University of Helsinki

Faculty of Agriculture and Forestry

Disease management, especially viruses in potato and sweetpotato

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Most important food crops:

Maize	840 milj. tn
Rice	696
Wheat	654
Potato	324
Cassava	230
Barley	123
Sweetpotato	108

FAOSTAT 2010

Over 1500 viruses detected in plants so far .

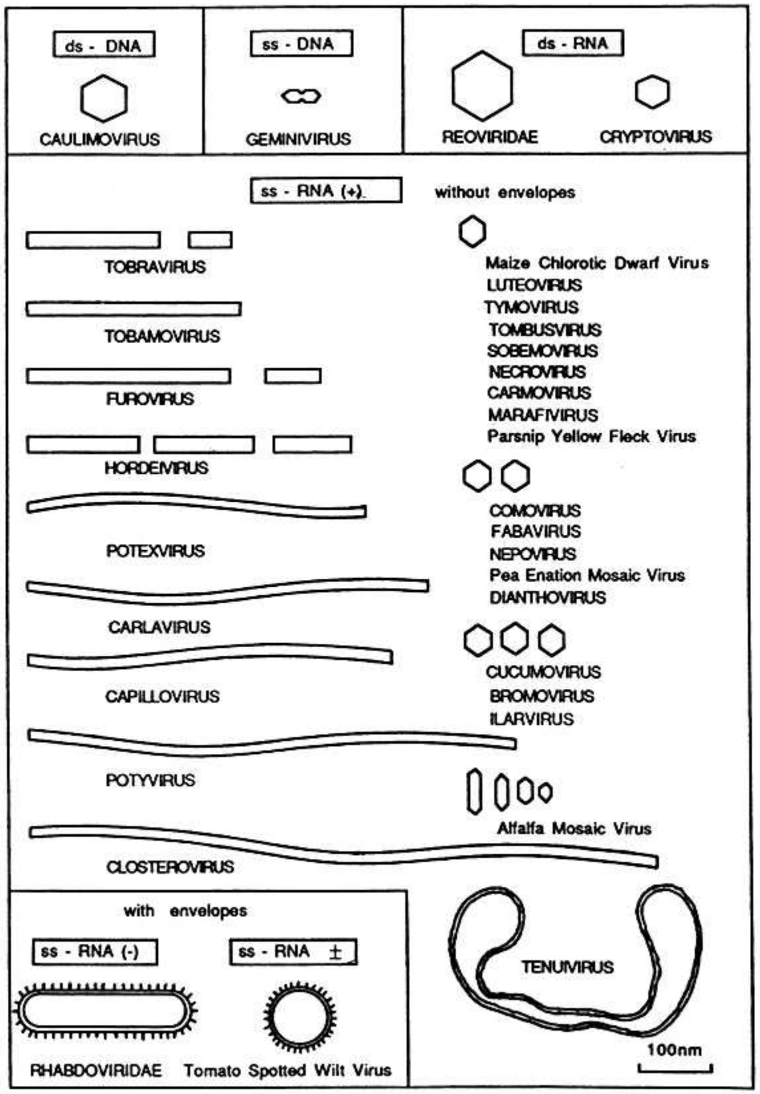

Figure 5.1 The families and groups of viruses infecting plants. Outline diagrams are drawn approximately to scale. (Courtesy R. I. B. Francki.) One additional group, the commelina yellow mottle virus group with dsDNA and bacilliform particles, was approved by the I.C.T.V. in August 1990.

Potato

Alfalfa mosaic virus (AMV), *Alfamovirus, Bromoviridae*
Andean potato latent virus (APLV), *Tymovirus, Tymoviridae*
Andean potato mottle virus (APMV), *Comovirus, Comoviridae*
Arracacha virus B (AVB), tentative *Cheravirus, Sequiviridae*
Beet curly top virus (BCTV), *Curtovirus, Geminiviridae*
Cucumber mosaic virus (CMV), *Cucumovirus, Bromoviridae*
Eggplant mottled dwarf virus (EMDV), *Nucleorhabdovirus, Rhabdoviridae*
Potato aucuba mosaic virus (PAMV), *Potexvirus, Flexiviridae*
Potato black ringspot virus (PBRSV), *Nepovirus, Comoviridae*
Potato deforming mosaic virus = *Tomato yellow vein streak virus* (ToYVSV), *Begomovirus, Geminiviridae*[d]
Potato latent virus (PotLV), *Carlavirus, Flexiviridae*
Potato leafroll virus (PLRV), *Polerovirus, Luteoviridae*
Potato mop-top virus (PMTV), *Pomovirus*, -
Potato rough dwarf virus = Potato virus P, tentative *Carlavirus* [e]
Potato virus A (PVA), *Potyvirus, Potyviridae*
Potato virus M (PVM), *Carlavirus, Flexiviridae*
Potato virus S (PVS), *Carlavirus, Flexiviridae*
Potato virus T (PVT), *Trichovirus, Flexiviridae*
Potato virus U (PVU), *Nepovirus, Comoviridae*
Potato virus V (PVV), *Potyvirus, Potyviridae*
Potato virus X (PVX), *Potexvirus, Flexiviridae*
Potato virus Y (PVY), *Potyvirus, Potyviridae*
Potato yellow dwarf virus (PYDV) *Nucleorhabdovirus, Rhabdoviridae*
Potato yellow mosaic virus (PYMV), *Begomovirus, Geminiviridae*
Potato yellow vein virus (PYVV), tentative *Crinivirus, Closteroviridae*
Potato yellowing virus (PYV), tentative *Alfamovirus*[f]
Solanum apical leaf curl virus (SALCV), tentative *Begomovirus*
Sowbane mosaic virus (SoMV), *Sobemovirus*, -
Tobacco mosaic virus (TMV), *Tobamovirus*, -
Tobacco necrosis virus (TNV), *Necrovirus, Tombusviridae*
Tobacco rattle virus (TRV), *Tobravirus*, -
Tobacco ringspot virus (TRSV), *Nepovirus, Comoviridae*
Tobacco streak virus (TSV), *Ilarvirus, Bromoviridae*
Tomato black ring virus (TBRV), *Nepovirus, Comoviridae*
Tomato mosaic virus (ToMV), *Tobamovirus*, -
Tomato mottle Taino virus (ToMoTV), *Begomovirus, Geminiviridae*
Tomato spotted wilt virus (TSWV), *Tospovirus, Bunyaviridae*

Sweetpotato

CMV
ICLCV
IYVV
SPPV
SPCV
SPCFV
SPCSV
SPFMV
SPGVaV
SPLV
SPLCV
SPLCCaV
SPLCV-CN
SPLCGV
SPLCLaV
SPLCESV
SPLCSCV
SPLCUV
SPLSV
SPMMV
SPMSV
SPMaV
SPSMV-1
SPVMV
SPV2
SPVC
SPVG
SPVCV
SPYDV

Incidence of PLRV, PVY, PVX and PVA in seed potatoes sold at rural markets in Kenya, September 2006

Gildemacher et al. 2009. Am. J. Pot Res 86:373–382

Virus incidence levels (%)

Market	District	PLRV	PVY	PVX	PVA	Virus free	Multiple infections
Elburgon	Nakuru	29	83	39	10	8	50
Kagio	Kirinyaga	68	91	83	56	0	96
Karatina	Nyeri	91	78	83	28	1	93
Kihingo	Laikipia	71	48	100	9	0	79
Mau Narok	Nakuru	61	83	30	15	9	68
Meru	Meru Central	91	58	70	40	1	84
Molo	Nakuru	49	70	64	14	6	66
Murang'a	Muranga	95	100	64	64	0	100
Nanyuki	Meru Central	96	100	55	65	0	98
Naru Moru	Nyeri	63	29	46	65	6	75
North Kinangop	Nyandarua	99	98	34	78	0	98
South Kinangop	Nyandarua	74	94	23	65	3	83
Grand mean		74	77	57	42	3	82

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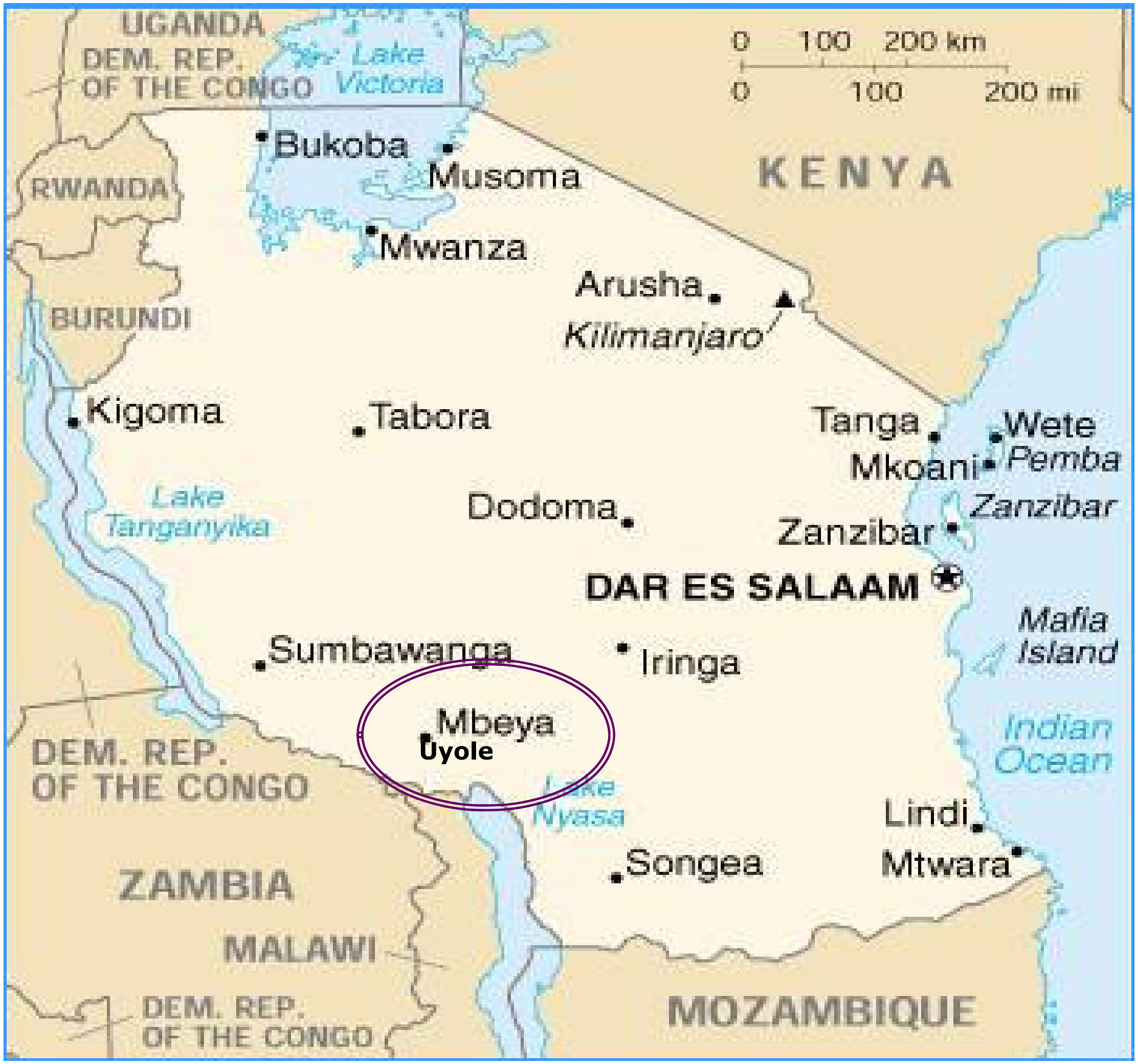
SEED POTATO DEVELOPMENT PROJECT IN TANZANIA

(2012-2014)

1. Healthy planting materials established
2. Seed potato production started
3. Seed potato certification started
4. Training for the aforementioned activities
   (14 Tanzanian specialists: 6 women and 8 men)

Funding: Ministry for Foreign Affairs of Finland and the Tanzanian government

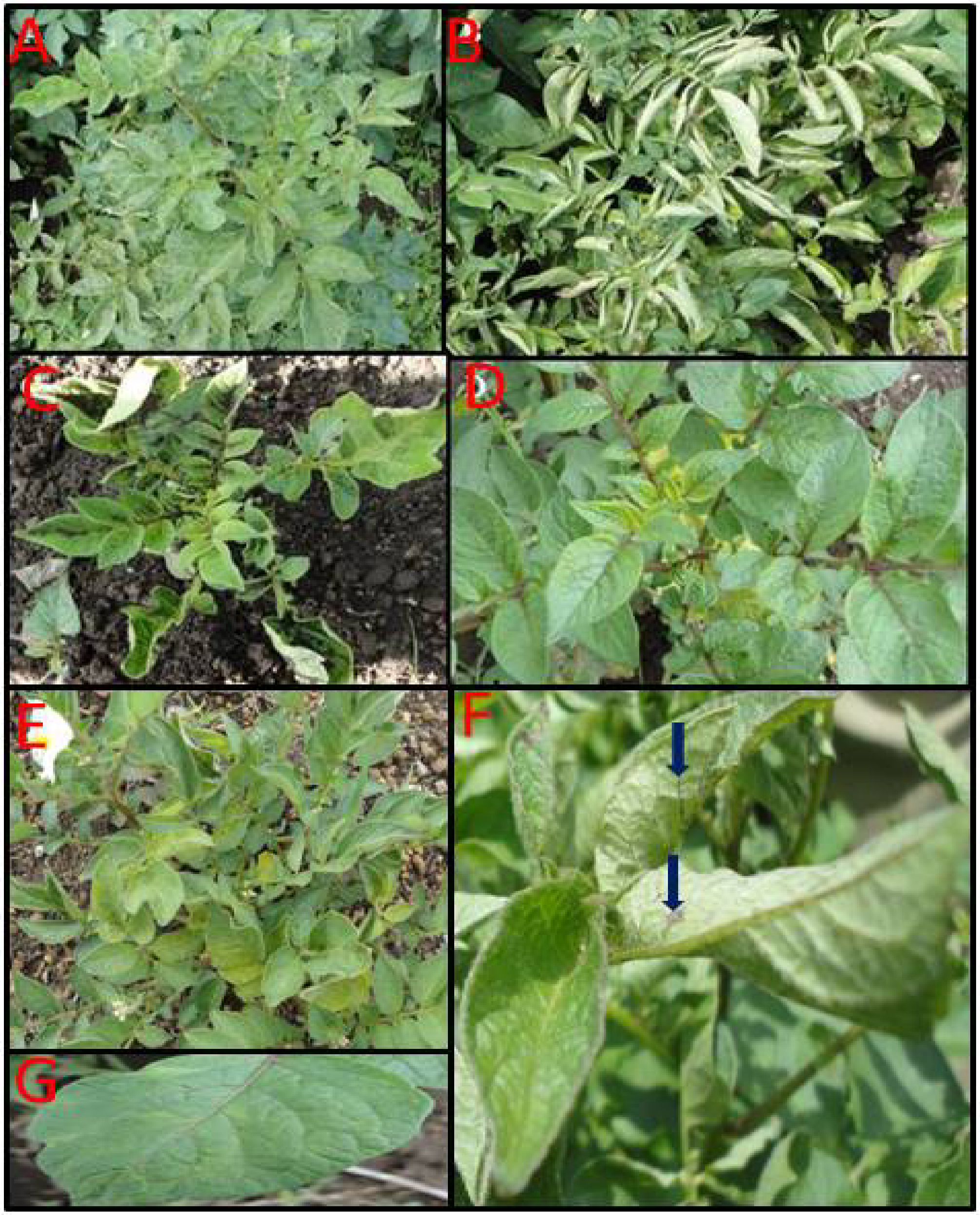


http://www.placesonline.com/maps_ok/tanzania.jpg


Mbeya, Tanzania


Agricultural Research Institute Uyole
Mbeya, Tanzania


© Evangelista Chiunga



Viruses occurring in potatoes in Mbeya region, Tanzania

Evangelista Chiunga

ARI-Uyole
ARI-Mikocheni
University of Helsinki

Leaf samples collected from13 potato farmers' fields in October-December 2011

Table 2. DAS- ELISA results from collected potato leaf samples

Locality	n	PVS	PVY	PVX	PVA	PLRV	PVM
Umalila	39	19	0	6	0	2	0
Kawetele	39	30	4	0	0	25	1
Kikondo	39	15	0	6	7	21	3
Mwakareli	39	10	0	14	2	14	1
Bonde la uyole	39	30	2	2	0	16	5
ARI- Uyole	24	16	0	3	0	7	1
∑	219	120	6	31	9	85	11
		56%	**3%**	**14%**	**4%**	**39%**	**5%**

n: Total number of potato leaves sampled per locality

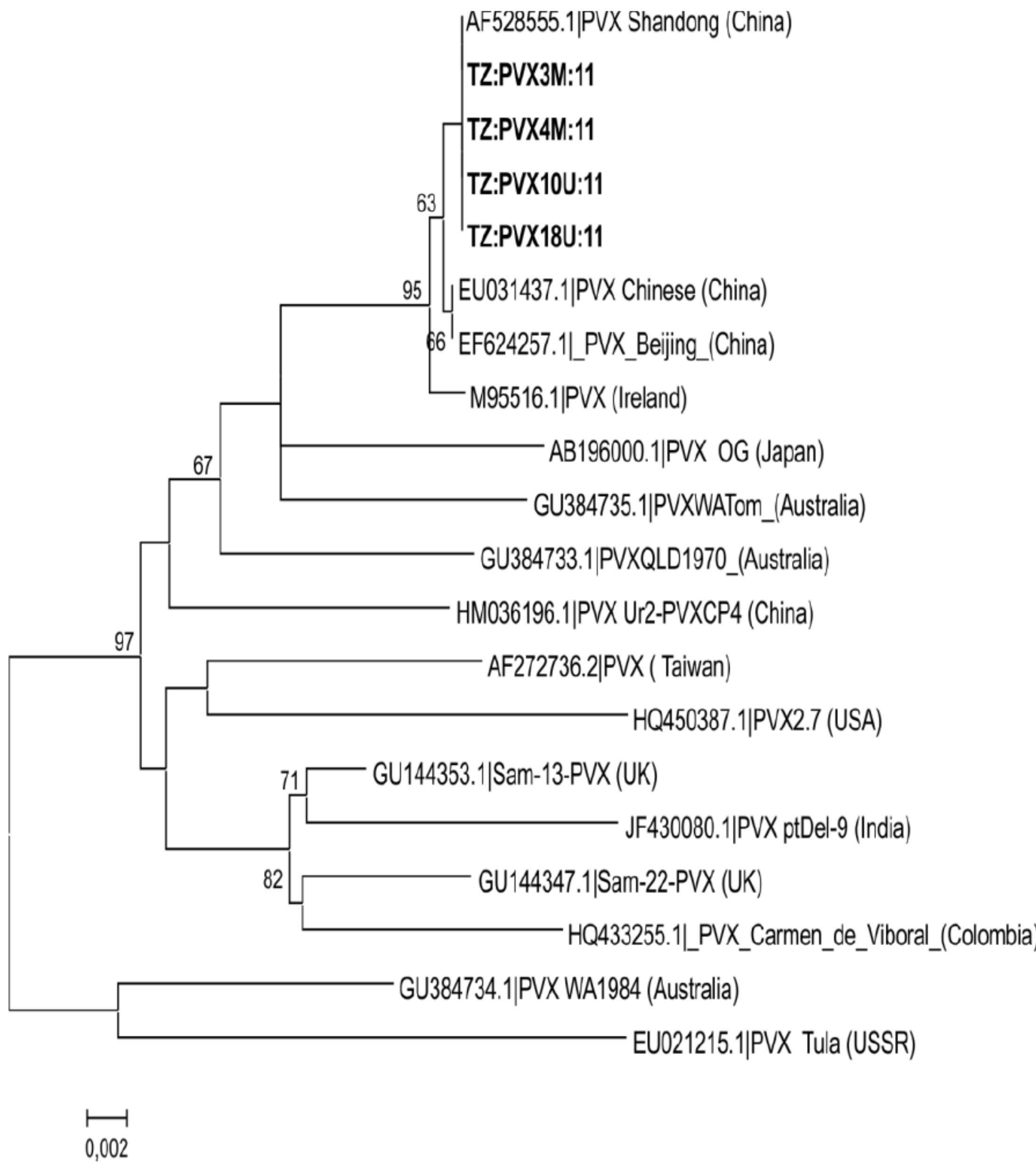
∑: Total number of potato leaves detected positive for each virus

Evangelista Chiunga
Master's thesis
University of Helsinki

Table 3. Mixed virus infections in potato plants

Locality	S + LR	S+ X	S + X	S + Y	S + A	S + M	S + X + LR	S + M + LR	S+M+LR+A	S + X + LR + A	X + LR	X + LR + A	X + M + LR	Y + LR	M + LR	M + LR + A	LR + A
Umalila	1	1	2	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Kawetele	16	0	0	2	0	0	0	0	0	0	0	0	0	2	1	0	0
Kikondo	9	0	0	0	1	0	1	0	0	1	0	1	1	1	0	1	0
Mwakareli	1	2	0	0	0	0	2	0	1	0	1	0	0	0	0	0	0
Uyole	5	0	0	2	0	1	0	4	0	0	2	0	0	0	0	0	0
ARI-Uyole	6	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Σ	38	5	2	4	1	1	3	4	1	1	5	1	1	3	1	1	1

International trade of potatoes distributes viruses



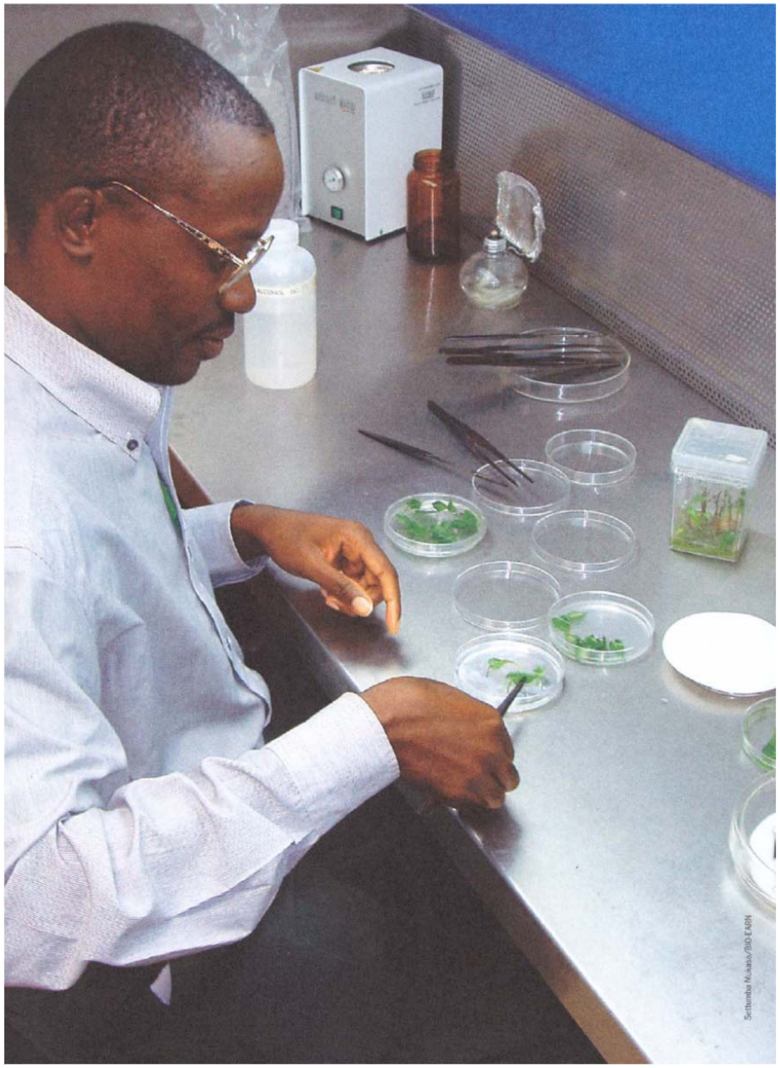
Control of virus diseases

1.Production and availability of healthy planting materials

Growth reduction caused by *Potato virus Y* strain O (PVY^O) when the plant grows from an infected seed tuber.

Potato virus Y^O	Healthy

Production of healthy plants using tissue culture techniques



Dr. Settumba Mukasa / BIO-EARN / Makerere University, Uganda

Jari Valkonen

Production of pathogen-free clones of potato cultivars

Regenerating meristem

Virus-free shoots propagated *in vitro*

Jari Valkonen

Photos: Jenni Kesulahti

Finnish Seed Potato Center, Tyrnävä

Finnish Seed Potato Center SPK, Tyrnävä

Finnish Food Safety Authority EVIRA, Loimaa

Control of virus diseases

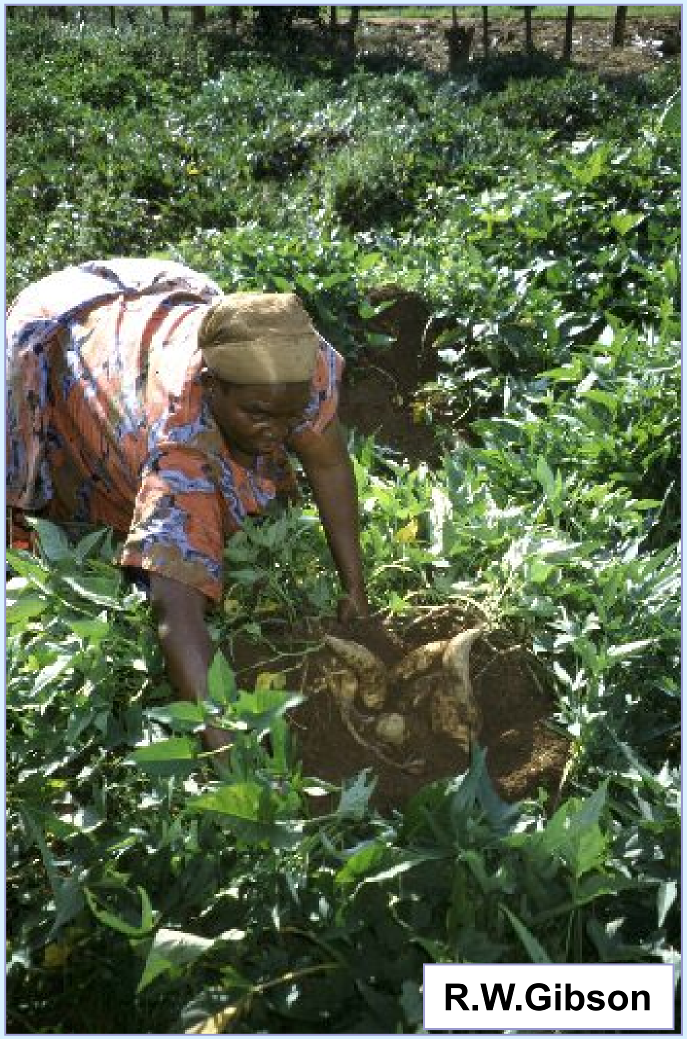
Production and availability of healthy planting materials: practises that can be applied at the farm level

- **Crop rotation (voluntary plants can be sources of viruses)**

- **"Select-the-Best" -practise introduced by International Potato Center (CIP): farmers mark disease-free potato plants in the field and use the tubers of them as seed.**

- **Symptomless sweetpotato vines used as planting materials**

Subsistence sweetpotato cultivation and piece-meal harvesting, Uganda



Control of virus diseases

Production and availability of healthy planting materials: practises that can be applied at the farm level

•Crop rotation (voluntary plants can be sources of viruses)

•"Select-the-Best" -practise introduced by International Potato Center (CIP): farmers mark disease-free potato plants in the field and use the tubers of them as seed.

•Symptomless sweetpotato vines used as planting materials

Control of virus diseases

1. Production and availability of healthy planting materials

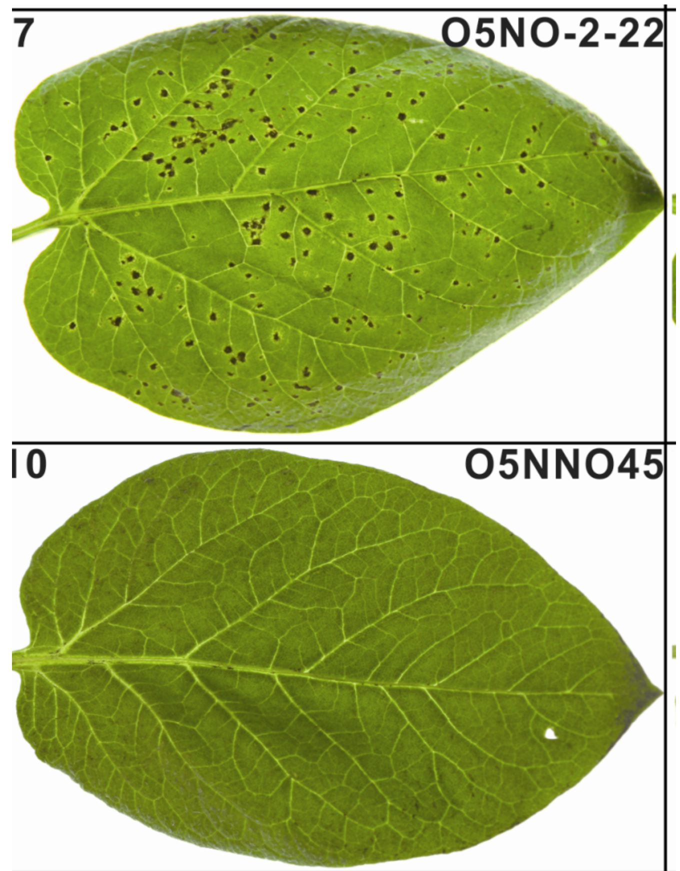
2. Use of virus-resistant cultivars

Gene-for-gene resistance

Hypersensitive, strain-specific resistance to *Potato virus Y* (PVY) in potato plants

**HR to PVY strain O is controlled by the gene *Ny* in potato:
Necrotic local lesions on the inoculated leaf.**

***Ny* does not recognize PVY strain N: the leaf becomes infected and no necrotic lesions appear**



Strain N of PVY (PVY^{N}) overcomes the resistance conferred by *Ny*

cv. Nicola

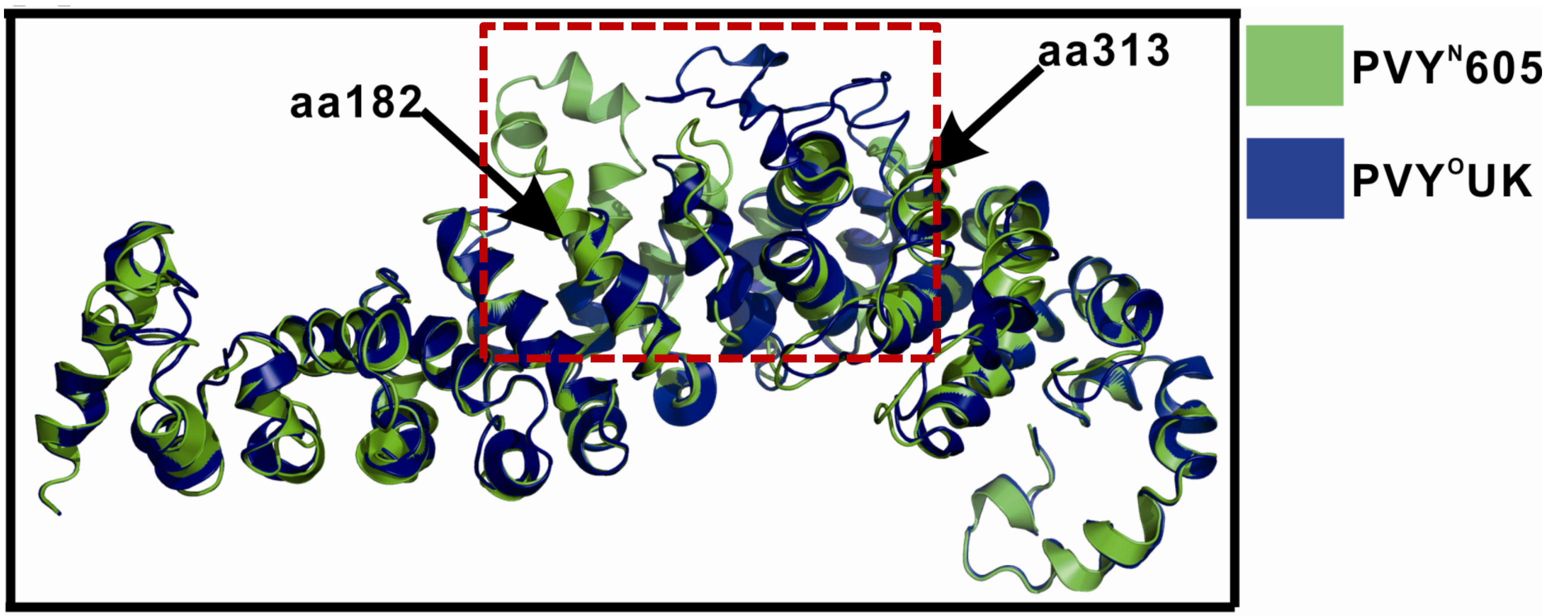
cv. Annabelle

PVY^{N}-NTN occurs in all potato growing areas, including Latin America, USA, Canada, Europe, Africa and Asia.

In some cultivars and under certain growth conditions, necrotic symptoms develop in tubers.

(Photos Y. Tian & J. Valkonen)

Specific recognition of PVY strain O by gene *Ny* in potato can be explained by predicted structural differences between strains O and N



3D modeling using I-TASSER

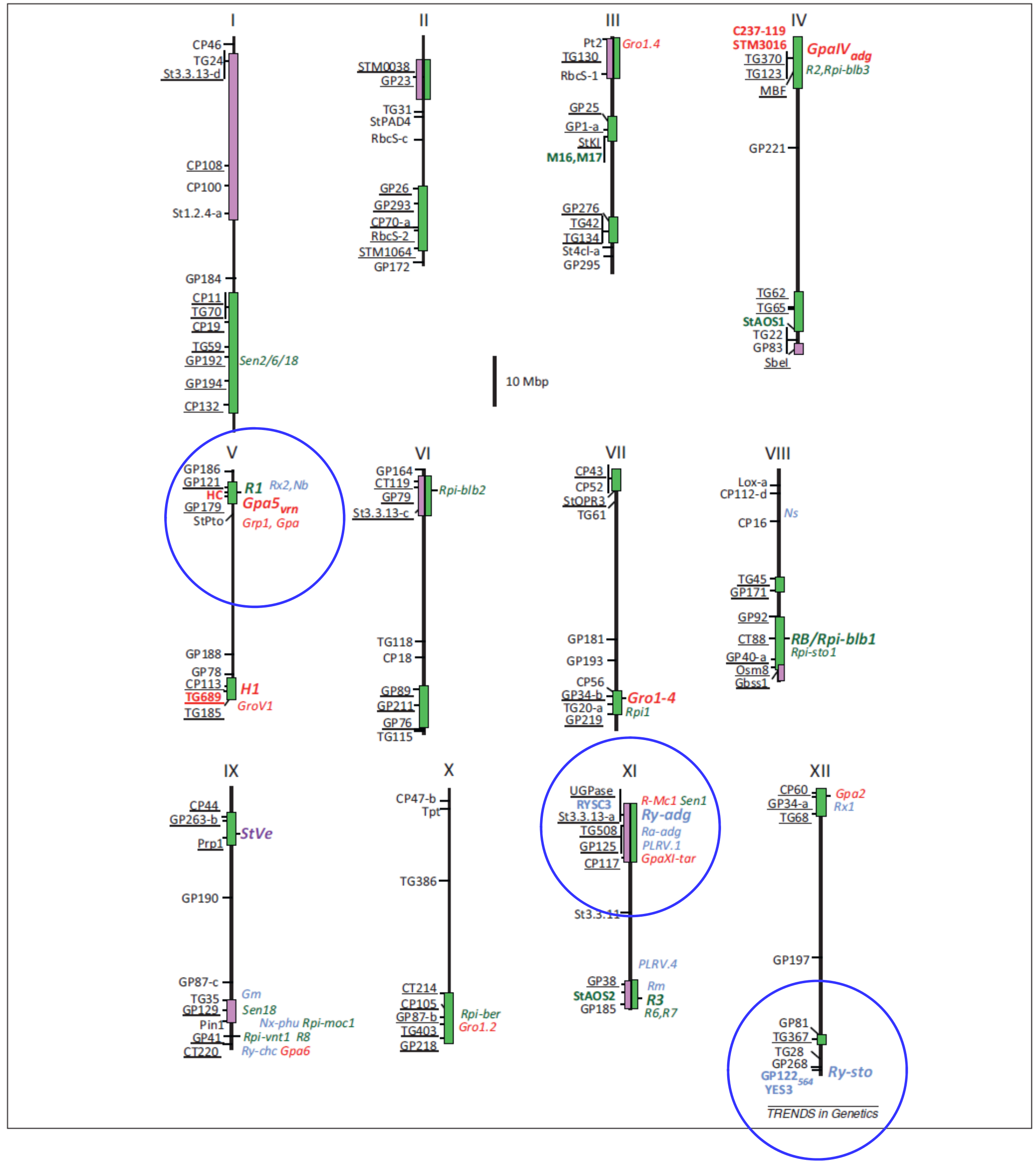
Tian & Valkonen 2013, MPMI 26: 297–305

Review
Christiane Gebhardt
Trends in Genetics April 2013, Vol. 29, No. 4

Virus resistance genes mapped to potato choromosomes

Extreme resistance (ER) (virus multiplication inhibited)

-No visible response
-Effective against all strains

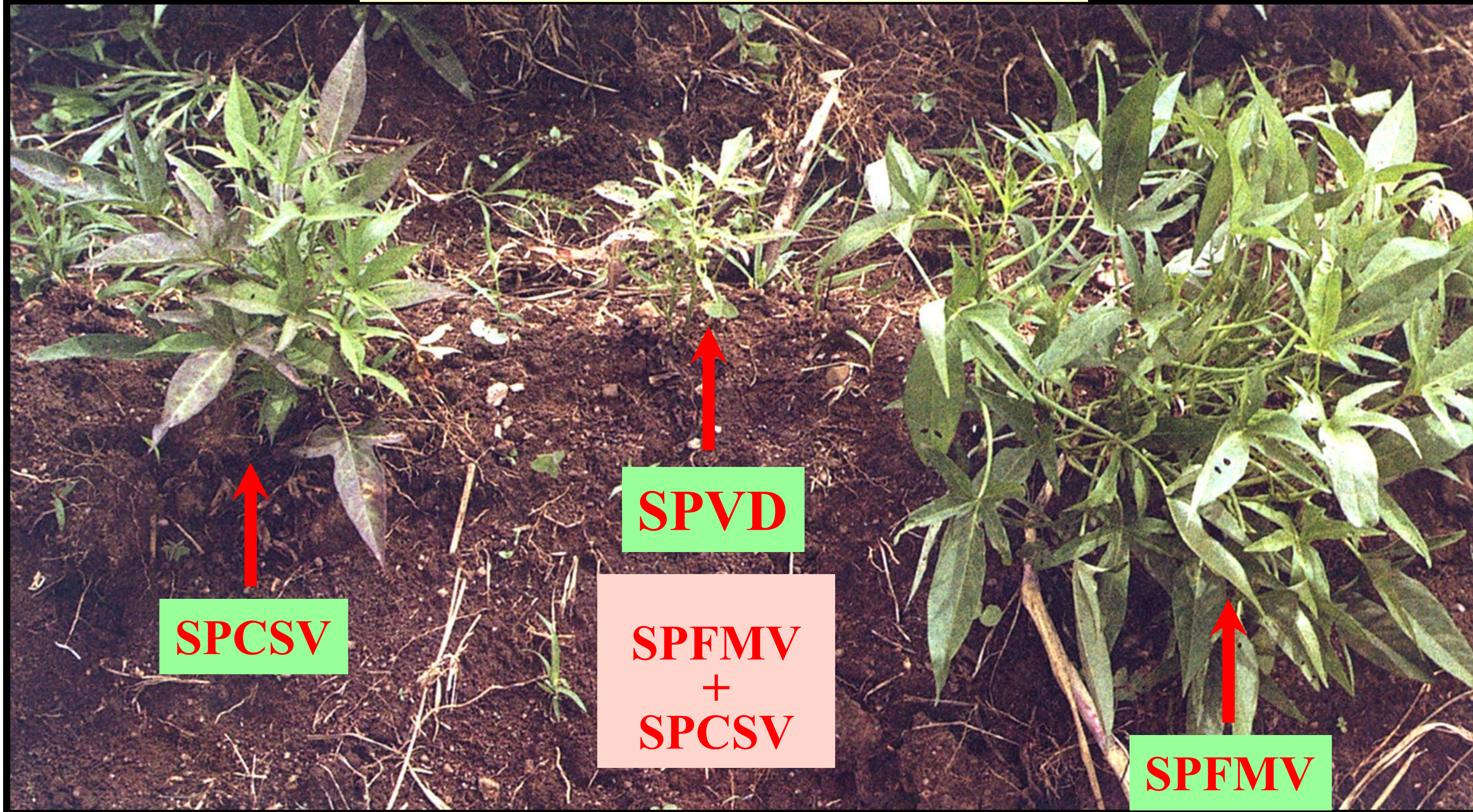


Control of virus diseases

2. Use of virus-resistant cultivars

- Durability of resistance in mixed virus infections?
  Which viruses should be targeted by resistance?

Viral synergism
Sweet Potato Virus Disease (SPVD)
- the main disease of sweetpotatoes

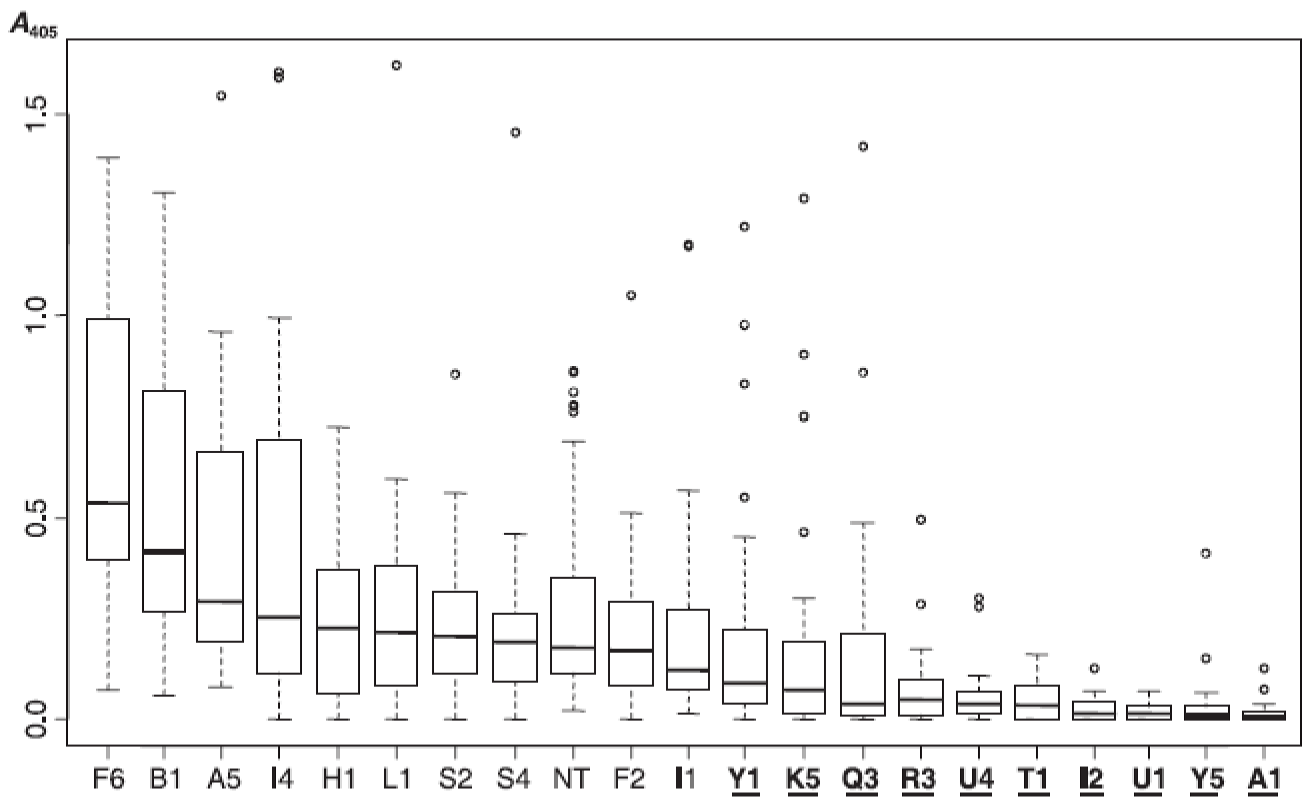


Karyeija et al. 2000. Virology 269: 26-36.
Gibson et al. 2004. Virus Res. 100: 115-122.

R.W.Gibson


SPFMV
+
SPCSV
= SPVD
R.W.Gibson

Virus-derived transgenic resistance to SPCSV: Titers of SPCSV in transgenic sweetpotato plants



The resistance to SPCSV broke down following infection with SPFMV, resulting in development of SPVD

KREUZE et al. (2008) MOLECULAR PLANT PATHOLOGY 9: 589–598

Control of virus diseases

2. Use of virus-resistant cultivars

•Durability of resistance in mixed virus infections?
Which viruses should be targeted by resistance?

Transgenic virus-specific resistance based on RNA silencing is vulnerable to break-down in mixed virus infections.

Other sources of resistance ?

NASPOT varieties bred by Dr Mwanga in Uganda ?

Control of virus diseases

1. Production and availability of healthy planting materials

2. Use of virus-resistant cultivars

3. Comprehensive knowledge on viruses infecting the crop and prevailing in the cultivation environment

Generic methods needed for detection of new viruses and virus strains

Detection of alien viruses and viroids in plants by siRNA deep-sequencing

RNA silencing mechanism is activated by double-stranded RNA (dsRNA)

Viruses form dsRNA

- replicative forms of RNA viruses
- ds secondary structures of single-stranded RNA virus genomes
- ds secondary structures of RNA transcripts produced by DNA viruses

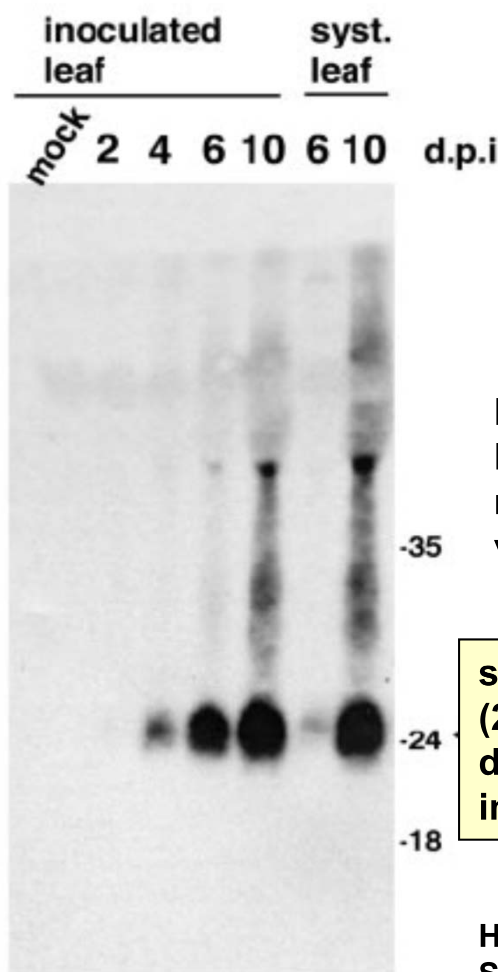
RNA silencing is an <u>antiviral defence mechamism</u>:

Viruses are always detected by the

RNA silencing defence mechanism in infected plants!

Viral RNA is detected and cleaved to small RNA by the RNA silencing mechanism

Northern blot,
virus-spefic probe



Dicer-like (DCL) enzymes DCL2 and DCL4 are responsible for detecting viral RNA in plants

siRNA
(21, 22 and 24 nt)
derived from Potato virus X
in an infected plant

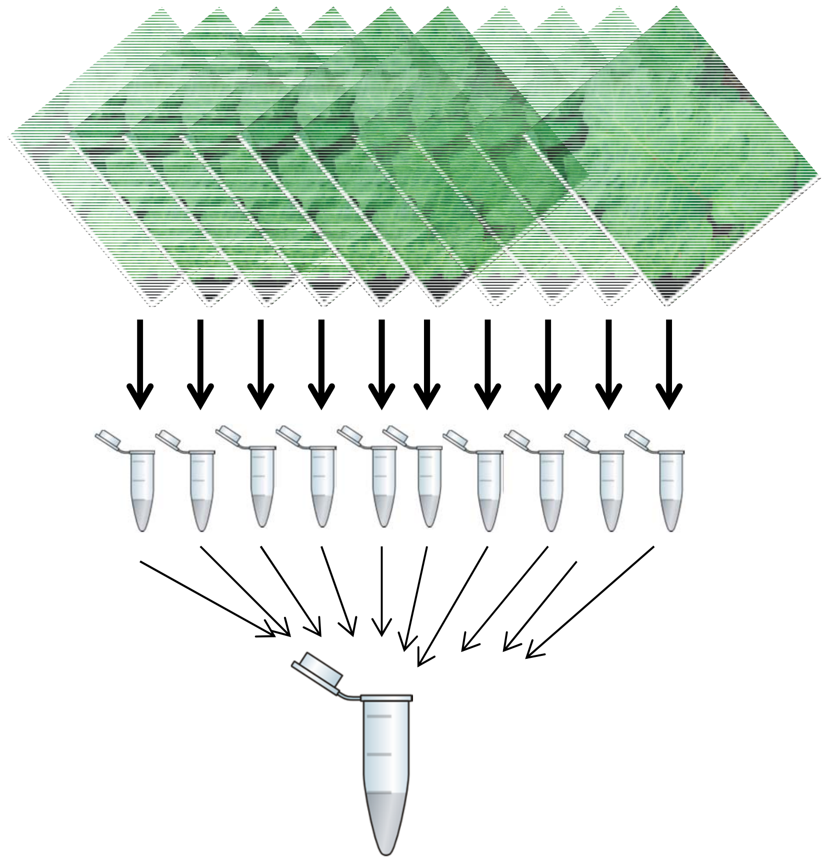
Hamilton & Baulcombe, 1999
Science 286:950-952

The plant detects the virus – we analyze the end products resulting from the defence response

siRNA can be isolated, sequenced, and viruses detected

Kreuze, J.F., Perez, A., Untiveros, M., Quispe, D., Fuentes, S., et al. (2009) Complete viral genome sequence and discovery of novel viruses by deep sequencing of small RNAs: a generic method for diagnosis, discovery and sequencing of viruses. Virology 388: 1–7.

Procedure



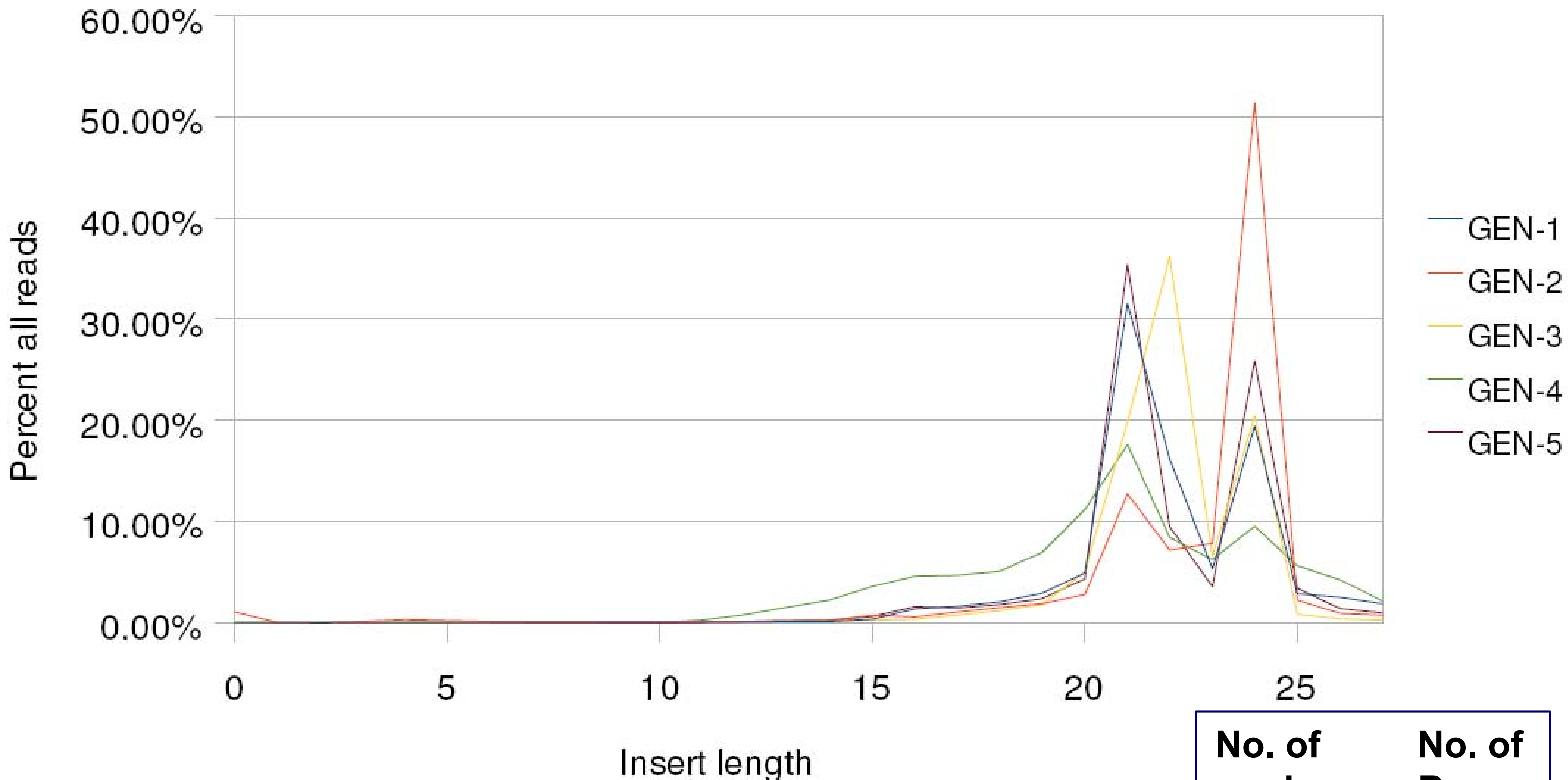
1. Collect samples (store in freezer)

2. Exract total RNA, check quality, measure concentration, store in freezer

3. Pool similar amounts of RNA from different samples (e.g., 50 plants)

The pool of RNA (5-10 µg) will be sent to a sequencing laboratory

Size classes of small RNA reads

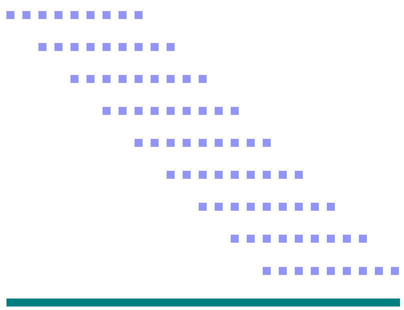


	No. of reads	No. of Bases
GEN-1	1'508'504	48'272'128
GEN-2	4'749'857	151'995'424
GEN-3	4'155'175	132'965'600
GEN-4	1'728'098	55'299'136
GEN-5	1'218'575	38'994'400

Jari Valkonen

Data analysis ja utilization - A

5. Original RNA molecules or parts thereof are reconstructed from overlapping siRNA sequences:



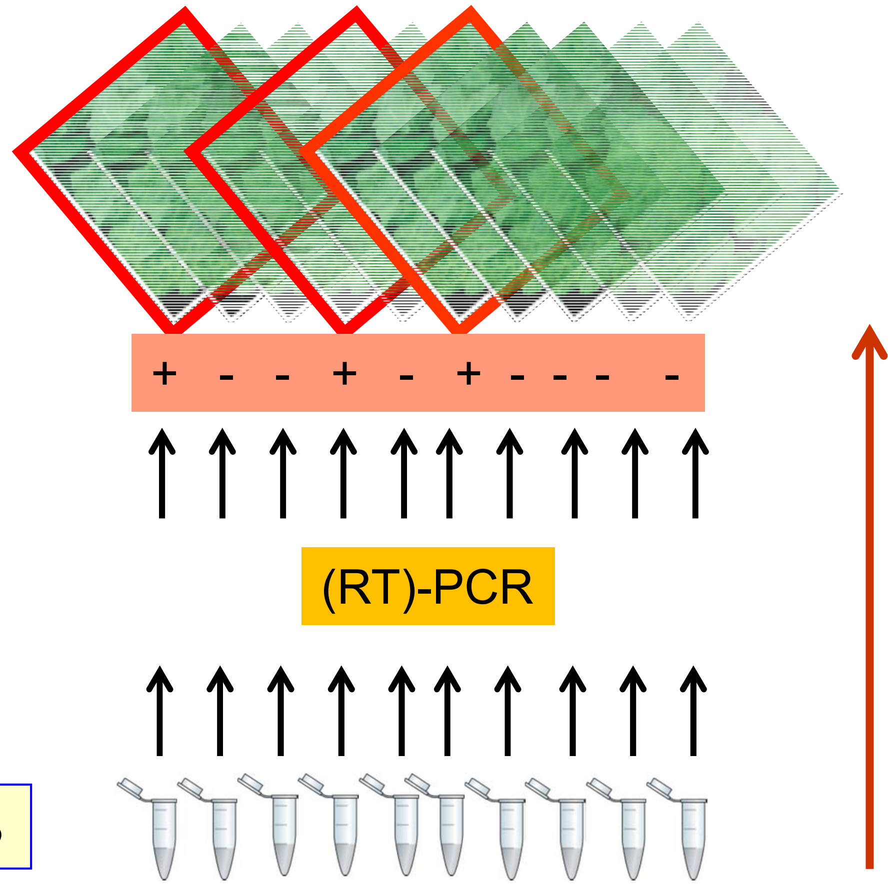
Data analysis using bioinformatics may be all what is needed

6. Reconstructed RNA molecules are identified by comparison with sequences in public databases

7. VIRUSES DETECTED!

8. Are the detected viruses new strains, or new viruses? Analyses can be continued by mapping siRNA reads to the genomes of viruses found in the sample (or to the closest-related viruses).

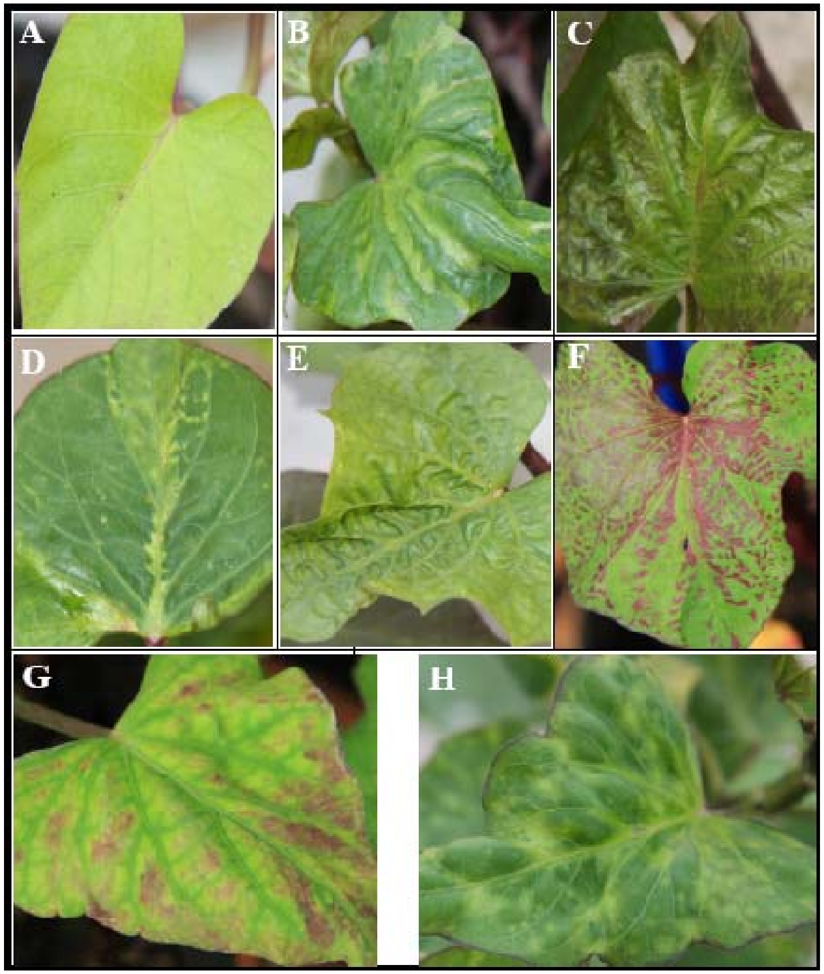
Identification of infected plants if needed



Data analysis ja utilization - B

9. PCR primer pairs designed based on the reconstructed viral genomes; original samples (RNA stored in freezer) tested by RT-PCR to detect the infected plants

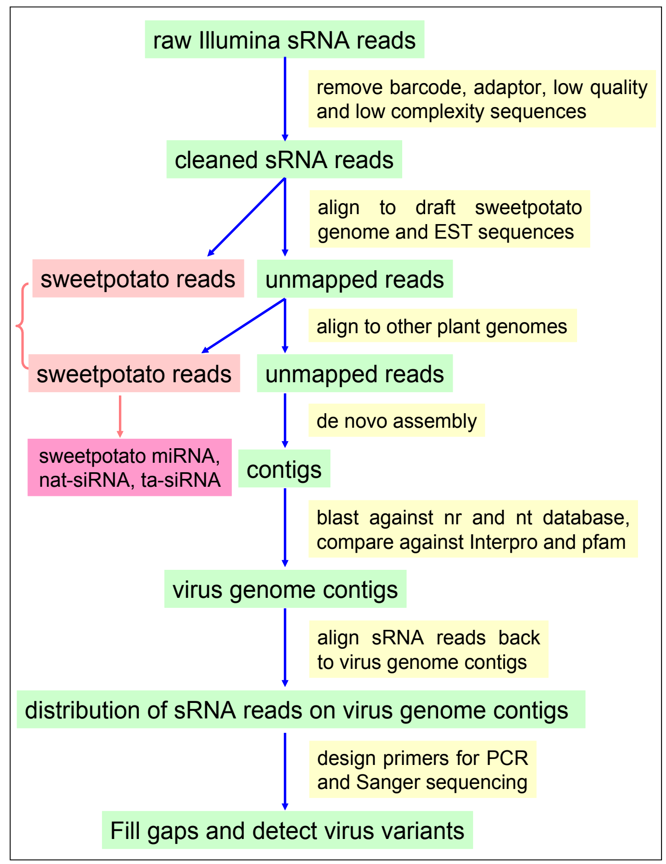
SPPV-A	*Sweet potato pakakuy virus*, strain A	DNA, pararetro
SPPV-B	*Sweet potato pakakuy virus*, strain A	DNA, pararetro
SPLCGV	*Sweet potato leaf curl Georgia virus*	DNA, gemini
SPCSV-WA	*Sweet potato chlorotic stunt virus*, strain WA	RNA, crini
SPFMV	*Sweet potato feathery mottle virus*	RNA, poty
SPVC	*Sweet potato virus C*	RNA, poty



Kashif, Pietilä, Artola, Jones, Tugume, Mäkinen and Valkonen:
Detection of viruses in sweetpotatoes from Honduras and Guatemala augmented by deep-sequencing of small-RNAs.
Plant Disease 96:1430-1437 (2012)

Going to scale: the pan African sweetpotato virome

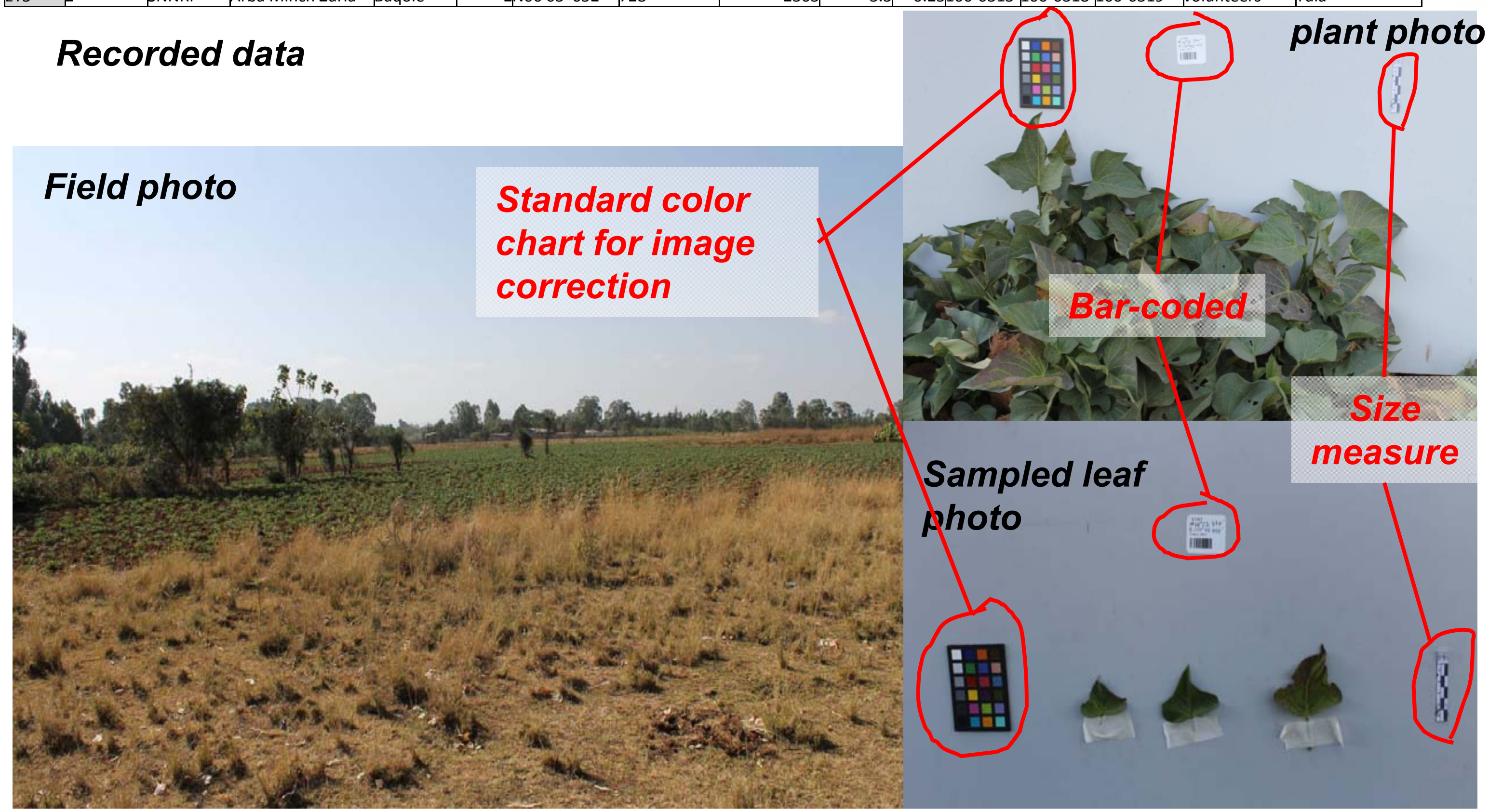
- **~2000 samples and bioinformatics pipeline for virus identification using siRNA assembly and genome subtraction**



Recorded data

Sample number	Date	Region	District	Locality	Field number	GPS Longitude	Latitude	Altitude (m)	Crop age (months)	Field size	Photo number field	Photo number plant	Photo number leaf	Intercrop	Cultivar/species	Notes
ET1	23/01/2012	SNNRP	Arba Minch Zuria	Zigiti Baqole	1	N06 04' 552"	E 037 27' 450"	2455	4	0.01	100-0304	100-0305	100-0306	Enset + kale	Local (Ambo)	
ET2	23/01/2012	SNNRP	Arba Minch Zuria	Zigiti Baqole	1	N06 04' 552"	E 037 27' 450"	2455	4	0.01	100-0304	100-0309	100-0310	Enset + kale	Local (Ambo)	
ET3	23/01/2012	SNNRP	Arba Minch Zuria	Zigiti Baqole	1	N06 04' 552"	E 037 27' 450"	2455	4	0.01	100-0304	100-0311	100-0312	Enset + kale	Local (Ambo)	
ET4	23/01/2012	SNNRP	Arba Minch Zuria	Zigiti Baqole	2	N06 03' 652"	E 037 27' 728"	2365	3.5	0.25	100-0313	100-0315	100-0317	Potato volunteers	Ambo	
ET5	23/01/2012	SNNRP	Arba Minch Zuria	Zigiti Baqole	2	N06 03' 652"	E 037 27' 728"	2365	3.5	0.25	100-0313	100-0318	100-0319	Potato volunteers	Tula	

Recorded data



Mozambique

sample		Virus identified										
#	region	SPFMV	SPVC	SPVG	SPV2	SPMMV	SPCSV	SPCFV	SPLCV	SPPV	SPSMV	new
1	Angonia									X		
2	Angonia	X								X		
3	Angonia	X	X							X		
4	Angonia	X	X		X	X	X		X	X		
5	Angonia	X	X	X			X		X	X		p
7	Angonia	X					X		X	X		
8	Angonia	XX	XX	X						X		p
10	Angonia	X							X	X		
14	Gurue											
15	Gurue	XX	XX		X	XX	X			X	X	
17	Gurue	X	X		X	XX	X		X	X		
18	Gurue	XX	X	X	X	XX				X	X	p
19	Gurue	X					X			X	X	
20	Gurue	XX	X	X						X	X	p
21	Gurue	X										
22	Gurue	X		X			X		X		X	
24	Gurue									X		
25	Gurue	XX	X		X	XX	X			X	X	
27	Gurue	X	X		X	X	X			X	X	
28	Maputo	XX							X	X		
31	Maputo	XX			X	XX	X			X		p
32	Maputo	XX	X	X					X	X	X	p
33	Maputo	X	X		X	X			X	X		
34	Maputo	X	XX			X	X		X	X		
35	Maputo	X					X			X		
36	Maputo	XX	XX	X		XX	XX			X		
37	Maputo	X	X	X					X	X		
39	Maputo	X	X				X			X		
41	Chockwe	XX	X	X		XX	X		X	X	X	
42	Chockwe	X	X	X		X	X		X	X		
44	Chockwe	XX	X	X		X		XX	X	X	X	
46	Chockwe	XX	X	X	X	XX	X		X	X		p,a
49	Chockwe	X				XX	X		X	X		
51	Chockwe	X	X	X		XX	X		X	X		p,a
55	Chockwe	XX				X	X		X	X		
66	**TANZANIA**	X					X		X	X		

Ghana & Burkina Faso

		Virus identified								
sample #	region	SPFMV	SPVC	SPCSV	SPCFV	SPLCV	SPVCV	SPPV	SPSMV	new
116	Baugonia					X		X		
23a	Bompro	X					X	X		
19a	Dompase	XX	XX	X		X				
30a	Dzogodze	XX				X		X		
104	Ejura	X				X		X	X	
102	Ejura	XX	X			X				
103	Ejura	X	XX	X				X		
105	Ejura	X		X		X		X	X	
11b	Esukyeano	X		X	XX	X		X		
12a	Esukyeano	X			X			X	X	
152b	Fumesua	X		X		X		X	X	
156a	Fumesua	X	X	X	X	X		X		
27a	Gomakarde	XX	X					X		
26a	Gomakarde	XX	X	X				X		
25a	Gomakarde	X		X		X		X		
133	Kamboinse	X		X		X		X	X	
137	Kamboinse	X		X		X				a
140	Kamboinse	X		X		X		X	X	a
135	Kamboinse	X		X				X		
13a	Komenda	XX	XX	X	X			X		
14a	Komenda	X	X					X		
15a	Komenda	XX			XX			X		
39a	Kporkuve	X		X		X		X		
6a	Krobo Kwamu	XX	XX		XX			X		
7a	Krobo Kwamu	X	X		X	X		X		
8a	Krobo Kwamu	X	X		X	X		X		
9a	Krobo Kwamu	X	X		X	X		X		
4a	Krobo Kwamu	X		X	XX	X		X		
32a	Kudzordzi Korpe	XX	XX			X		X		
31a	Kudzordzi Korpe	X				X		X		
40b	Lume			X		X		X		
41a	Lume					X		X		s
43a	Lume	X				X		X		
119	Manchoro					X		X		
122	Manchoro					X			X	
123	Manchoro					X		X	X	
124	Nimbasinia					X		X		
126	Nimbasinia	XX			X	X		X		
113	Nyangua					X		X	X	
111	Nyangua	XX	X		X	X		X		
130	Tekuru					X		X		
34a	Vume	XX	XX	X		X		X		
36a	Vume	X						X		
35a	Vume	X				X		X		

→ Cotton leaf curl Gezira alphasatellite – Burkina Faso

→ 'Nodavirales superfamily'

Control of virus diseases

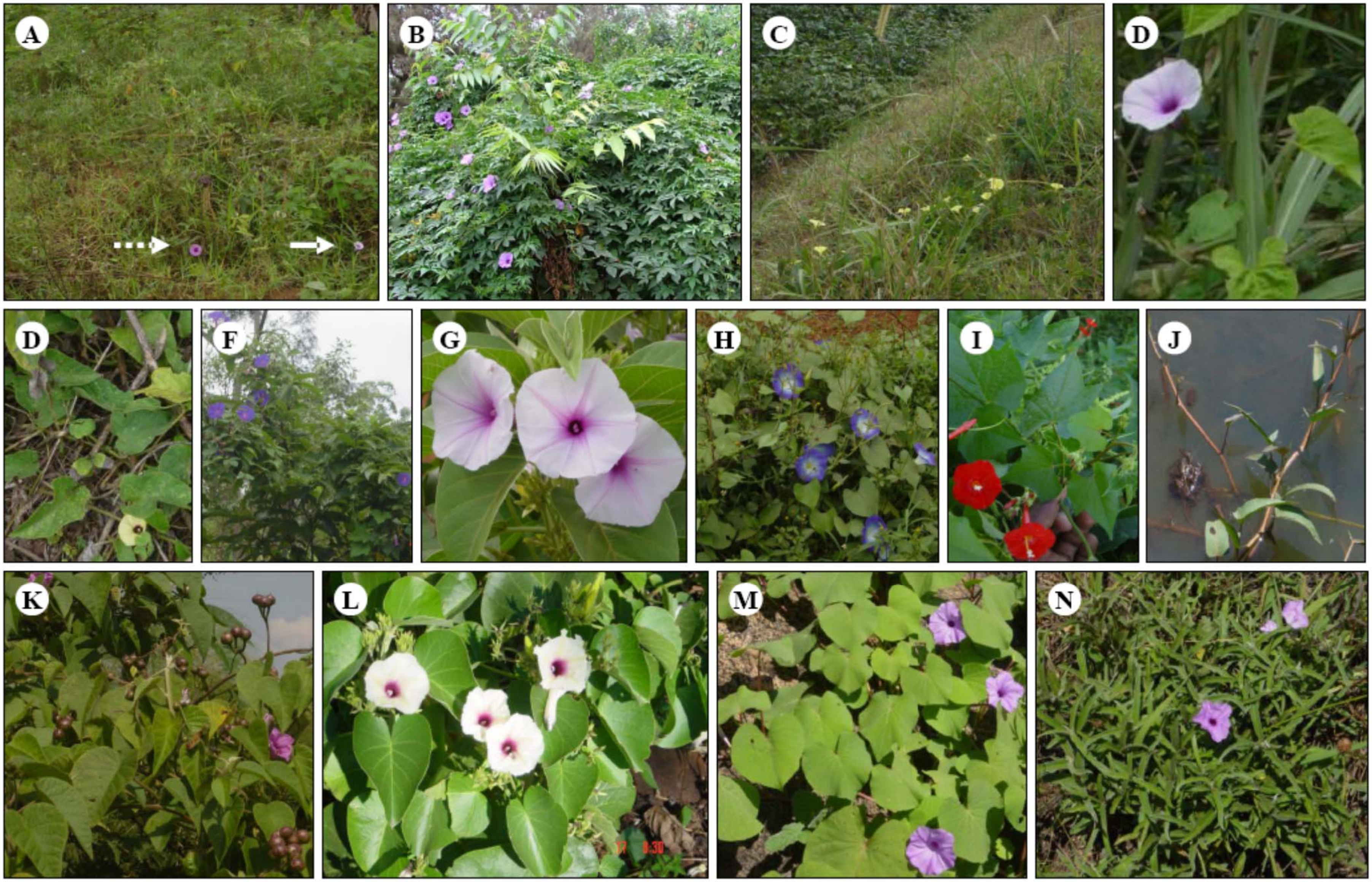
1. Production and availability of healthy planting materials
2. Use of virus-resistant cultivars

Control of virus diseases

1. Production and availability of healthy planting materials
2. Use of virus-resistant cultivars
3. Comprehensive knowledge on viruses infecting the crop and prevailing in the cultivation environment

- **Viruses infecting wild plants?**

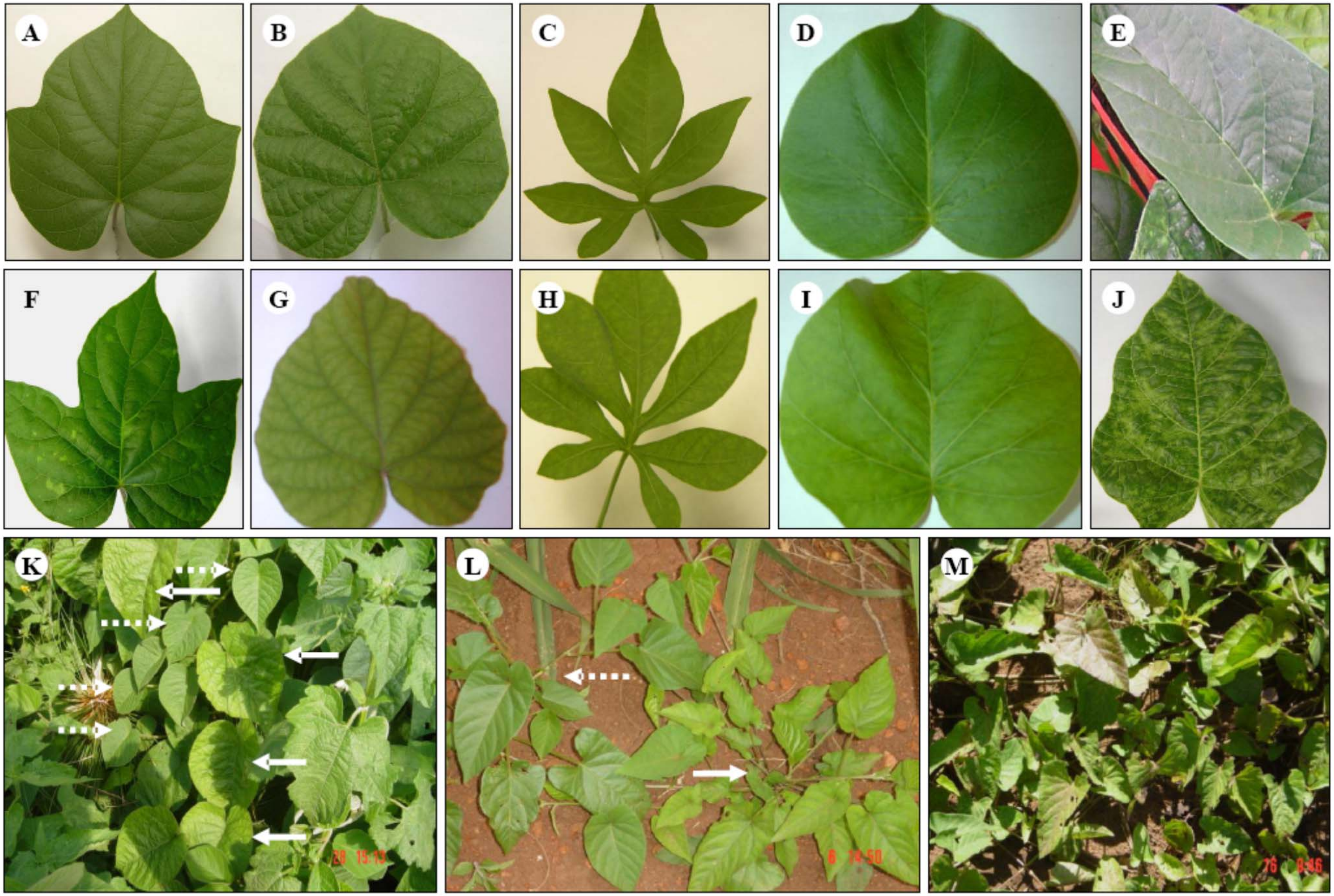
Ipomoea aquatica **just fished from the edge of a swamp by Arthur Tugume in Katakwi district, Uganda, in April 2007**



Wild species of *Ipomoea* in Uganda

Tugume et al. 2008.
Phytopathology 98: 640-652.

Various types of virus-like symptoms in wild *Ipomoea* species in Uganda



Tugume et al. (2010) Mol Ecol 19, 3139–3156

Survey in Uganda:

In all, 2,864 wild plants were observed for virus-like symptoms and tested for SPFMV in 2004 and 2007.

22 *Ipomoea* species, *Hewittia sublobata*, and *Lepistemon owariensis* were infected with SPFMV.

19 species were new hosts for SPFMV.

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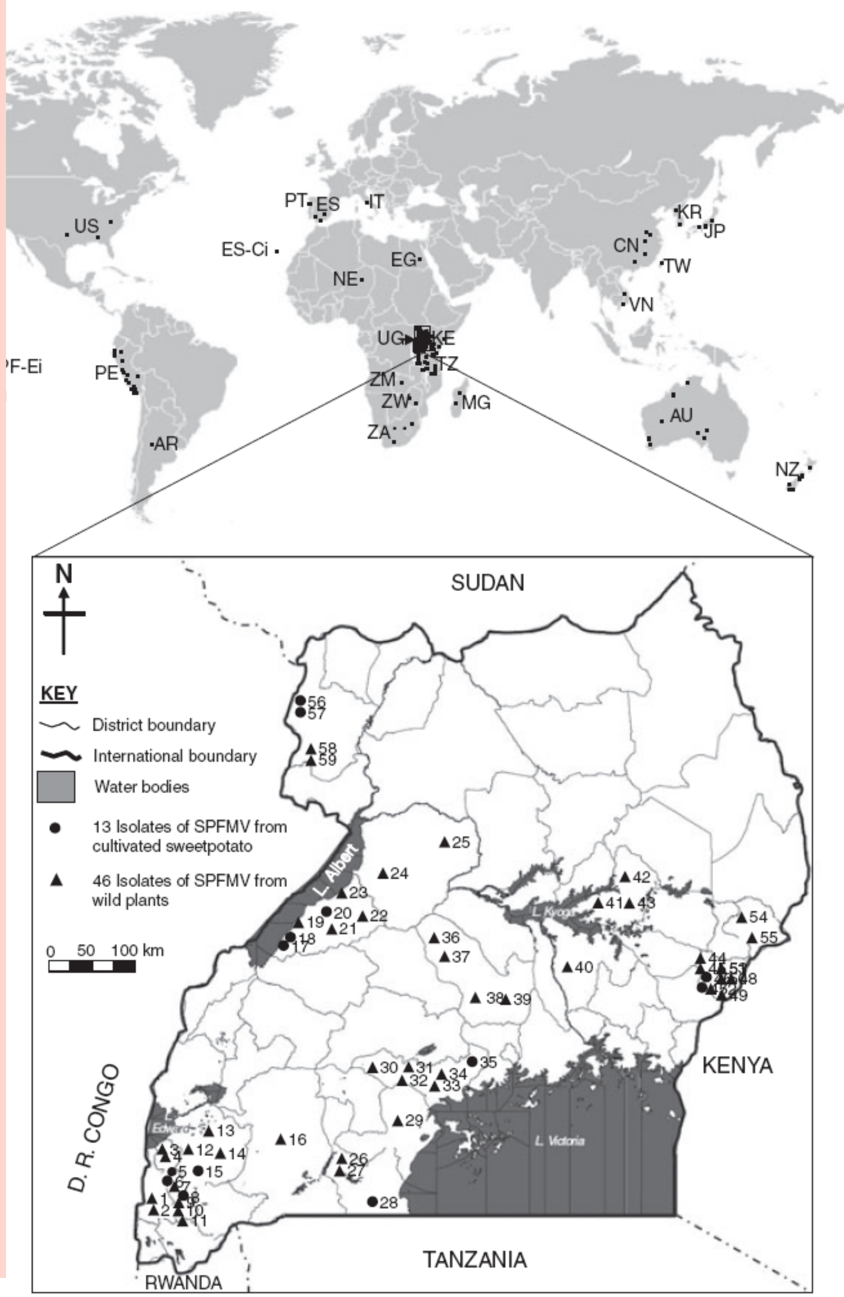

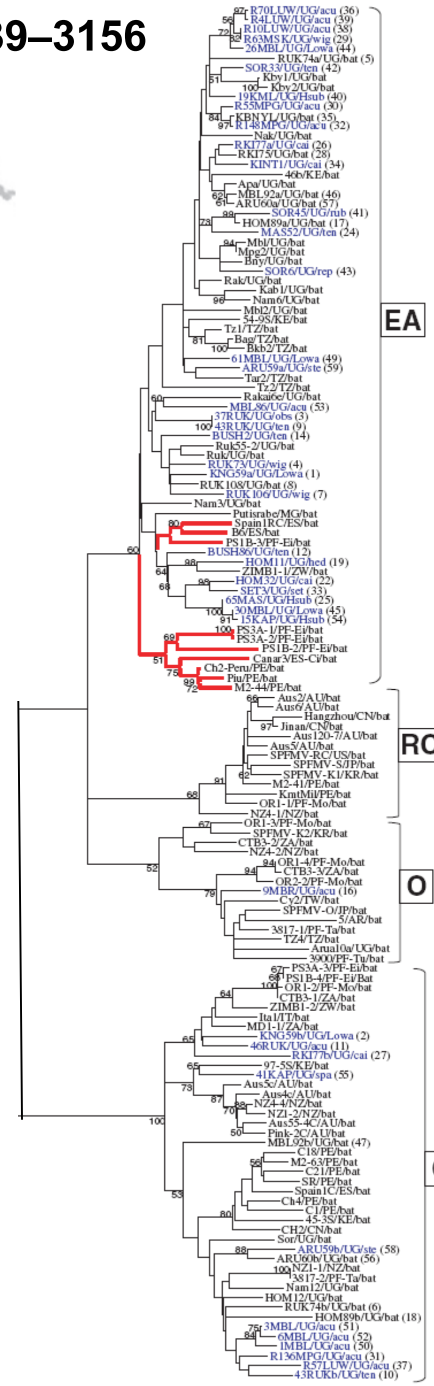

Conclusions

1. **Production of healthy planting materials is in progress but does not yet reach all farmers**

2. **Virus-resistant varieties of potato are needed, and while especially landrace sweetpotatoes show resistance to many viruses, resistance to mixed virus infections needs to identified**

3. **New methods will allow building comprehensive knowledge on viruses infecting the current crops and prevailing in the cultivation environment, especially in wild plant species, which informs strategies aiming to prevent infection of crops with viruses.**

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A Decade of Bioscience Development in Eastern Africa:
The BIO-EARN Programme 1999–2010

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TABLE 4. Number of plants that were expressing virus-like symptoms, those that were symptomless, and those that tested positive for *Sweet potato feathery mottle virus* (SPFMV) in nitrocellulose membrane enzyme-linked immunosorbent assay (NCM-ELISA) from each plant species observed and tested in 2004 and 2007[a]

		With virus-like diseases		Symptomless plants		Overall
Plant species	Total no. of plants	Total (%)[b]	SPFMV+[c]	Total (%)[d]	SPFMV+ (%)[e]	SPFMV+ (%)
2004						
Ipomoea acuminata	55	15 (27.3)	60	40 (73.7)	3 (7.5)	12 (21.8)
I. aquatica	12	4 (33.0)	100	8 (67.0)	3 (37.5)	7 (58.3)
I. blepharophylla	14	4 (29.0)	75	10 (71.0)	7 (70.0)	10 (71.4)
I. cairica	99	9 (9.1)	88.9	90 (90.9)	29 (32.2)	37 (37.4)
I. cordofana	10	0 (0.0)	0	10 (100.0)	1 (10.0)	1 (10.0)
I. crepidiformis	18	4 (22.0)	75	14 (78.0)	4 (28.6)	7 (38.9)
I. eriocarpa	134	5 (4.0)	0	129 (96.0)	1 (0.8)	1 (0.7)
I. grantii	9	0 (0.0)	0	9 (100.0)	1 (11.1)	1 (11.1)
I. hederifolia	13	5 (38.0)	60	8 (62.0)	1 (12.5)	4 (30.7)
I. hildebrandtii	11	1 (9.1)	100	10 (90.9)	2 (20.0)	3 (27.3)
I. involucrata	78	3 (4.0)	33.3	75 (96.0)	1 (1.3)	2 (2.6)
I. obscura	79	10 (12.7)	100	69 (87.3)	2 (2.9)	12 (15.2)
I. polymorpha	10	0 (0.0)	0	10 (100.0)	2 (20.0)	2 (20.0)
I. purpurea	10	2 (20.0)	100	8 (80.0)	3 (37.5)	5 (50.0)
I. repens	24	7 (29.0)	42.8	17 (71.0)	0 (0.0)	3 (12.5)
I. rubens	27	3 (11.0)	66.7	24 (89.0)	8 (33.3)	10 (37.0)
I. sinensis	143	45 (31.5)	88.9	98 (68.5)	10 (10.2	50 (35.0)
I. spathulata	15	1 (7.0)	100	14 (93.0)	6 (42.8)	7 (46.7)
I. stenobasis	13	6 (46.0)	100	7 (54.0)	1 (14.3)	7 (53.8)
I. tenuirostris	230	23 (10.0)	74	207 (90.0)	2 (0.9)	19 (8.3)
I. velutipes	10	1 (10.0)	100	9 (90.0)	2 (22.2)	3 (30.0)
I. wightii	62	10 (16.1)	90	52 (83.9)	4 (7.7)	13 (21.0)
Hewitta sublobata	420	67 (16.0)	91	353 (84.0)	22 (6.2)	83 (19.8)
Lepistemon owariensis	44	5 (11.4)	80	39 (88.6)	21 (53.8)	25 (56.8)
2007						
I. acuminata	102	20 (20.0)	80	82 (80.0)	14 (17.1)	30 (29.0)
I. aquatica	12	3 (25.0)	33.3	9 (75.0)	2 (22.1)	3 (25.0)
I. blepharophylla	–	–	–	–	–	–
I. cairica	121	6 (5.0)	66.7	115 (95.0)	10 (8.7)	14 (11.5)
I. cordofana	–	–	–	–	–	–
I. crepidiformis	12	0 (0.0)	0	12 (100.0)	1 (8.3)	1 (8.3)
I. eriocarpa	–	–	–	–	–	–
I. grantii	–	–	–	–	–	–
I. hederifolia	34	8 (24.0)	75	26 (76.0)	1 (3.8)	7 (20.5)
I. hildebrandtii	6	1 (17.0)	100	5 (83.0)	0 (0.0)	1 (16.7)
I. involucrata	–	–	–	–	–	–
I. obscura	75	10 (13.0)	50	65 (87.0)	4 (4.6)	8 (10.7)
I. polymorpha	–	–	–	–	–	–
I. purpurea	14	1 (7.1)	100	13 (92.9)	0 (0.0)	1 (7.1)
I. repens	3	1 (33.0)	100	2 (67.0)	0 (0.0)	1 (33.3)
I. rubens	10	2 (20.0)	50	8 (80.0)	0 (0.0)	1 (10.0)
I. sinensis	231	31 (13.0)	67.8	200 (87.0)	7 (3.5)	28 (12.1)
I. spathulata	27	2 (7.4)	100	25 (92.6)	2 (8.0)	4 (14.8)
I. stenobasis	10	1 (10.0)	100	9 (90.0)	0 (0.0)	1 (10.0)
I. tenuirostris	165	19 (12.0)	73.6	146 (88.0)	8 (5.5)	22 (13.3)
I. velutipes	–	–	–	–	–	–
I. wightii	51	6 (12.0)	50	45 (88.0)	1 (2.2)	4 (7.8)
H. sublobata	267	22 (8.2)	63.6	245 (91.8)	4 (1.6)	18 (6.7)
L. owariensis	53	4 (8.0)	75	49 (92.0)	5 (10.2)	8 (15.1)

[a] Dash (–) indicates that no observations and NCM-ELISA tests were conducted for a given species in the year 2007.
[b] Numbers in parenthesis represent the proportion of plants with virus-like symptoms as a percentage of total number of plants observed in a given year.
[c] Percentage and number of symptomatic plants that consistently and unambiguously showed a positive reaction in NCM-ELISA for SPFMV among the total number of plants with virus-like disease symptoms in a given year.
[d] Numbers in parenthesis represent the proportion of plants without virus-like symptoms as a percentage of total number of plants observed in a given year.
[e] Percentage and number of symptomatic plants that consistently and unambiguously showed a positive reaction in NCM-ELISA for SPFMV among the total number of plants without virus-like disease symptoms in a given year. Numbers in parenthesis represent the percentage of symptomless plants infected with SPFMV.

Tugume, Mukasa & Valkonen 2008. Phytopathology 98: 640-652.

Natural wild hosts of *Sweet potato feathery mottle virus* show spatial differences in virus incidence and virus-like diseases in Uganda.

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Seed Potato Development Project in Tanzania

1. Strengthened capacity for potato pathogen testing and cleaning
2. Capacity for pre-basic potato production improved
3. Increased capacity of certified potato production in Tanzania
4. Field management practices improved

Tanzania Official Seeds Certification Institute (TOSCI).

TOSCI's capacity to inspect and certify seed will be enhanced in the project through training in Quality Declared Seed protocol for potato.

- Increased number of private and community based seed potato producers;
- Increase in certified seed production (has);
- Number of TOSCI inspectors trained;
- Testing capacity of TOSCI (samples per season); and
- Number of farmers benefiting from clean seed.

All field multiplied seeds will be certified by TOSCI using the FAO QDS standard and/or other Tanzanian seed standards that may be in force. Prior to the certification, there need to be capacity building activities for TOSCI staff.