

BIOTECH 3R POTATO FOR LATE BLIGHT RESISTANCE IN UGANDA



By

Arinaitwe Abel, Kiggundu Andrew, Barekye Alex, Baguma Gerald, Arthur Wasukira, Douglas Mutembi, Aharita Faith, Magembe Eric and Ghislain Marc

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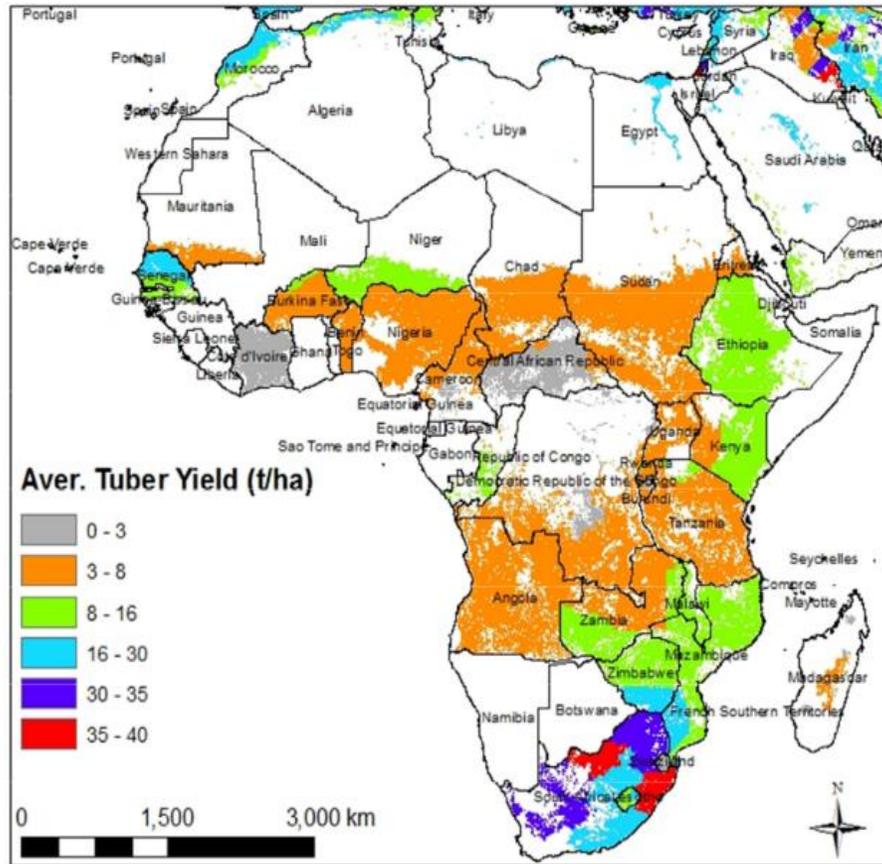


Background

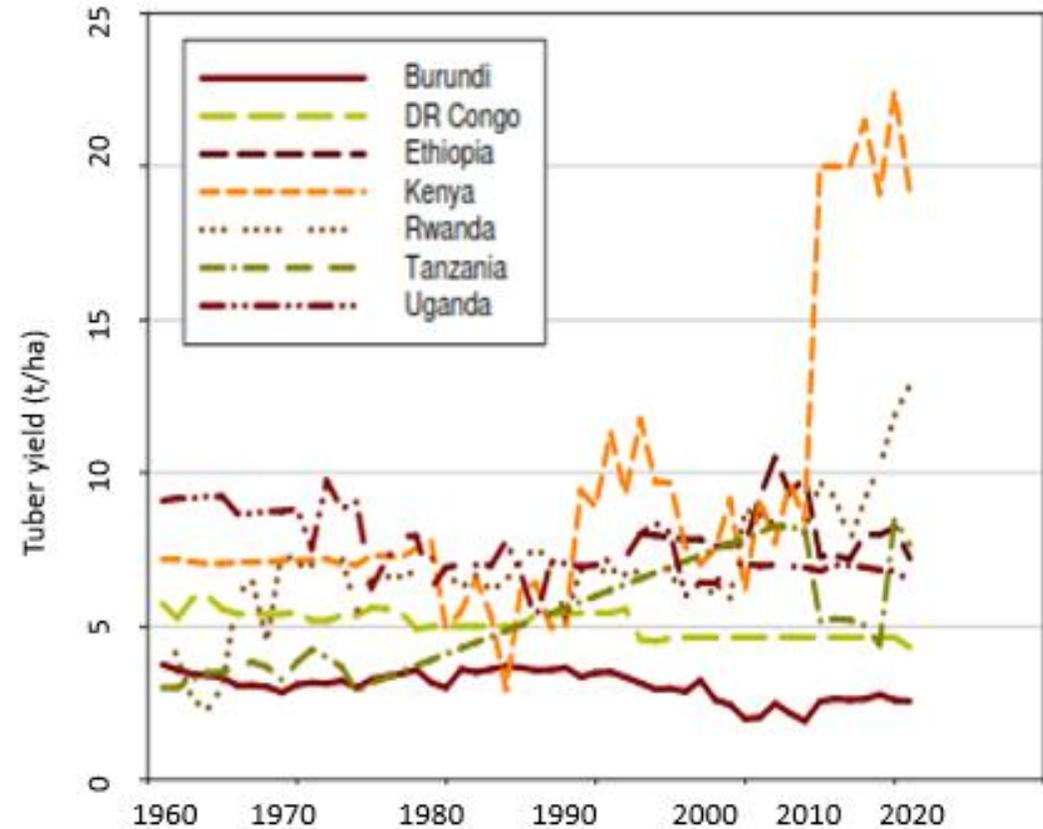


- Potato is an important food and cash crop in Uganda - 3rd tuber crop, 8th overall; Global ranking - 3rd most important.
- Potato production contributes to smallholder household income and food security in Uganda ([Mugisha et al., 2016](#) ; [Namugga et al., 2017](#))
- Potato varieties currently grown in Uganda are highly susceptible to late blight and control of this disease relies exclusively on fungicide applications (> 10 rounds of sprays in season)
- Late blight disease causes 40-60% yield loss (equiv to 500 billions shillings /year)
- In Uganda, the Cost of fungicide (chemicals, sprayers) to control late blight is estimated at 150,000-200,000UGX/ha)
- With 43,000 Ha under potato production, the cost of fungicides, translates to 17.5b per year

Potato productivity in Africa / Eastern Africa

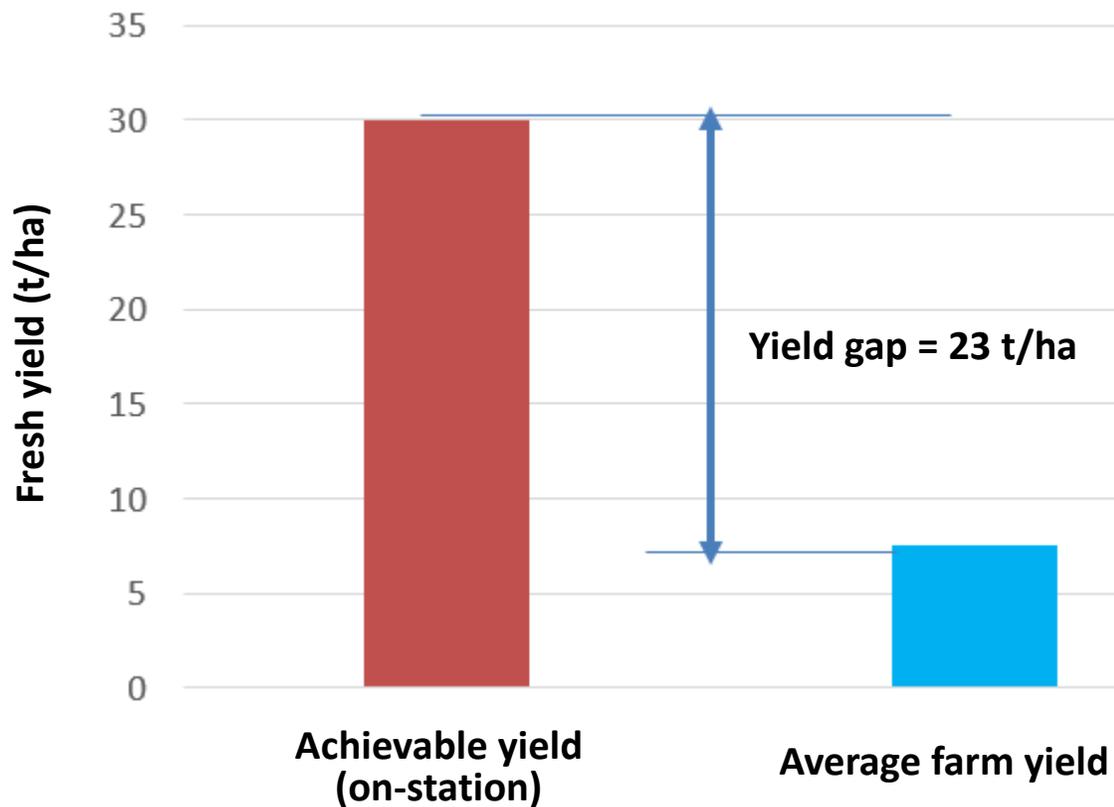


Harahagazwe *et al.*, 2018



Average farmer in Uganda yield: 4-7.5 t/ha

Achievable and average tuber yield (t/ha) in Uganda



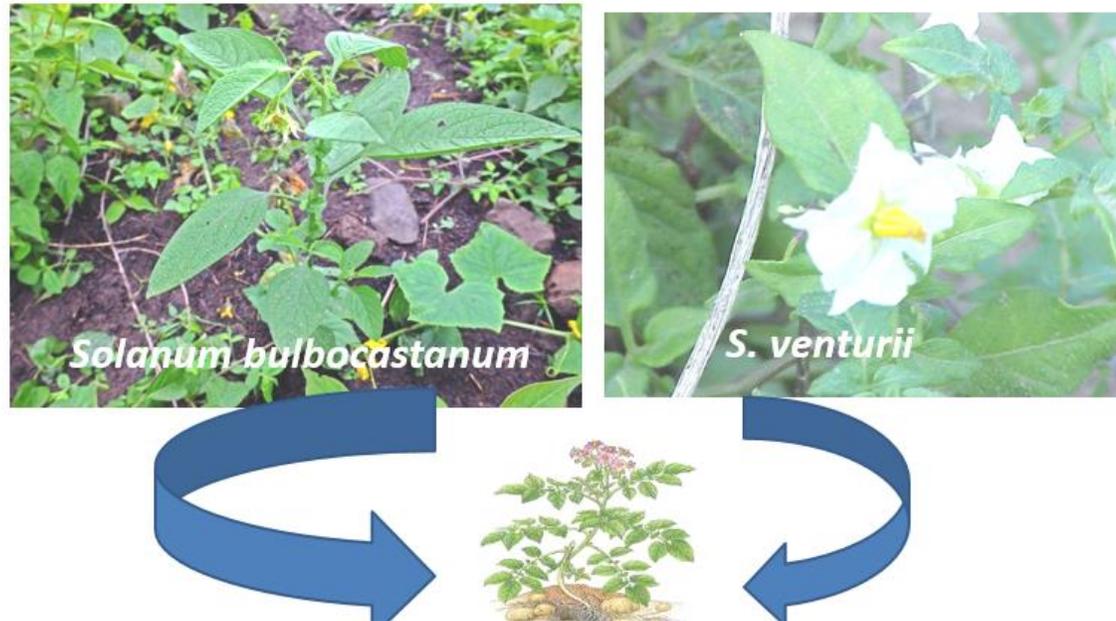
Harahagazwe et al., 2018

Key production challenges

- Pest and Diseases (Late blight, BW and Viruses,
- Inadequate supply of quality seed
- Poor management practices , weeds
- Low soil Fertility levels
- Climate change impacts

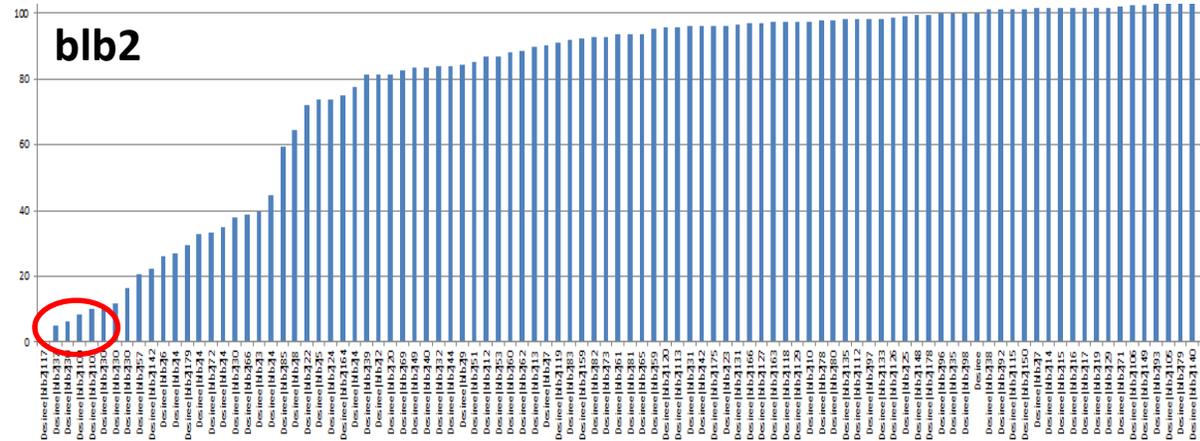
Providing a solution to effects due to late blight using biotechnology

- In order to reduce the costs associated with potato production, the losses caused by the disease, and protect the farmers from their exposure to harmful chemicals
- Resistant genes *RB*, *Rpi-blb2* from *Solanum bulbocastanum*, and *Rpi-vnt1.1* from *S. venturii* were introduced into four African-grown potato varieties (Victoria, Desiree, Tigoni, Shangi) using genetic transformation techniques.

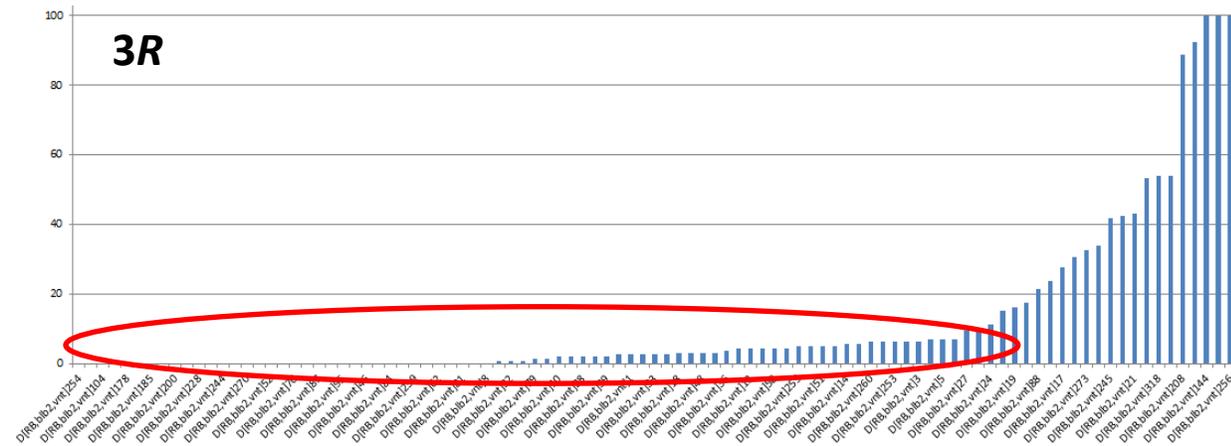


- The transgenic events were evaluated in the greenhouse at CIP-Lima and CIP-BecA in Nairobi and in the field for 10 seasons in Uganda with several transgenic events

Stack gene increased frequency of resistant events - Durability

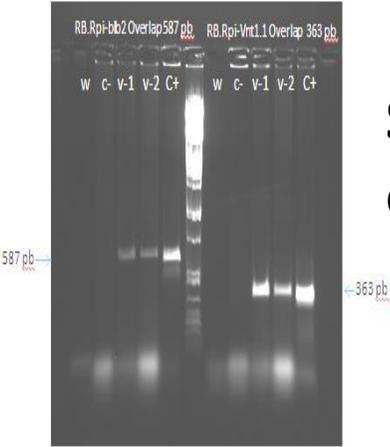


5% of 1R events are extremely resistant



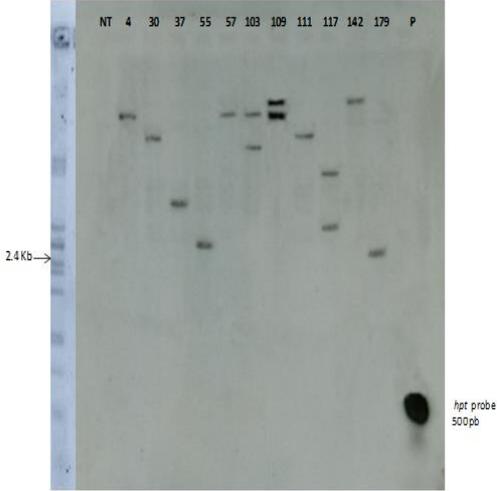
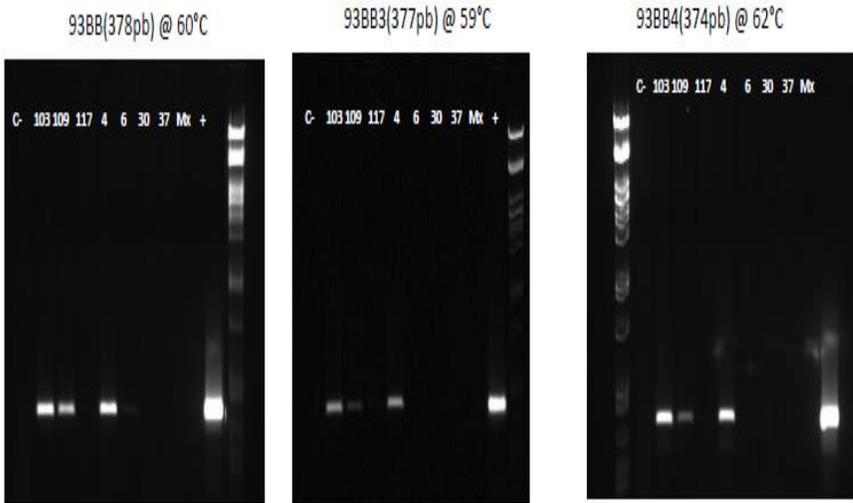
75% of 3R events are extremely resistant

Molecular characterization prior to field trials



Screening for the presence of the 3 *R* genes

Screening for absence of vector backbone sequences

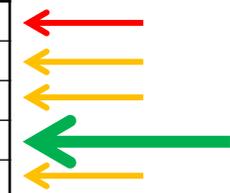


Screening for low copy number of the T-DNA

Events selected for CFT at Kachwekano ZARDI

Transgenic events	Bioassays	CFT-1	CFT-2	CFT-3	CFT-4	ML-CFT-1	ML-CFT-2	CFT-5
		Jun 2015 – Sept 2015	Oct 2015 – Jan 2016	Mar 2016 – Jun 2016	Oct 2016 – Feb 2017	Nov 2017 – Mar 2018	Mar 2018 – Jul 2018	Mar 2019 – Jul 2019
Des.1	ABL	X	X	X				
Des.6	ABL	X	X	X				
Des.14	ABL	X	X	X				
Des.16	ABL	X	X	X				
Des.21	ABL	X	X	X				
Des.245	ABL	X	X	X				
Des.25	ABL	X	X	X				
Des.254	ABL	X	X	X				
Des.255	ABL	X	X	X	X			
Des.259	ABL	X	X	X				
Des.260	ABL	X	X	X				
Des.262	ABL	X	X	X				
Vic.1	ABL	X	X	X	X	X	X	
Vic.14	ABL						X	
Vic.39	ABL							
Vic.172	ABL, BecA							X
Vic.179	ABL							
Desiree	ABL, BecA	X	X	X	X			
Cruza 148	ABL, BecA	X	X	X				
Victoria	ABL, BecA	X	X	X	X	X	X	X

a - o h n o



Vic 172 was selected based on molecular characterisation as a lead event and confirmed in season A 2019- (CFT-5) and confirmed to be resistant.

Abandoned Back-up Lead

CFT and ML-Confined field trials in Uganda (2014-2021)



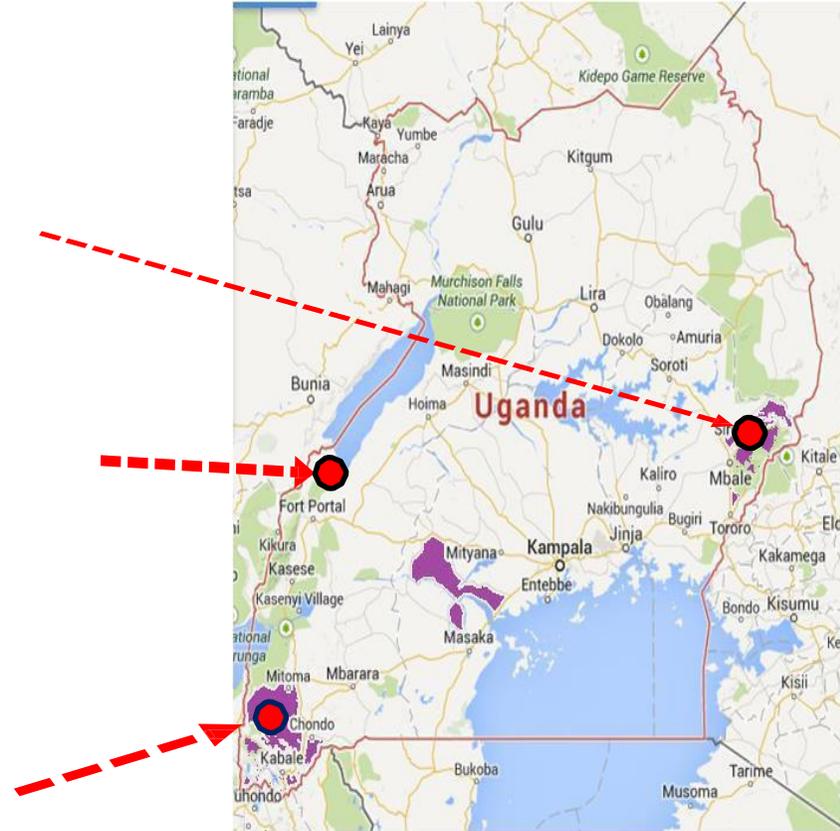
Buginyanya
ZARDI



Rwebitaba
ZARDI



Kachwekano
ZARDI



Field Trials conducted in Uganda under the Guidance of NBC

- 1) CFT mock trial [March – May 2014] Staff training and confinement modifications
- 2) CFT-1 [June 17 – September 28, 2015] 12+1 events from Desiree and Victoria with non-transgenic as spreaders = off-season; No late blight
- 3) CFT-2: October 14, 2015– January 20, 2016] Same events, same design = great results
- 4) CFT-3: = 14/03/2016- 28/06/2016: Same results as in CFT-2
- 5) CFT-4= conducted between 21/10/2016 -09/02/2017 = excellent performance
- 6) ML-CFT-1: [Nov 28, 2017– March 14, 2018] good performance
- 7) ML-CFT-2: [March 15, 2018 – July 12, 2018]: good performance
- 8) CFT-5 (March 19th 2019- 15th, July 2019)
- 9) ML-CFT-3 (October 14th to 27/01/2020)- Good performance
- 10) ML-CFT-4-(21st Sept 2020-Jan 07 2021): Confirmation of the Agronomic performance in different multi-location sites. Late blight resistance are consistent with other previous trials and yield very good

Trait efficacy for LB resistance

CFT -2



Transgenic plots showing extreme resistance to late blight

Non Transgenic plots

CFT -3



CFT-5

ML-CFT-3

ML-CFT-4

Non Transgenic plots completely destroyed by Late blight disease

Transgenic plots showing extreme resistance to late blight



Plot of Victoria with out 3 R genes

Plot of Victoria with 3 R genes

Yield comparison when both are protected with fungicides



Kachwekano

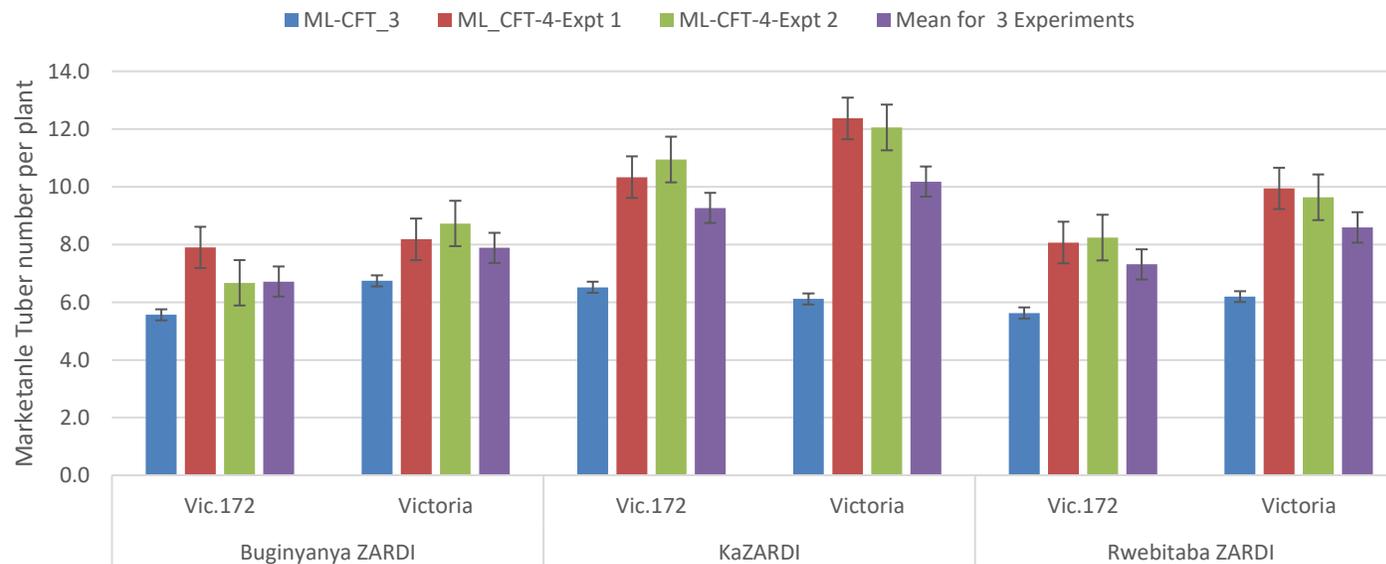
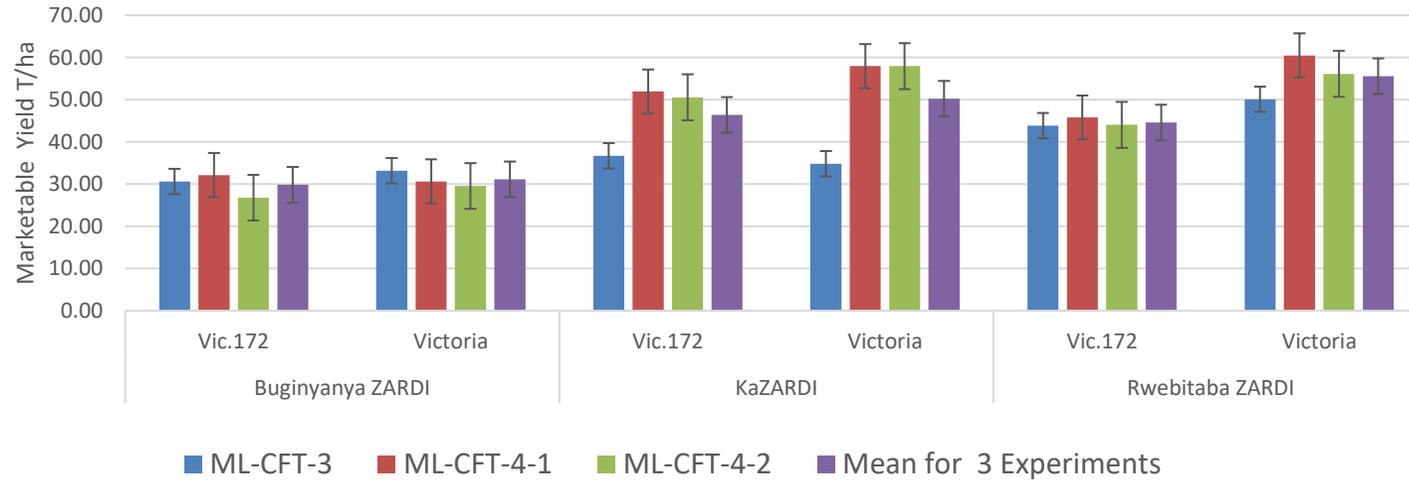


Rwebitaba



Buginyanya

Yield of Non Transgenic Victoria Transgenic across sites when protected with fungicides



Composition Analysis

Location	Genotype	Dry matter (%)	Sucrose (g/100g) DWB	Glucose (g/100g) DWB	Fructose (g/100g) DWB	% Protein (FWB)	Average Vit C (mg/100g) (FWB)	Average TGA (mg/kg) (FWB)
Kachwekano	Vic.172	24.14*	2.67	2.02	0.8	2.17	1.84	16.51*
	Victoria	21.74	1.75	2.74	1.06	2.27	1.35	11.31
Rwebitaba	Vic.172	26.43*	2.51	1.95	0.81	2.05	0.21	7.26*
	Victoria	24.77	1.77	1.94	0.79	1.93	0.17	4.3
Buginyanya	Vic.172	23.33*	1.52	2.1	1.32	2.27	3.17	12.03*
	Victoria	24.91	1.33	2.81	1.66	2.25	1.21	5.64

Compliance with SOP

- All the trials were conducted following the guidelines as specified in in the NBC decision document.
- All of them were conducted within the designed and approved confinement facility under the supervision of the NARO trial managers, directors of research and CIP staff.
- These CFT were aiming at demonstrating that the 3*R*-gene stack confers resistance to late blight disease (proof-of-concept) and ascertaining the agronomic performance of the lead transgenic events in different agro-ecological zones.

Mid season inspection with NBC, IBC and farmers



Committee of Parliament on Science and Technology Visit the CFT-4



Safety of the genes

- These R genes have been in Use in potato and have a history of safe use as they have also been used in convectional breeding

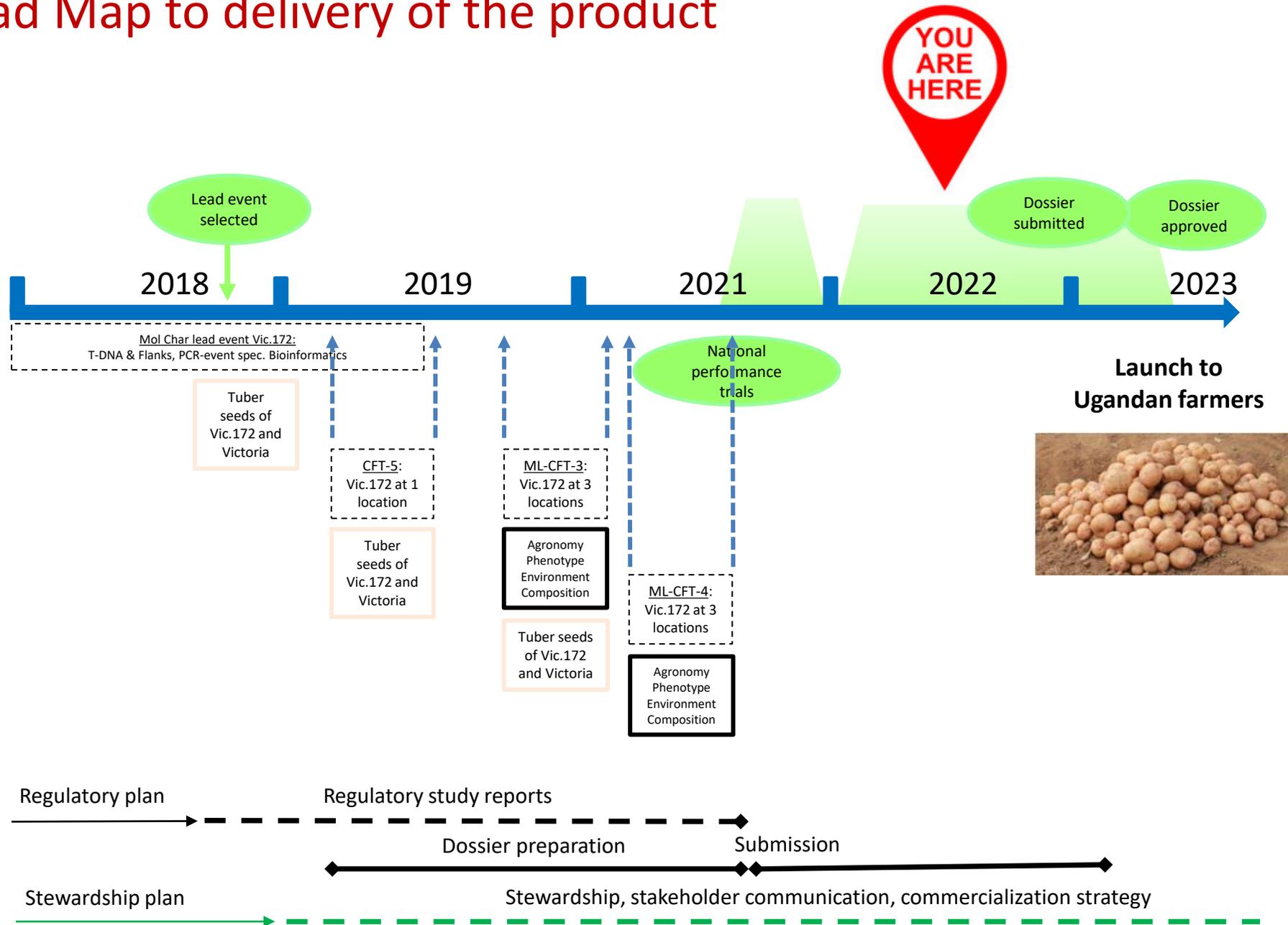
Conclusions

- We have been able to confirm that Vic. 172 is a good event with complete resistance to late blight and yield of > 40T/Ha producing marketable tubers /plant of 6-10 tubers that can be utilized for commercial purpose.
- There were no differences with Victoria, on tuber morphology, skin color, fresh color, growth phenology
- The GE event provides a new hope for the Ugandan potato farmer to improve potato productivity with minimum costs, without any worries of fungicide applications and better productivity.

Expected benefits from the use of GE (Social economic benefits)

- Under 25% adoption, the 3R potato would represents yield increase of 20%
- Ugandan potato farmer growing the 3R potato on 0.25 ha will have at least an additional income of 550,000UGX per year, which represents 40% income improvement.
- The adoption would also save the cost of fungicides, spraying and sprayers estimated 17.5b UGX per year

Road Map to delivery of the product



Communication material on Biotech 3R potato in Uganda

Video

- [NARO institute develops new Irish potato variety to curb late blight](https://www.youtube.com/watch?v=eldO7itrSpk) <https://www.youtube.com/watch?v=eldO7itrSpk>
- [GMO potatoes outwit late blight disease](https://www.youtube.com/watch?v=0wAPDs-YcU8) <https://www.youtube.com/watch?v=0wAPDs-YcU8>
- [Towards a Late Blight resistant potato for Africa](https://www.youtube.com/watch?time_continue=4&v=C4V-4e7JqAc) https://www.youtube.com/watch?time_continue=4&v=C4V-4e7JqAc
- [Biotech potato: solution to devastating late blight disease?](https://www.youtube.com/watch?v=B1jIH4eOQCU) <https://www.youtube.com/watch?v=B1jIH4eOQCU>
- [Conquering potato-late-blight disease: African farmers to benefit from new resistant varieties](https://www.youtube.com/watch?v=leCg3qRrZcY) <https://www.youtube.com/watch?v=leCg3qRrZcY>
- [Uganda's GMO potato story](https://www.youtube.com/watch?v=GUEXOWpYkGA&t=35s) <https://www.youtube.com/watch?v=GUEXOWpYkGA&t=35s>
- <https://www.youtube.com/watch?v=zLASbODn6YI&feature=youtu.be>
- Ugandan farmer testimonials:
 - https://m.youtube.com/watch?v=SyQ_ztmfULA
 - <https://m.youtube.com/watch?v=GrdfcZFOMHw>
 - <https://m.youtube.com/watch?v=uUsWntsAgOY>

Briefs/ brochures

- [Bioengineered potato: Resistance to late blight disease and higher crop yields. CIP Research Brief 01](https://hdl.handle.net/10568/101265) <https://hdl.handle.net/10568/101265>
- [Late blight resistant potato for Africa. Project profile](https://hdl.handle.net/10568/106948) <https://hdl.handle.net/10568/106948>

Blogs

- [Ugandan experts forecast 40-50% adoption of new bioengineered potato Victoria](https://cipotato.org/blog/ugandan-experts-forecast-adoption-new-bioengineered-potato-victoria/) <https://cipotato.org/blog/ugandan-experts-forecast-adoption-new-bioengineered-potato-victoria/>
- [Biotech potato keeps late blight disease in check, new study finds](https://cipotato.org/blog/biotech-potato/) <https://cipotato.org/blog/biotech-potato/>
- [Potato farmers in Uganda wait on new 'Victoria'](https://cipotato.org/press_room/blogs/potato-farmers-in-uganda-wait-on-new-victoria) https://cipotato.org/press_room/blogs/potato-farmers-in-uganda-wait-on-new-victoria
- [Bold for change: fighting potato late blight disease in Africa](https://cipotato.org/blog/bold-for-change/) <https://cipotato.org/blog/bold-for-change/>
- [Field test of biotech potato shows impressive control of late blight disease](https://cipotato.org/press_room/blogs/field-test-biotech-potato-shows-impressive-control-late-blight-disease/) https://cipotato.org/press_room/blogs/field-test-biotech-potato-shows-impressive-control-late-blight-disease/
- [Late-blight-resistant potatoes hold promise for farmers in Uganda and beyond](https://cipotato.org/blog/late-blight-resistant-potatoes-hold-promise-farmers-uganda-beyond/) <https://cipotato.org/blog/late-blight-resistant-potatoes-hold-promise-farmers-uganda-beyond/>
- <https://theconversation.com/why-a-new-potato-variety-could-be-a-game-changer-for-farmers-in-east-africa-150801>

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