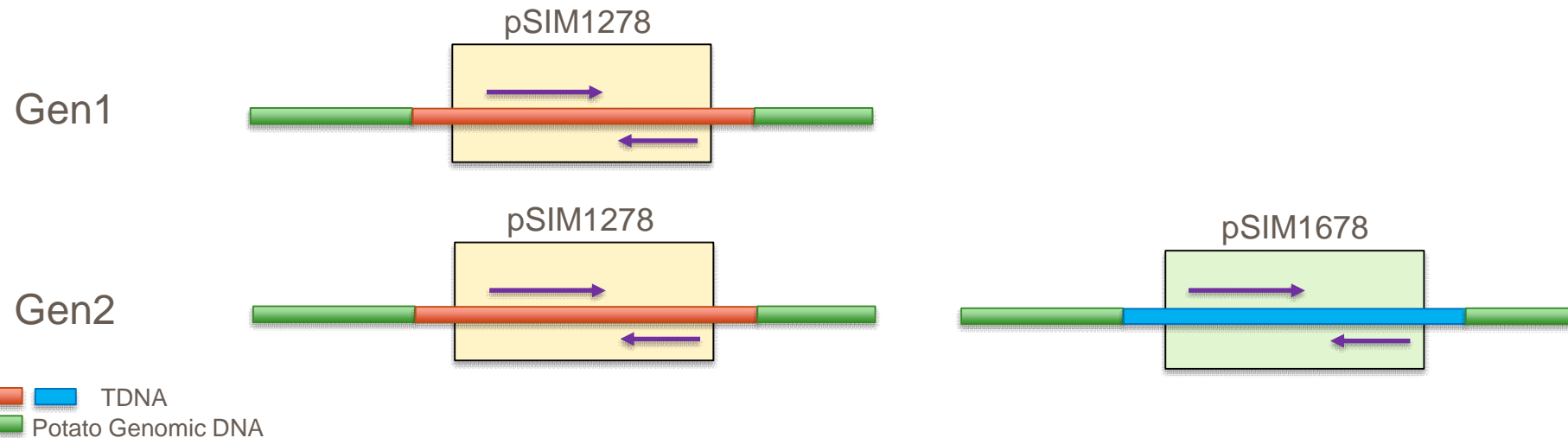
❑ Regulatory agencies have typically required a full regulatory package for all Innate[®] potato events



Event Detection

- ❑ Challenge
 - Innate® plasmid T-DNA designed using potato DNA sequences
- ❑ Need primers sets that do not amplify native potato DNA while being construct specific
- ❑ Allows quick determination of the presence of Innate® events (e.g. presence of Innate® in a batch of Atlantic potatoes)

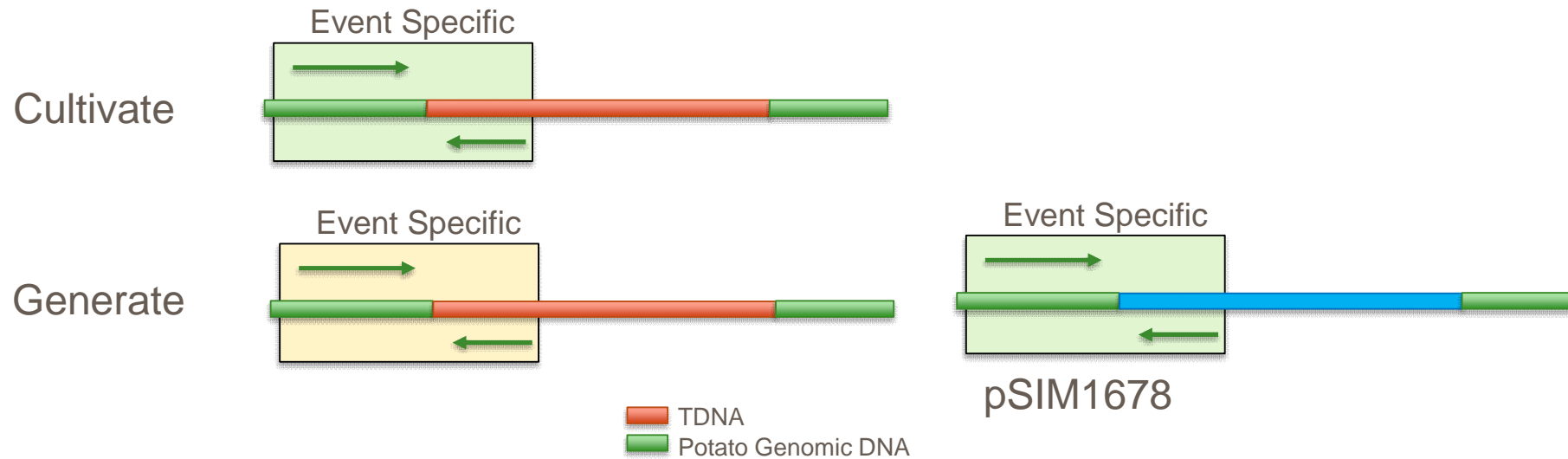
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Ranger	Generate	Acclimate
Atlantic	Accelerate	Hibernate
Snowden	Invigorate	Elevate
Construct	pSIM1278	pSIM1678



Event Detection

- ❑ Challenge
 - Multiple Innate® events contain same T-DNA
- ❑ Need primers sets that do not amplify native potato DNA and can distinguish between the same T-DNA in different events.
- ❑ Event specific primers are designed using junctions between the insert and genomic DNA sequences

Conventional	Gen 1 Innate®	Gen 2 Innate®
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❑ Potato is unfamiliar to most regulatory agencies

- Vegetative/clonal propagation
- Requested to show that traits are stable across “generations” in a clonally propagated crop
- Request for measuring analytes typically not important in potato (e.g. dietary fiber, protease inhibitors)

❑ RNAi is not well understood

- Developed detailed rationale for siRNA safety for both humans and animals based on published data
- One country claimed that RNAi safety has not been confirmed in their country and request more detailed safety rationale.

❑ VNT-1 (R-proteins) is different compared to more common GM proteins

- Intractable protein, expressed at levels too low to be detected
- Published weigh-of-evidence paper for R-protein Safety (Habig et al., 2018)
- Many countries struggle with how to address safety of proteins that are below the level of detection, suggesting that scientist in their country can likely purify and quantitate the protein of interest.

Gen3 Potatoes

Four Popular Varieties

Russet Burbank, Ranger Russet, Atlantic and Snowden.

Grower & Consumer Traits

Benefits the grower and consumer simultaneously for market acceptance.

Sustainability at the Core

The ability to grow more efficiently, cutting down on inputs, water and pesticides while significantly reducing food waste.

Gen 1

2015

Reduced Bruising
and Black Spots

Low Asparagine

Gen 2

2017

Low Sugars

Late Blight Protection

Reduced Bruising
and Black Spots

Low Asparagine

Gen 3

2020 +

PVY Resistance

3 Late Blight Protection Genes

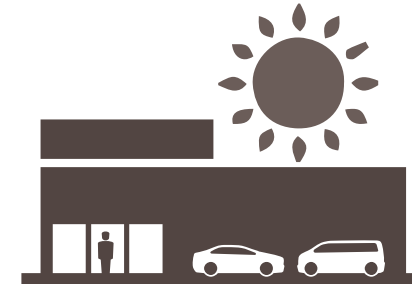
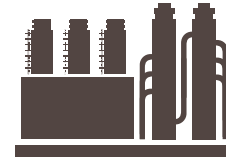
Low Sugars

Reduced Bruising
and Black Spots

Low Asparagine

Acclimate: The most sustainable potato of its kind

Consumer, environmental and grower economic benefits



Farm:

Fewer inputs;
higher useable
yields; less waste

Storage:

Consistent
sugars, late
season storage

Shipping:

Reduced
bruising, black
spots

Processing:

Potential for
increases in
recovery

Consumer:

Low bruise, less
waste, and
healthier option

BENEFITS:

- Late blight disease resistance
- Lower sugar content

- Less browning and black spot from bruising
- Reduced acrylamide when cooked

Aardevo: Imagine an Entire Shift in How Commercial Seed Potatoes are Grown

- Develop new hybrid potato varieties—turn potato into a hybrid crop using diploids and conventional breeding
- Tuber seed to be eventually replaced by true potato seed, which would revolutionize growing potatoes



Aardevo is a joint venture between Simplot and KWS, a German seed company. Through breeding, we will transform the way potato varieties are developed and seeds are made.

Market Acceptance



