

Fusarium, een schimmel met vele gezichten

10-03-2016

Cees Waalwijk



Review

The Top 10 fungal pathogens in molecular plant pathology

RALPH DEAN¹, JAN A. L. VAN KAN², ZACHARIAS A. PRETORIUS³, KIM E. HAMMOND-KOSACK⁴, ANTONIO DI PIETRO⁵, PIETRO D. SPANU⁶, JASON J. RUDD⁴, MARTY DICKMAN⁷, REGINE KAHMANN⁸, JEFF ELLIS⁹ AND GARY D. FOSTER^{10,*}

Rank	Fungal pathogen
1	<i>Magnaporthe oryzae</i>
2	<i>Botrytis cinerea</i>
3	<i>Puccinia</i> spp.
4	<i>Fusarium graminearum</i>
5	<i>Fusarium oxysporum</i>
6	<i>Blumeria graminis</i>
7	<i>Mycosphaerella graminicola</i>
8	<i>Colletotrichum</i> spp.
9	<i>Ustilago maydis</i>
10	<i>Melampsora lini</i>

One Fungus, One Name: Defining the Genus *Fusarium* in a Scientifically Robust Way That Preserves Longstanding Use

David M. Geiser, Takayuki Aoki, Charles W. Bacon, Scott E. Baker, Madan K. Bhattacharyya, Mary E. Brandt, Daren W. Brown, Lester W. Burgess, Sofia Chulze, Jeffrey J. Coleman, James C. Correll, Sarah F. Covert, Pedro W. Crous, Christina A. Cuomo, G. Sybren De Hoog, Antonio Di Pietro, Wade H. Elmer, Lynn Epstein, Rasmus J. N. Frandsen, Stanley Freeman, Tatiana Gagkaeva, Anthony E. Glenn, Thomas R. Gordon, Nancy F. Gregory, Kim E. Hammond-Kosack, Linda E. Hanson, María del Mar Jiménez-Gasco, Seogchan Kang, H. Corby Kistler, Gretchen A. Kuldau, John F. Leslie, Antonio Logrieco, Guozhong Lu, Erik Lysøe, Li-Jun Ma, Susan P. McCormick, Quirico Migheli, Antonio Moretti, Françoise Munaut, Kerry O'Donnell, Ludwig Pfenning, Randy C. Ploetz, Robert H. Proctor, Stephen A. Rehner, Vincent A. R. G. Robert, Alejandro P. Rooney, Baharuddin bin Salleh, Maria Mercedes Scandiani, Jonathan Scauflaire, Dylan P. G. Short, Emma Steenkamp, Haruhisa Suga, Brett A. Summerell, Deanna A. Sutton, Ulf Thrane, Francis Trail, Anne Van Diepeningen, Hans D. VanEtten, Altus Viljoen, Cees Waalwijk, Todd J. Ward, Michael J. Wingfield, Jin-Rong Xu, Xiao-Bing Yang, Tapani Yli-Mattila, and Ning Zhang

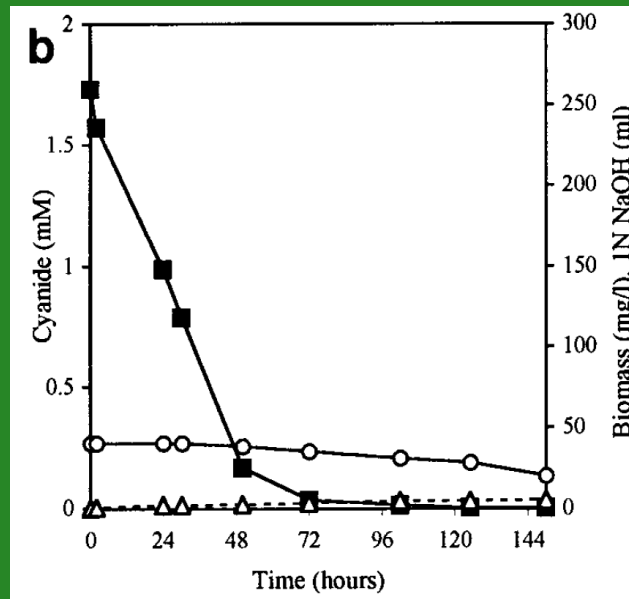
TABLE 1. Reference and internet search results for 15 agriculturally and medically important fungal/oomycete names; names associated with *Fusarium* are in bold

Taxon ^a	References ^b	h-index ^c	Google hits ^d
<i>Saccharomyces</i>	9,917	108	7,620,000
<i>Candida</i>	9,016	100	39,900,000
<i>Aspergillus</i>	7,822	81	6,440,000
<i>Fusarium</i>	5,397	66	3,810,000
<i>Cryptococcus</i>	1,665	59	395,000
<i>Neurospora</i>	789	51	317,000
<i>Phytophthora</i>	2,656	48	1,920,000
<i>Trichoderma</i>	1,738	45	1,790,000
<i>Penicillium</i>	2,066	35	2,470,000
<i>Magnaporthe</i>	619	37	671,000
<i>Ustilago</i>	368	34	171,000
<i>Colletotrichum</i>	1,032	31	673,000
<i>Gibberella</i>	277	30	314,000
<i>Verticillium</i>	749	29	282,000
<i>Mycosphaerella</i>	401	28	513,000
<i>Alternaria</i>	965	28	1,230,000
<i>Nectria</i>	51	11	388,000
<i>Neocosmospora</i>	8	2	62,200
<i>Haematonectria</i>	2	1	14,900
<i>Cyanonectria</i>	2	2	8,750
<i>Geejayessia</i>	1	1	1,050
<i>Albonectria</i>	1	1	7,260
<i>Fusarium solani</i>	299	21	433,000
<i>Nectria haematococca</i>	27	10	207,000
<i>Fusarium graminearum</i>	568	37	447,000
<i>Gibberella zeae</i>	152	24	132,000
<i>Fusarium verticillioides</i>	285	24	133,000
<i>Gibberella moniliformis</i>	11	6	51,700



De vele gezichten van Fusarium

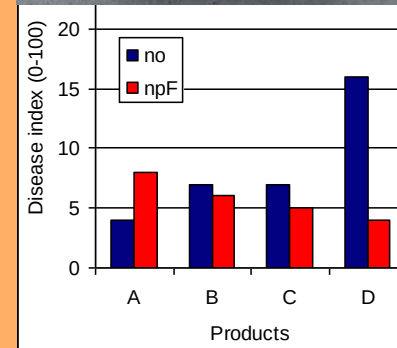
Bioremediation



Cyanide afbraak door
Fusarium solani

Dumestre *et al*, 1997

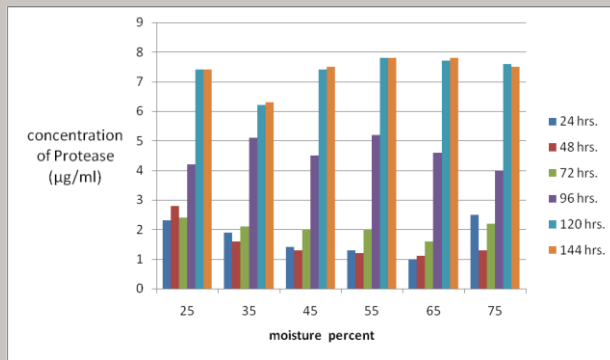
Biocontrol



Postma *et al*, 2003

De vele gezichten van Fusarium

Industriële enzymen



Vidhale, 2015

Vleesvervanger

F. venenatum

mycoprotein (QUORN)



- myco – fungus
- *Fusarium venenatum* / *graminearum*
- Single cell protein (SCP)
- http://www.mycoprotein.org/what_is_mycoprotein/product_process.

- Advantages
 - Similar texture to meat
 - Faster growth than meat
 - All essential amino acids, lower in fat, no cholesterol
 - Production can easily be changed with demand
 - Can be grown all year round
- Disadvantages
 - taste
 - Can be grown using waste as a substrate material such as paper and whey(curdled milk from which curds are removed)
 - Protein needs to be purified to avoid contamination
 - Care needs to be taken to avoid microbial infection of product



De vele gezichten van Fusarium

Plantpathogeen

F. graminearum e.v.a.
toxine-producent



Waalwijk *et al.*

Plantpathogeen

F. oxysporum
verwelking
rot



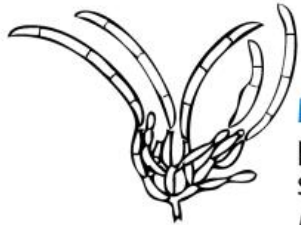
Scholten *et al.*



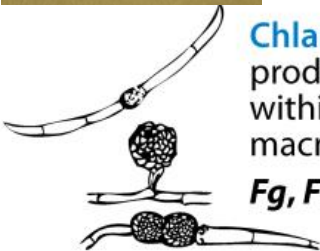
Asexual (mitotic) sporulation



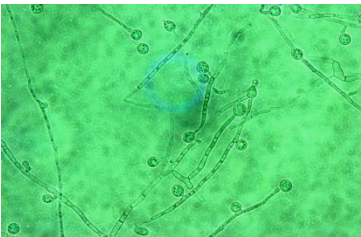
Microconidia
produced from
mycelial
conidiophores
Fol, Fs, Fv



Macroconidia
produced from
sporodochium
Fg, Fol, Fp, Fs, Fv

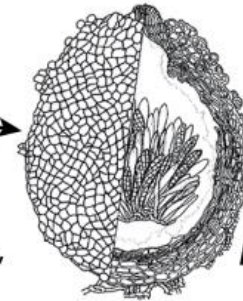


Chlamydospores
produced on and
within hyphae and
macroconidia
Fg, Fol, Fp, Fs



Fertilization by strain of
opposite mating type

Sexual (meiotic) sporulation



**Outcrossed perithecium
with asci and ascospores**

Karyogamy,
meiosis

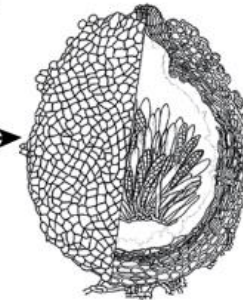
**Outcrossing: heterothallic
and homothallic species**



ascospore

**Apomictic selfing: restricted
to homothallic species**

Karyogamy,
meiosis



**Selfed perithecium
with asci and ascospores**

Fg

Haploid mycelium

Fusarium oxysporum een pathogeen met vele gastheren



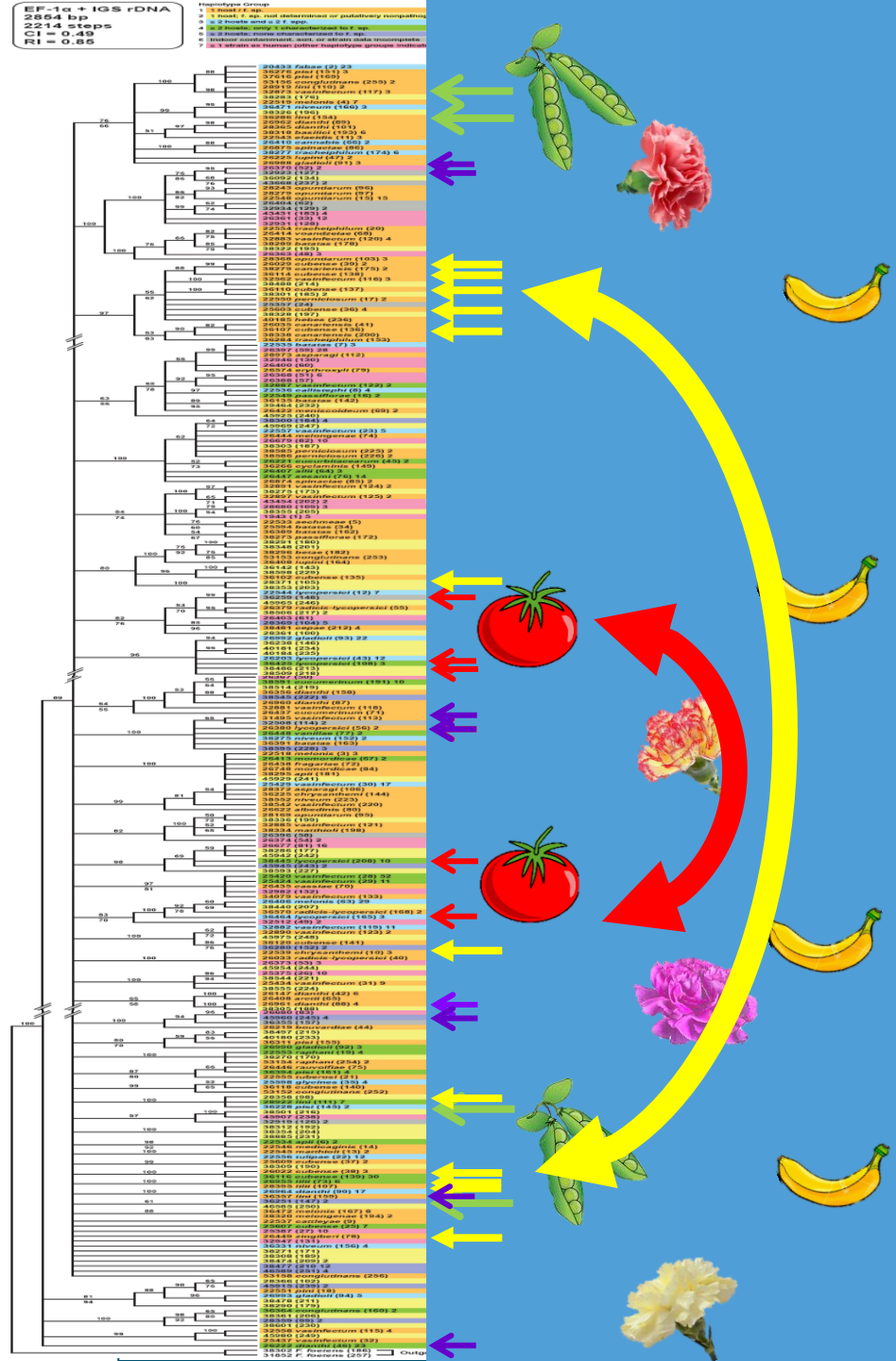
Meer dan 80
verschillende gastheren
>>> *formae speciales*

Table 1
Summary of *formae speciales* included in study.

Forma specialis ^a	# Isolates ^b	# Haplotypes ^c	VCGs ^d	Two-locus haplotype # [=ST]
<i>aechmeae</i>	1	1		5
<i>albedinis</i>	3	2	1	30, 80
<i>allii</i>	1	1	≥ 1	64
<i>apii</i>	5	4	3	2, 6, 145, 181
<i>arctii</i>	1	1		65
<i>asparagi</i>	8	5	≥ 1	7, 51, 93, 106, 112
<i>basilica</i>	5	2	1	66, 193
<i>batatas</i>	6	6	≥ 2	7, 34, 142, 162, 163, 178
<i>betae</i>	1	1	≥ 7	182
<i>bouvardiae</i>	1	1		44
<i>callistephi</i>	3	2		2, 8
<i>canariensis</i>	3	2	≥ 1	41, 200
<i>cannabis</i>	1	1		66
<i>cassiae</i>	1	1		70
<i>cattleyae</i>	1	1		9
<i>cepa</i>	3	3	1	7, 12, 212
<i>chrysanthemi</i>	4	2	2	10, 44
<i>conglutinans</i>	17	8	≥ 3	2, 27, 160, 174, 252, 253, 255, 256
<i>cubense</i>	25	13	≥ 24	7, 25, 36–39, 115–116, 135–141
<i>cucumerinum</i>	2	2	≥ 6	71, 91
<i>cucurbitacearum</i>	2	2		3, 45
<i>cyclaminis</i>	1	1	3	149
<i>dianthi</i>	34	9	6	7, 42, 46, 87–90, 101, 158
<i>elaeidis</i>	6	2	≥ 5	11, 256
<i>erythroxyli</i>	1	1	2	79
<i>fabae</i>	2	2		2 (= <i>F. inflexum</i>), 30
<i>fatshederae</i>	1	1		43
<i>fragariae</i>	1	1	≥ 4	72
<i>gladioli</i>	28	8	6	7, 22, 23, 91–94
<i>glycines</i>	1	1		35
<i>heliotropae</i>	1	1		22
<i>koae</i>	1	1		231
<i>lactucum</i>	1	1	1	22
<i>lagenariae</i>	1	1	1	35
<i>lentis</i>	1	1		171
<i>lilii</i>	4	2	1	73, 107
<i>lini</i>	15	6	1	2, 90, 110, 111, 154, 159
<i>loti</i>	1	1	1	2
<i>lupine</i>	3	2	≥ 2	47, 164
<i>lycopersici</i>	37	8	≥ 4	43, 56, 63, 108, 150, 165, 166, 208
<i>matthioli</i>	5	3	1	13, 22, 198
<i>medicaginis</i>	5	3	3	14, 82, 93
<i>melongenae</i>	3	2	1	74, 194
<i>melonis</i>	18	5	≥ 8	3, 4, 63, 165, 167
<i>meniscoideum</i> (var)	2	1		69
<i>momordicae</i>	2	2		67, 84
<i>narcissi</i>	3	1		8
<i>nicotianae</i>	1	1	≥ 2	93
<i>niveum</i>	5	4	3	150, 156, 166, 223
<i>opuntiarum</i>	22	6	7	15, 30, 95–97, 103
<i>palmarum</i>	5	2		250, 251
<i>passiflorae</i>	2	2		16, 172
<i>perniciosum</i>	7	4		17, 94, 225, 226
<i>phaseoli</i>	4	2	8	51, 93
<i>pini</i>	3	1		18
<i>psi</i>	26	10	≥ 5	2, 27, 51, 90, 93, 145, 151, 155, 161, 169
<i>radicis-lycopersici</i>	5	4	≥ 9	40, 55, 165, 168
<i>raphani</i>	5	2	1	19, 254
<i>rauvolfiae</i>	1	1		75
<i>sesame</i>	1	1		76
<i>spinaciae</i>	3	2	3	85, 86
<i>tracheiphilum</i>	4	4	1	20, 81, 153, 174
<i>tuberosae</i>	1	1	6	21
<i>tulipae</i>	3	1	1	22
<i>vanillae</i>	1	1	≥ 2	77
<i>vasinfectum</i>	135	24	≥ 12	7, 23, 28–32, 63, 81, 113, 115–125, 133, 134, 220
<i>voandzeiae</i>	1	1		68
<i>zingiberi</i>	3	2		78, 119



Moleculaire verwantschappen



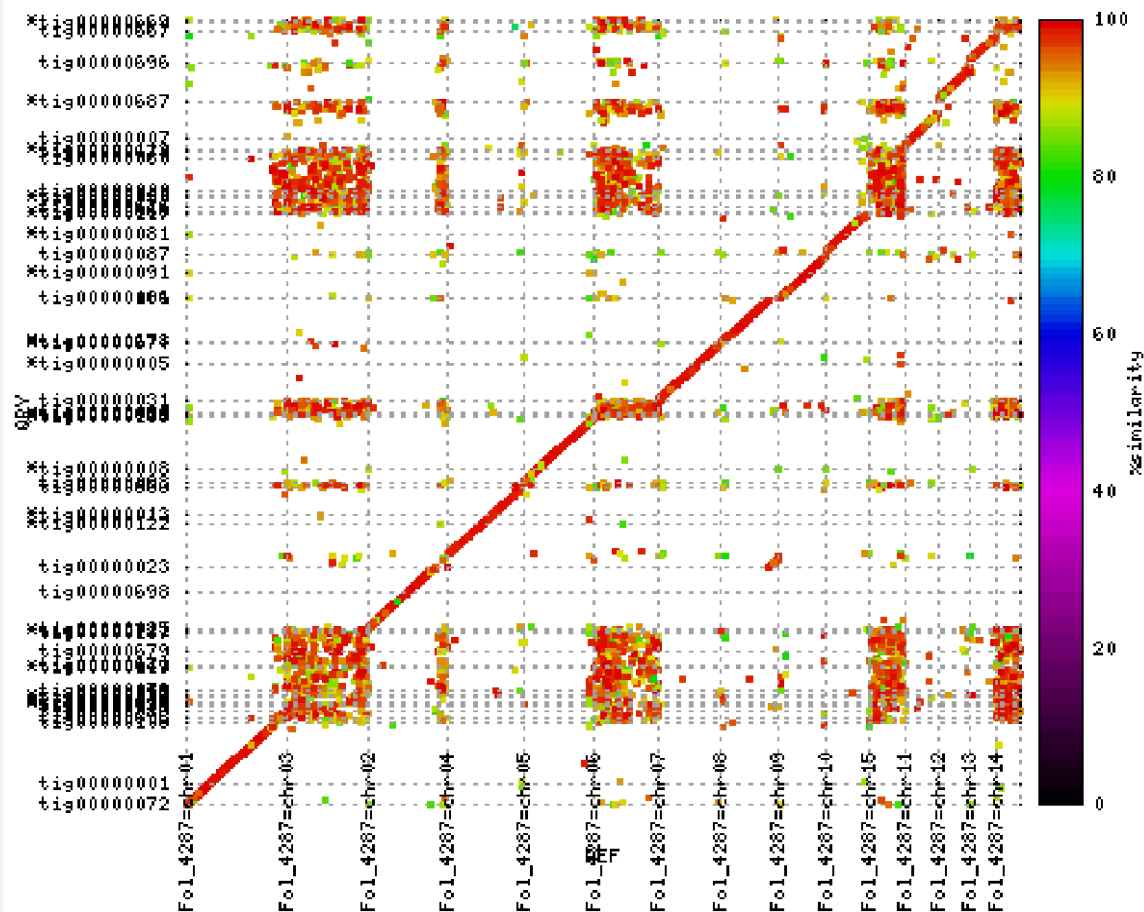
LS chromosomes and pathogenicity



Fol reference genome 4287
race 2 - VCG 0030

F. oxysporum strain Fo47
Biocontrol

DNA van *F. oxy* van radijs

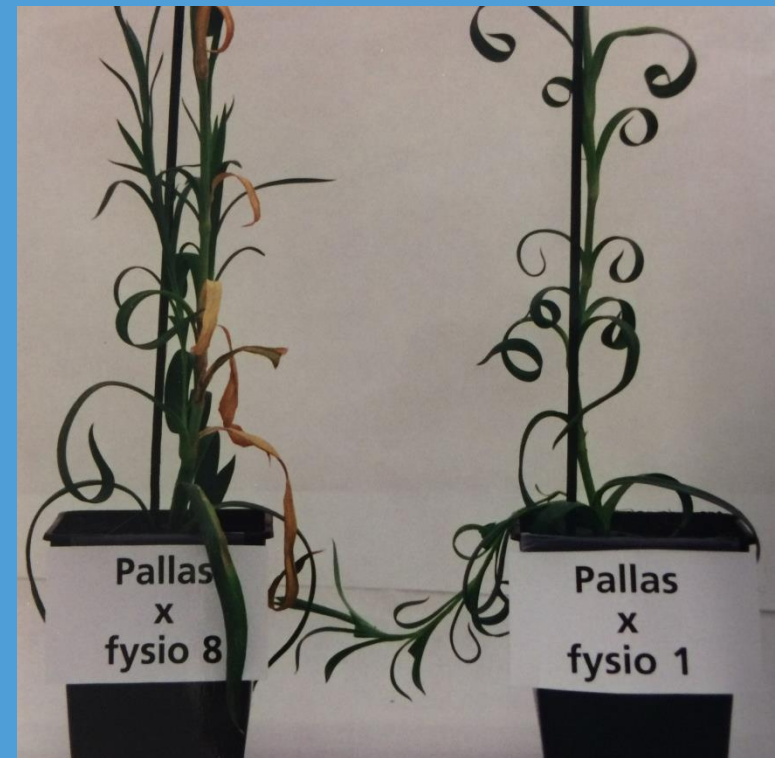


Chromosomen van *F. oxy* van tomaat

Fysio concept = pathogene verwantschap

Taxon (ITS type)	<i>Fusarium oxysporum</i> f.sp. <i>dianthi</i> (I)						
VCG	0020	0021	0022	0022	0025	0027	0028

Race	4	2,5,6,7	1	8	11	10	9
Virulence ⁴ on cvs.							
White Royalette	+++	+++	+++	+++	+++	+++	+++
Early Sam	+++	+++	+++	+++	+++	+++	+++
Raggio di Sole	+	++	-	+	+++	+++	++
Izmir	+	++	-	-	+++	+++	++
Lena	++	++	-	-	+	+	++
Pallas	+++	-	-	+++	±	+	++
Elsy	-	-	-	-	+	+	++
Golia	+++	+++	+++	+++	+++	-	
Handy	-	-	-	-	+++	-	
Jordan	-	+++	-	-	+++	+++	



Samenvatting:

- Schimmel met vele gezichten
- Pathogeen op zeer veel gewassen
- Bestrijder van “weeds” (*F.oxyl erythroxyli*)
- Systematiek niet consistent

DNA ~ genetica ≠ waardspecificiteit

- Waardplant-specificiteit (nog) niet ontrafeld

