Genetic Diversity and Fumonisin Analyses of Fusarium species in the Philippines

ASIAHORC Symposium
July 18-20, 2009
Nagoya, Japan

Christian Joseph R. CUMAGUN
Crop Protection Cluster
College of Agriculture
University of the Philippines Los Baños
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*)
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
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
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 aggressiveness and cultural characters

Front cover of Vol 53 of *Plant Pathology* : Cumagun et al. (2004)
20 isolates grouped into 19 VCGs

VCG diversity = 0.72

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

Source: Cumagun et al., 2009
Effective population number for *F. verticillioides*

<table>
<thead>
<tr>
<th>Mating</th>
<th>$N_{f} : N_{h}$</th>
<th>Mating</th>
<th>Male/hermaphrodite</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>27:23</td>
<td>35:15</td>
<td>81</td>
<td>42</td>
<td>Cumagun et al 2008</td>
</tr>
<tr>
<td>16:23</td>
<td>10:29</td>
<td>97</td>
<td>98</td>
<td>Danielsen et al. 1998</td>
</tr>
<tr>
<td>237:446</td>
<td>342:341</td>
<td>91</td>
<td>89</td>
<td>Leslie and Klein 1996</td>
</tr>
</tbody>
</table>

*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

F. oxysporum in Batangas and Bulacan

<table>
<thead>
<tr>
<th>Host</th>
<th>Batangas</th>
<th>Bulacan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upo</td>
<td>11</td>
<td>17</td>
</tr>
<tr>
<td>Ampalaya</td>
<td>17</td>
<td>11</td>
</tr>
<tr>
<td>Tomato</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>38</td>
<td>28</td>
</tr>
</tbody>
</table>

No compatibility was detected between upo and ampalaya isolates

Cross infection was observed normally in young plants

No association between pathogenicity and VCG

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*

![Graph showing correlation between aggressiveness and fumonisin B1 production](image)

$r = -0.24$

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

<table>
<thead>
<tr>
<th>Source</th>
<th>Host</th>
<th>No of isolates</th>
<th>Mean fumonisin production (µg/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>FB1</td>
</tr>
<tr>
<td>Isabela</td>
<td>maize</td>
<td>20</td>
<td>146.75</td>
</tr>
<tr>
<td>Laguna</td>
<td>maize</td>
<td>16</td>
<td>30.05</td>
</tr>
<tr>
<td>N. Ecija</td>
<td>rice</td>
<td>7</td>
<td>31.47</td>
</tr>
</tbody>
</table>

Source: Cumagun et al. (2007) Asian Conference on Plant Pathology
Genotypic variation among populations of three *Fusarium* species for aggressiveness and mycotoxin production

<table>
<thead>
<tr>
<th><em>Fusarium</em> species</th>
<th>Host</th>
<th>No of isolates</th>
<th>Genotypic Range</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>F. verticillioides</em></td>
<td>maize</td>
<td>20</td>
<td>13.6-25.1cm</td>
<td>0.44-128.45µg/g</td>
</tr>
<tr>
<td><em>F. fujikuroi</em></td>
<td>rice</td>
<td>43</td>
<td>47.63-125.25 mm</td>
<td>0.86-210.03µg/g</td>
</tr>
<tr>
<td><em>F. graminearum</em></td>
<td>wheat</td>
<td>155</td>
<td>5.03-47.75%</td>
<td>4.2-43.7mg/kg</td>
</tr>
<tr>
<td><em>F. oxysporum</em></td>
<td>ampalaya upo</td>
<td>10</td>
<td>2.92-4.50</td>
<td>-</td>
</tr>
</tbody>
</table>
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 fumonisn producers** compared to Southern Luzon.
• **No to low association** between aggressiveness and fumonisn production in both rice and maize isolates of *F. verticillioides*