Genetic Diversity and Fumonisin Analyses of Fusarium species in the Philippines

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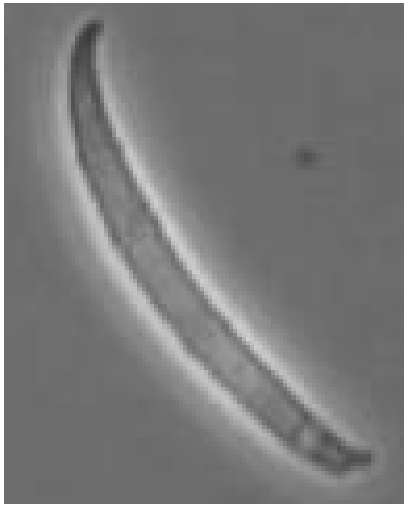
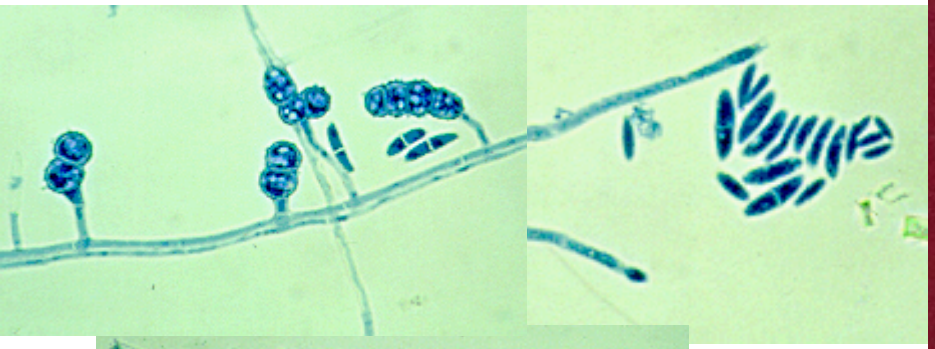
Fusarium (*Gibberella*)– A notorious pathogen

- Can incite diseases in plants, humans and animals
- Many plants at least one *Fusarium*-associated disease (81 of the 101 economically important plants)
- Produce secondary metabolites

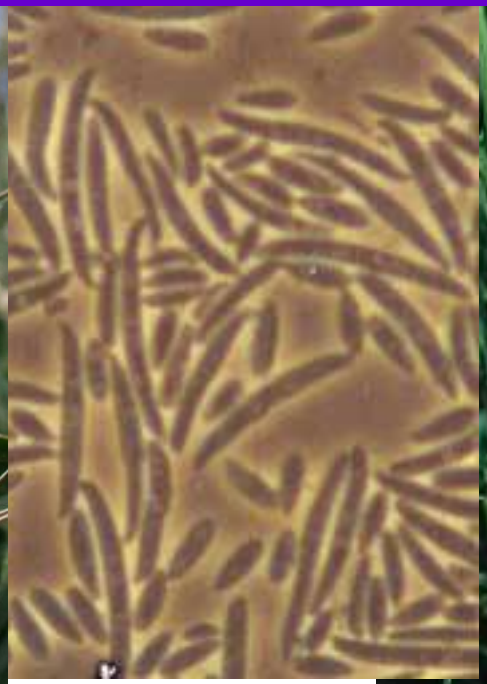


Ear rot of maize (*Fusarium verticillioides*)



Bakanae disease of rice (*Fusarium fujikuroi*)

Fusarium head blight of wheat (*Fusarium graminearum*)



Crown rot of banana (*Fusarium verticillioides*)

Fusarium wilt of bottle gourd (*F. oxysporum* f.sp. *lagenariae*)

Fusarium wilt of bitter gourd (*F. oxysporum* fsp. *momordicae*)

Plant Disease 81(12):1340-1348

Scab of Wheat and Barley: A Re-emerging Disease of Devastating Impact

Marcia McMullen
North Dakota State University, Fargo

Roger Jones
University of Minnesota, St. Paul

Dale Gallenberg
South Dakota State University, Brookings

Bakanae disease on the rise: A cause for concern

Gergon, E & Angeles, AT. Poster presented at the 37th Anniversary & Annual Scientific Conference of PMCP. May 2-5,2006. Davao City

INTERNATIONAL JOURNAL OF PEST MANAGEMENT, 1994, 40(4) 326–336

Panama disease: return of the first banana menace

(*Keywords:* banana, electrophoretic karyotype, *Fusarium oxysporum* f. sp. *cubense*, fusarium wilt of banana, *Musa acuminata*, *Musa balbisiana*, Panama disease, plantain, random amplified polymorphic DNA, restriction fragment length polymorphism, vegetative compatibility)

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Abstract. Before 1960, Panama disease (fusarium wilt) was the most important disease in the banana export trades. Although the importance of Panama disease decreased after the Cavendish cultivars replaced Gros Michel, recent outbreaks have renewed interest in this problem. Race 4 affects cultivars of the Cavendish subgroup in the subtropics, as well as race 1 and race 2 suscepts. It has caused concern in the tropically based export trades which depend almost entirely on the Cavendish clones. Attention is also drawn to affected non-exported bananas which are important cash crops or staple foods. Although they are not as well documented as those on the Cavendish subgroup, epidemics of the disease on non-exported bananas are far more important.

Revived interest in Panama disease has prompted new research. Breeding programmes have developed dessert and cooking bananas which resist Panama disease, as well as black Sigatoka and the burrowing

export plantations are large monocultures, Panama disease spread rapidly in plantings of the uniformly susceptible host. In addition, since the cause of the disease and its seed-borne dissemination were not clearly understood until about 1920, infected rhizomes were used to establish new plantations long after the disease was recognized (Brandes, 1919; Stover, 1962). The unwitting spread of FOC in seed pieces helped seal the fate of Gros Michel.

Thirty years after the trades converted to the Cavendish cultivars they have been little affected by Panama disease. What, then, are the reasons for this review? One is the appearance of race 4 (Su *et al.*, 1977). Race 4 affects

POPULATION GENETICS : What do we know about it?

Fisher's Fundamental Theorem of Natural Selection:

- Mean fitness of population always increases
- Rate of increase in fitness is proportional to additive genetic variance for genes that affect fitness

↓

More genetically diverse pathogen populations have greater evolutionary potential

Pathogenic traits affect fitness

Genetic Structure of Pathogen Populations

The amount and distribution of genetic diversity within and among populations varies

INCREASE

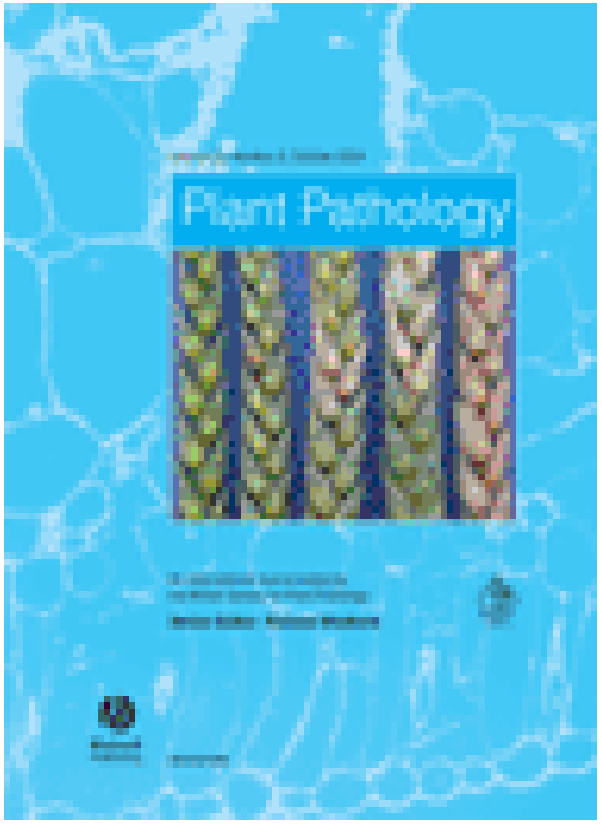
- Recombination
- Gene flow
- Mutation

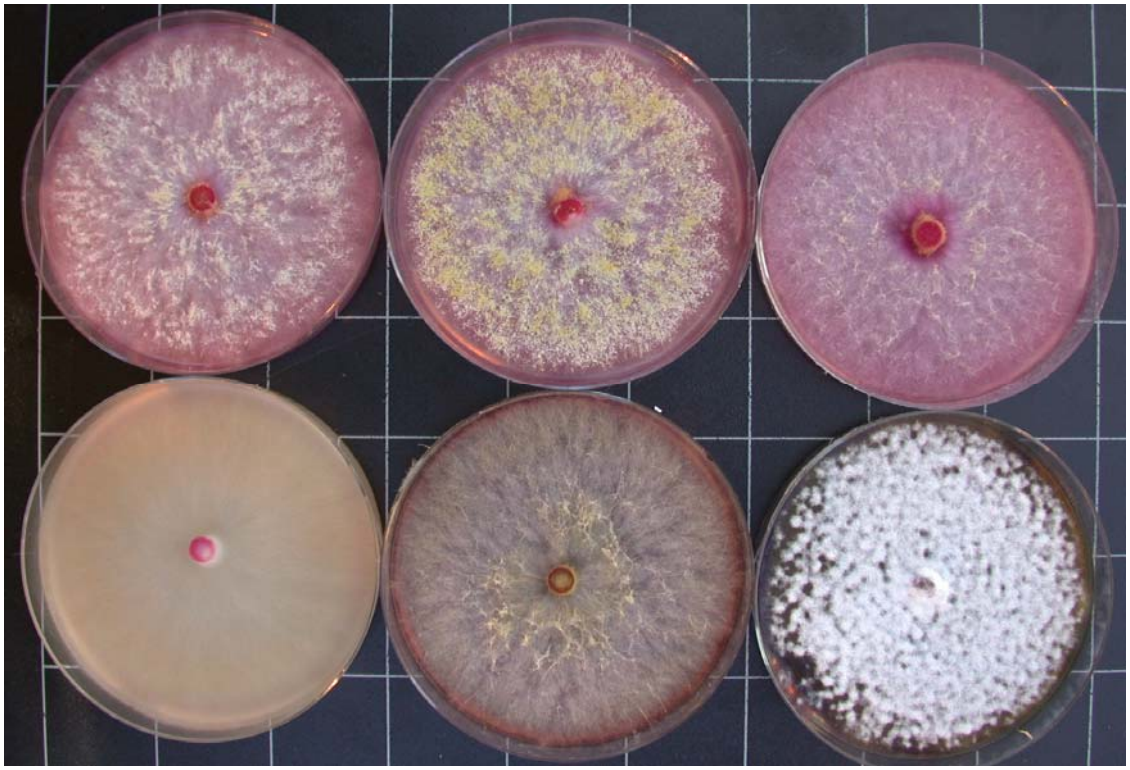
DECREASE

- Selection
- Random drift

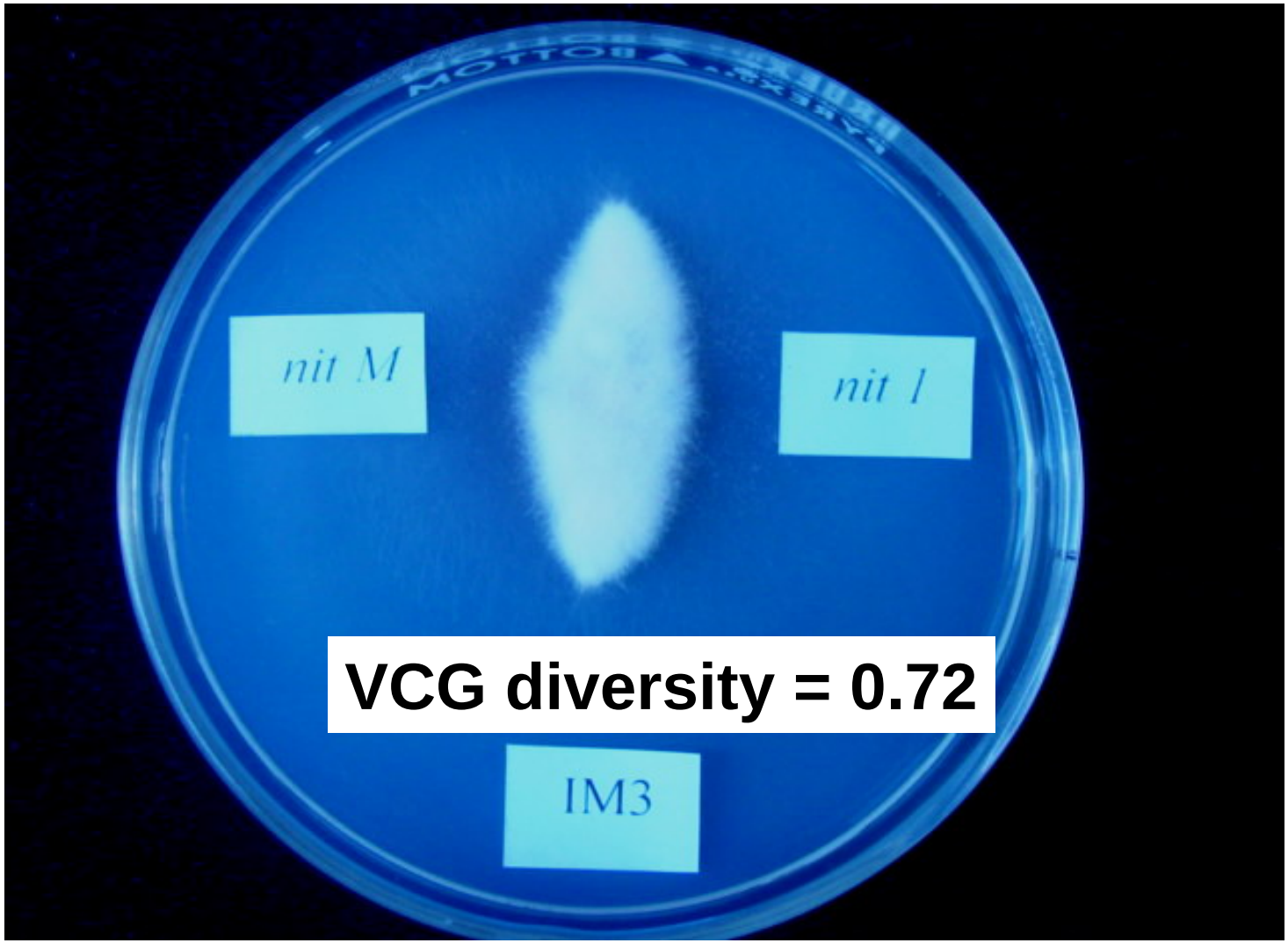
Genetic structure is a result of all evolutionary processes that have affected a population (species) through time and space

Variation of agressiveness and cultural characters





Front cover of Vol 53 of *Plant Pathology* : Cumagun et al. (2004)

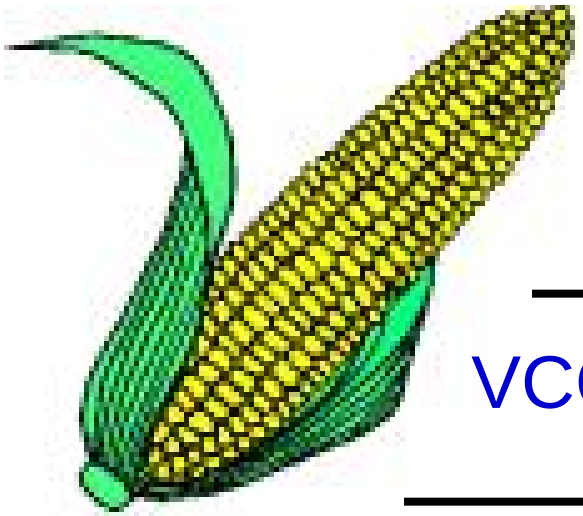


VCG diversity = 0.72

20 isolates grouped into 19 VCGs

Cumagun et al., 2009

High diversity at small spatial scale



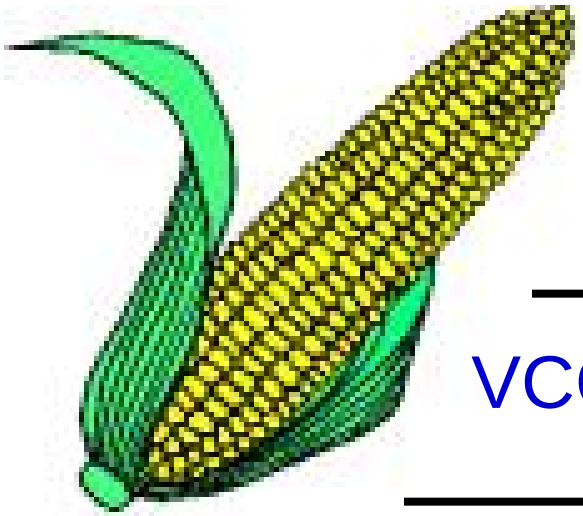
VCG1 → Isolate T3

VCG2 → Isolate IM3

VCG3 → Isolate IB3

Cumagun et al., 2009

High diversity at small spatial scale



VCG1 → Isolate T3 *MATA*-1 (‘+’)

VCG2 → Isolate IM3 *MATA*-2 (‘-’)

VCG3 → Isolate IB3 other mating population

Source: Cumagun et al., 2009

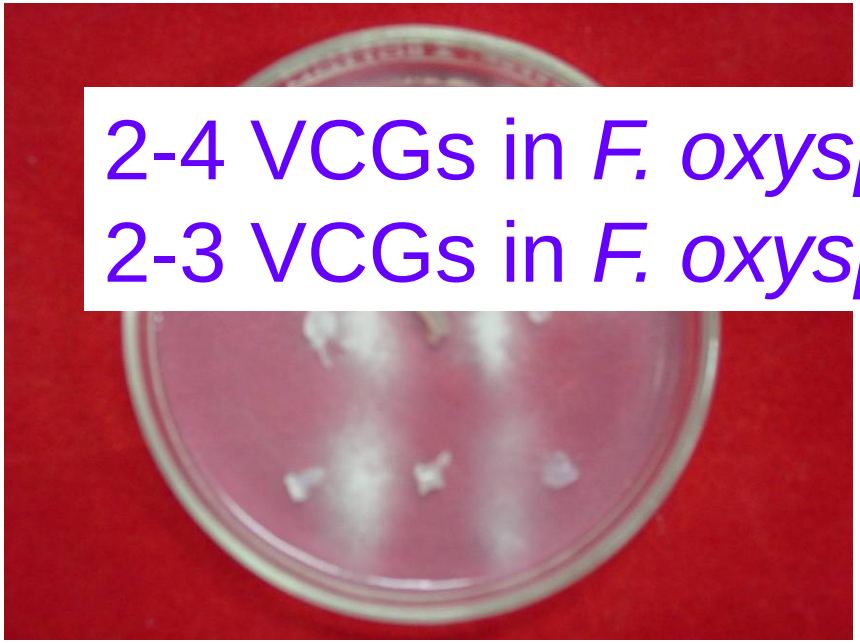
Effective population number for *F. verticillioides*

		Effective population number (*Ne*)		
Mating	N_{fs}:N_h	Mating	Male/hermaphrodite	Reference
27:23	35:15	81	42	Cumagun et al 2008
23:47	62:8	89	26	Chulze et al. 2000
16:23	10:29	97	98	Danielsen et al. 1998
59:17	39:37	69	88	Mansuetus et al. 1997
237:446	342:341	91	89	Leslie and Klein 1996

Sexual reproduction of *F. verticillioides* in the Philippines does not occur frequently

Source; Cumagun (2008). Journal of Applied Genetics

Vegetative Compatibility Grouping



2-4 VCGs in *F. oxysporum* in bitter gourd
2-3 VCGs in *F. oxysporum* in bottle gourd

Medium compatibility

Strong compatibility

Source: Cumagun et al. (2008) Journal of Plant Protection Research

F. oxysporum in Batangas and Bulacan

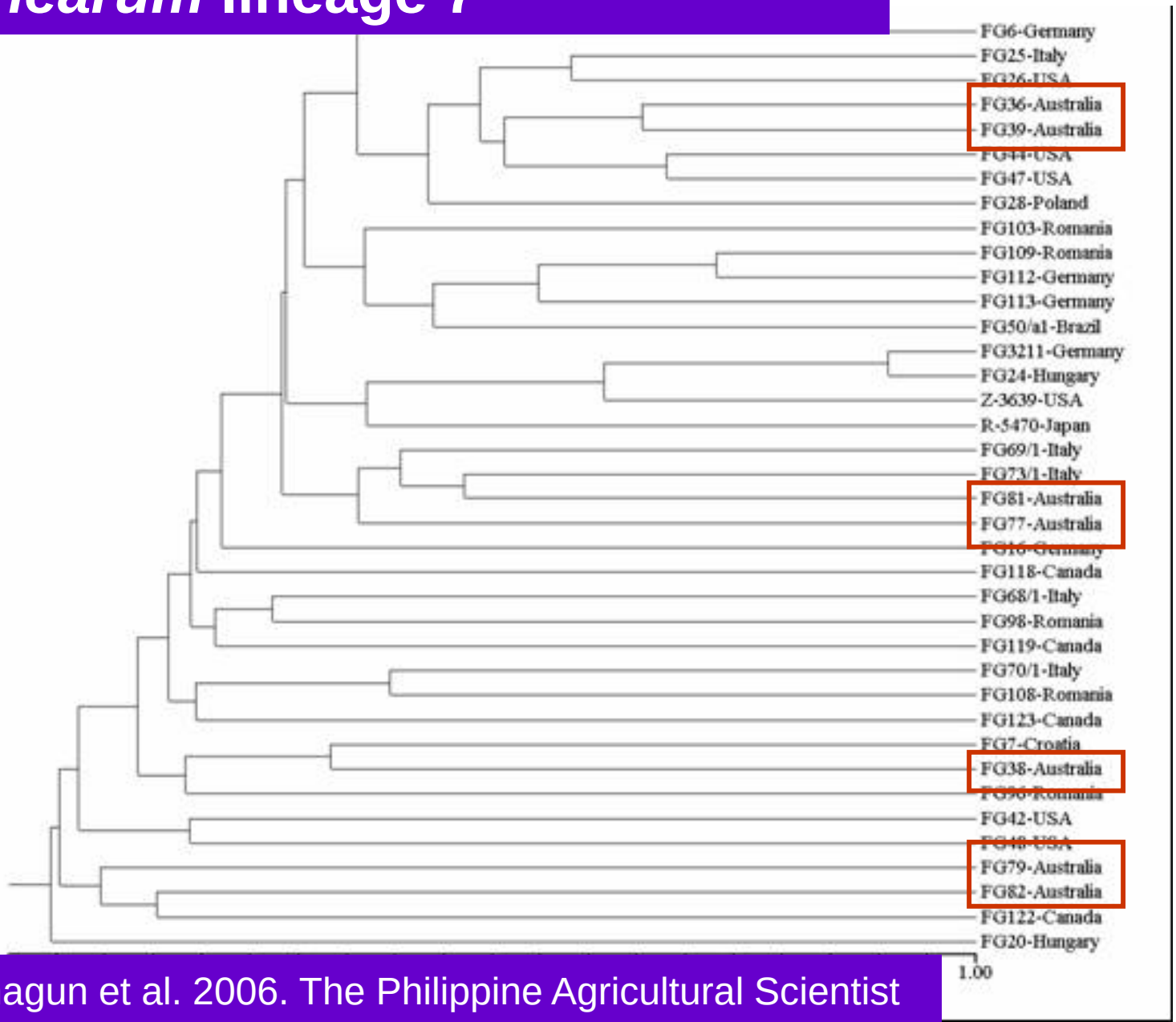
No compatibility was detected between upo and ampalaya isolates

Cross infection was observed normally in young plants

No association between pathogenicity and VCG

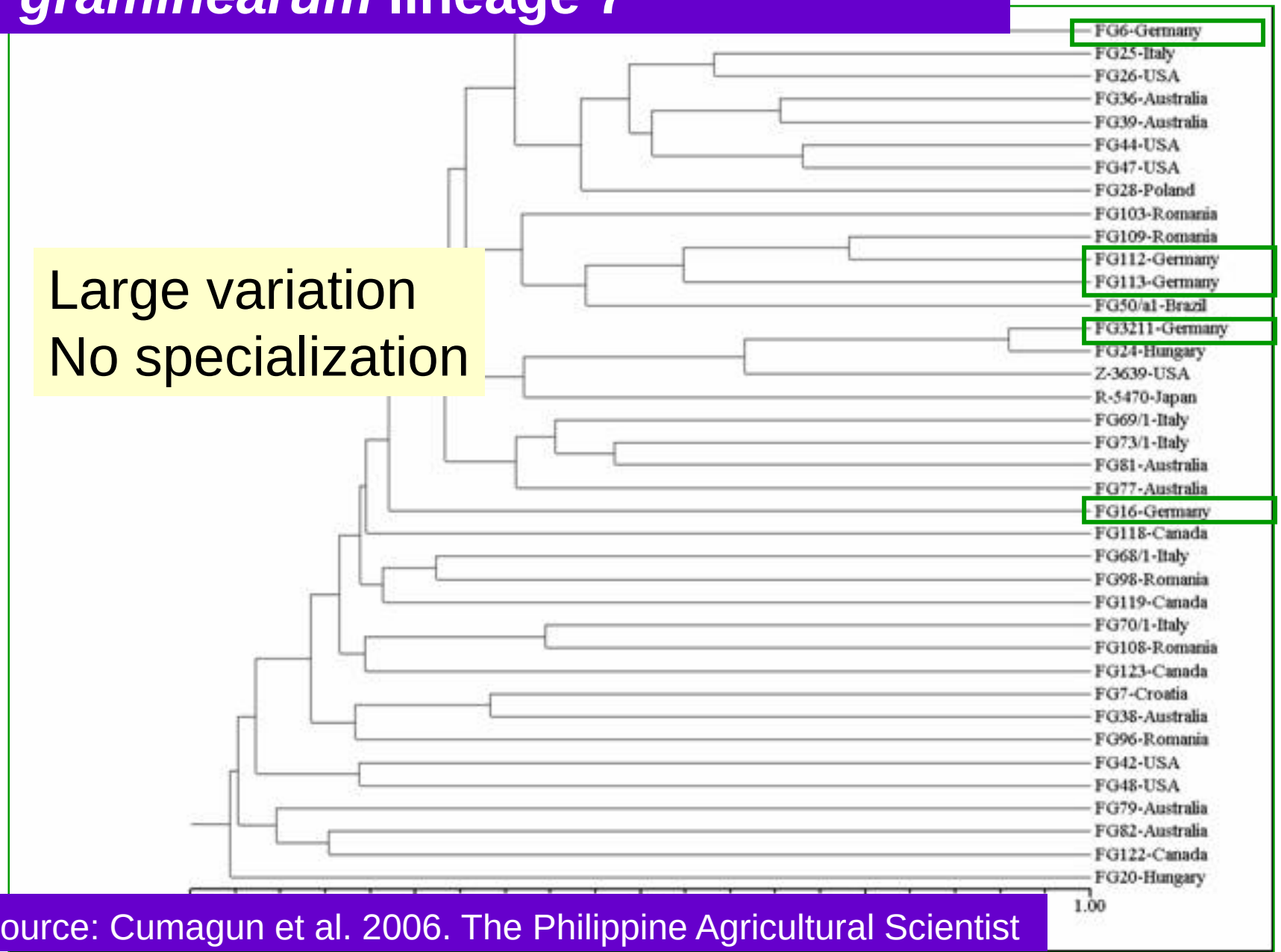
Source: Cumagun et al. (2008) Journal of Plant Protection Research

Worldwide Collection: AFLP dendrogram of *F. graminearum* lineage 7



Source: Cumagun et al. 2006. The Philippine Agricultural Scientist

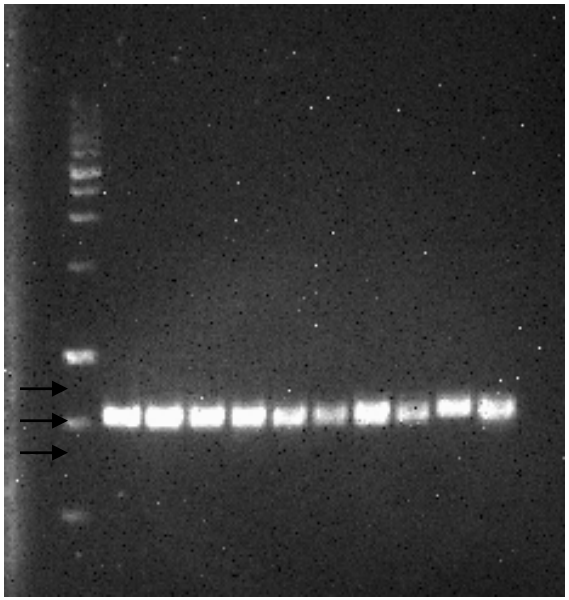
Worldwide Collection: AFLP dendrogram of *F. graminearum* lineage 7

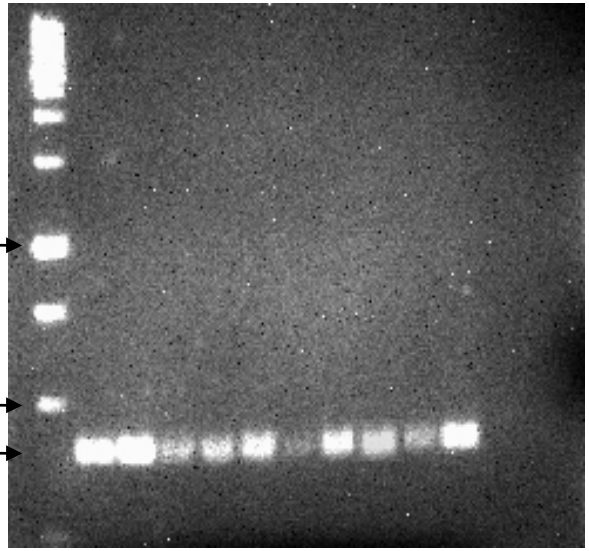


Large variation
No specialization

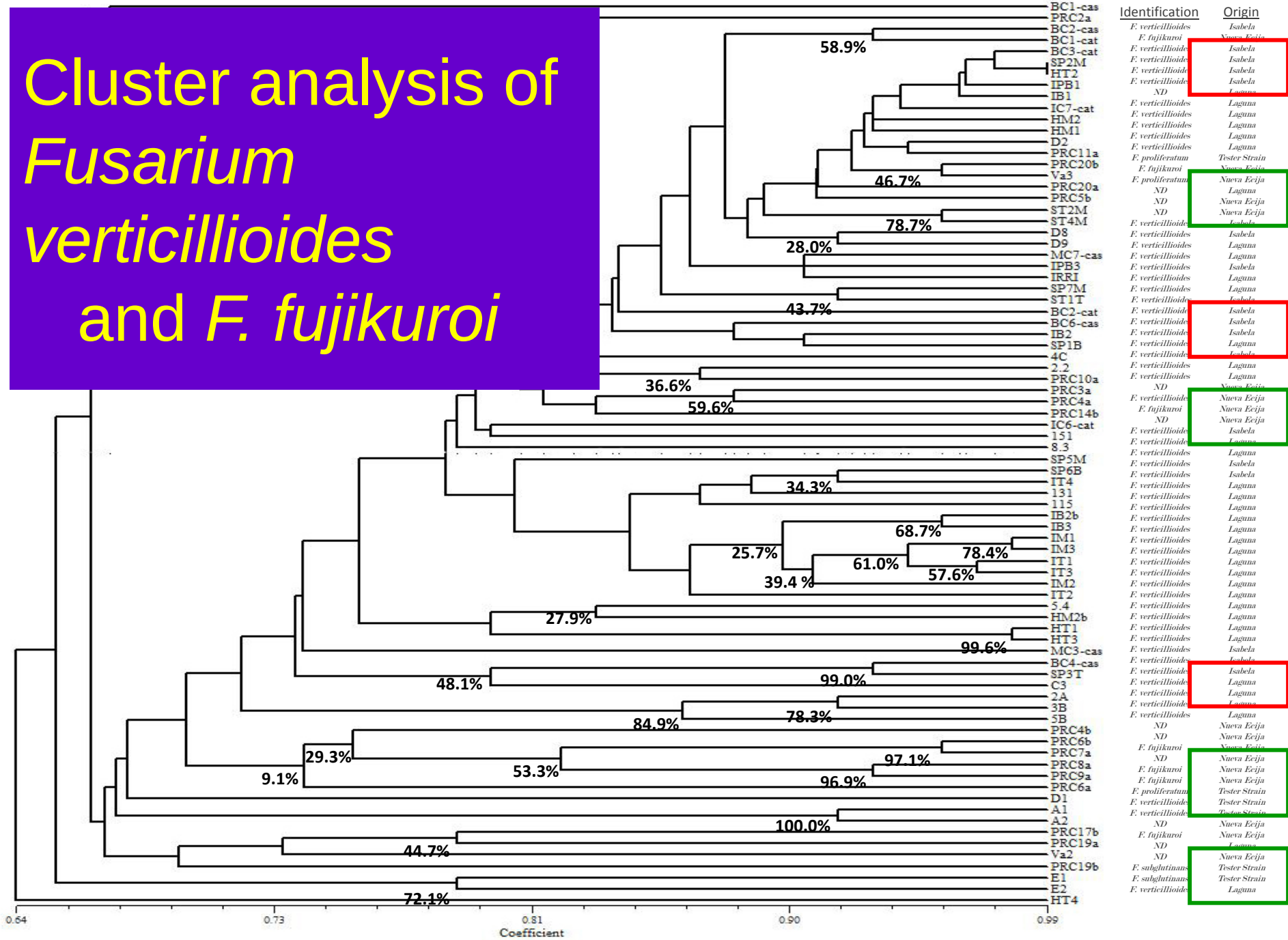
Source: Cumagun et al. 2006. The Philippine Agricultural Scientist

. *F. verticillioides* and Fumonisin Detection using PCR Assay





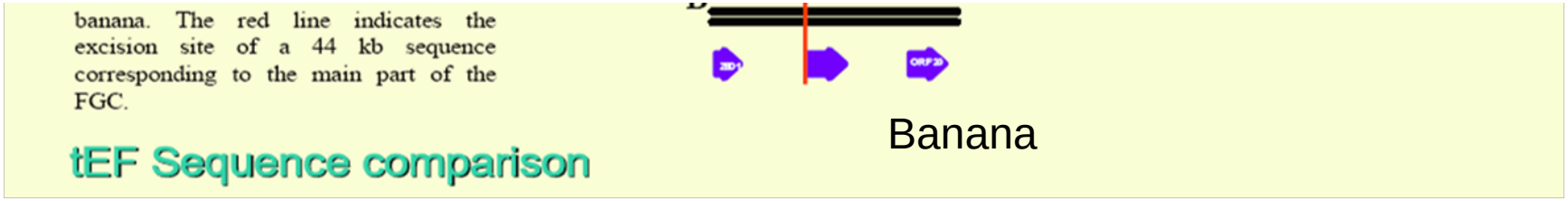
Cluster analysis of *Fusarium verticillioides* and *F. fujikuroi*



What is the cause of the non production of fumonisin by *F. verticillioides* strains isolated from banana?

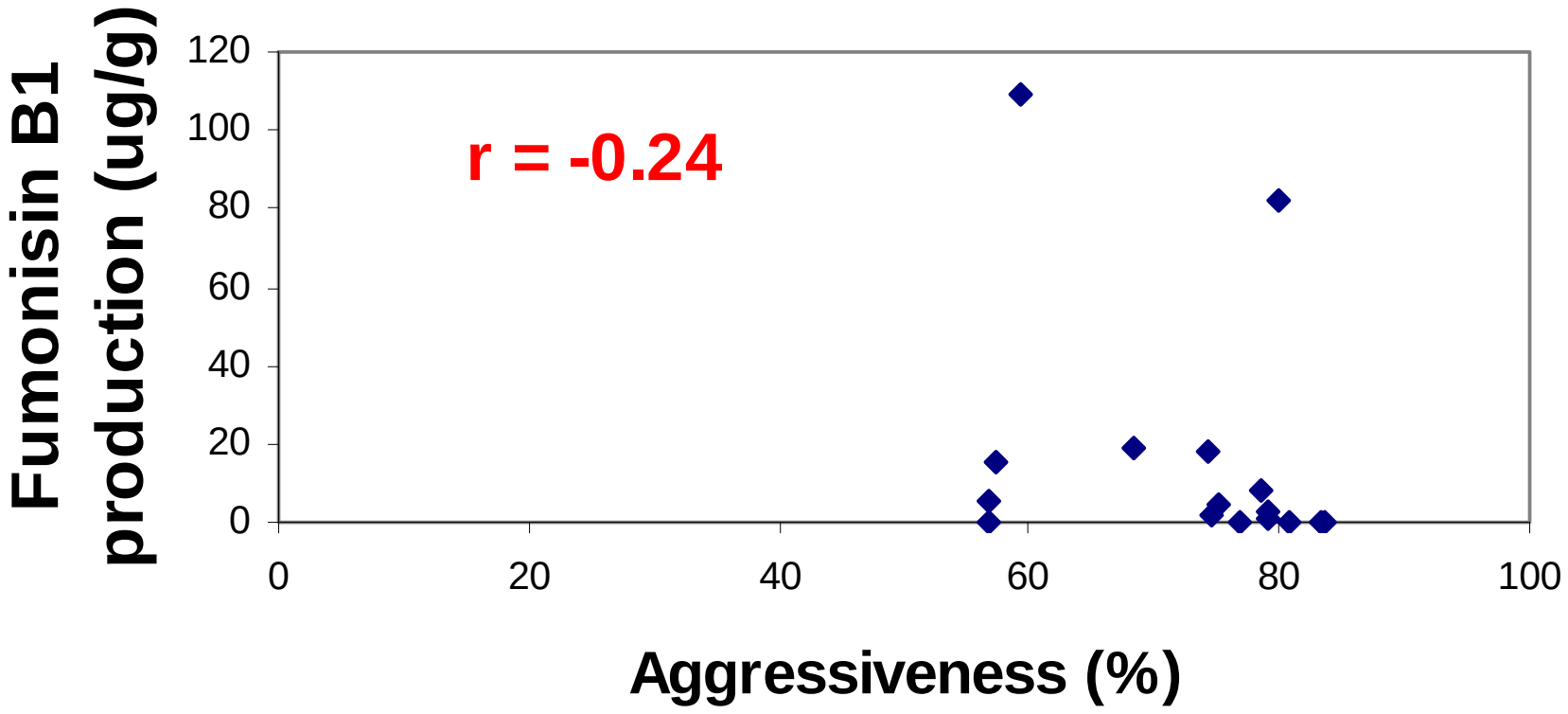
Excision Hypothesis: 44 kb of the FGC has been excised from banana

***F. verticillioides* from Philippine banana have the FGC while those in Central America do not have!**



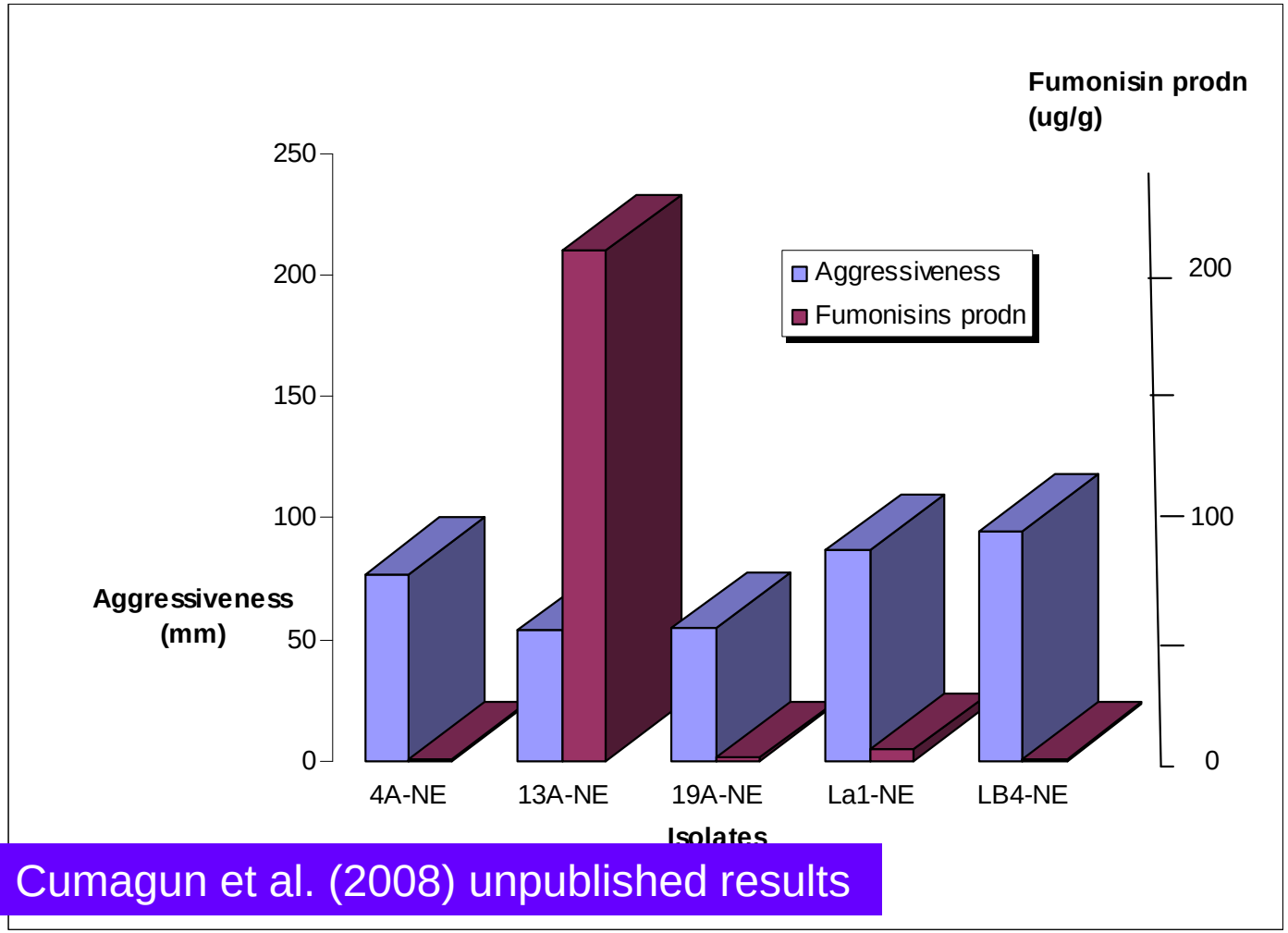
Source: Van Hove et al. (2006)

Low association between aggressiveness and fumonisin production of *F. verticillioides*



Source: Cumagun et al. (2007) Asian Conference on Plant Pathology

No association between aggressiveness and fumonisin production of *F. fujikuroi*



Source: Cumagun et al. (2008) unpublished results

Fumonisin production of *F. verticillioides* and *F. fujikuroi* isolates in the Philippines

Source	Host	No of isolates	Mean fumonisin production (µg/g)		
			FB1	FB2	FB3
Isabela	maize	20	146.75	45.54	9.70
Laguna	maize	16	30.05	10.22	2.12
N. Ecija	rice	7	31.47	5.36	0.52

Source: Cumagun et al. (2007) Asian Conference on Plant Pathology

Genotypic variation among populations of three *Fusarium* species for aggressiveness and mycotoxin production

Fusarium species	Host	No of isolates	Genotypic Range		Reference
			Aggressiveness	Mycotoxin production	
F. verticillioides	maize	20	13.6-25.1cm	0.44-128.45µg/g	Alviar, 2006, Cumagun et al., 2006 Cumagun et al., 2007
F. fujikuroi	rice	43	47.63-125.25 mm	0.86-210.03µg/g	Aguilar, 2007 Cumagun et al., 2007
F. graminearum	wheat	155	5.03-47.75%	4.2-43.7mg/kg	Cumagun and Miedaner 2004
F. oxysporum	ampalaya upo	10	2.92-4.50 1.32-3.63	-	Aguirre, 2007

Conclusions

- VCG is not correlated with aggressiveness
- Large variation and no specialization for *F. graminearum*, *F. verticillioides* and *F. fujikuroi.*
- High variation in aggressiveness in *F. verticillioides, F. fujikuroi and F. graminearum.*
- Sexual reproduction in *F. verticillioides* is less frequent.
- *F. verticillioides* from Asia and Africa have the *FUM* gene cluster while Central America do not.
- Mating population A is prevalent in Philippine corn.
- Philippine *F. fujikuroi* isolates are low fumonsin producers.
- *F. verticillioides* isolates from Northern Luzon are high fumonisin producers compared to Southern Luzon.
- No to low association between aggressiveness and fumonisin production in both rice and maize isolates of *F. verticillioides*

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