

Plant Pathogen Forensics: *For a Balanced National Plant Disease Recovery System*

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National and international crop biosecurity issues

- A strong National security plan should include:
 - Early detection and diagnostic systems
 - Epidemiological models for predicting pathogen spread
 - Reasonable yet effective strategies and policies
 - Distributed physical and administrative infrastructure
 - National response coordination plan
 - ***Validated microbial forensic technology and investigative capability***

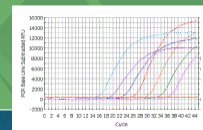
Is this something new?



- **The usual goals of an applied plant pathologist:**
 - Identify the pathogen as needed for management
 - Respond quickly to manage a disease outbreak
 - Recommend/apply optimal control strategies
- **New issue: Has a crime occurred?**
 - Discerning natural vs. intentional outbreaks

Goals of a microbial forensic investigator:

- Collect very specific forensic evidence via tests that are
 - Standardized and validated
 - Very high confidence levels
 - Sufficiently robust to withstand rigorous adversarial review in a court of law
- Attribution
 - Determine source of agent
 - Identify the perpetrators
 - Prosecute the criminal
- Deterrence of future attempts
- *Applying our science to a new national and international need*



“A highly proficient and science-based national forensic capability will require significant **new initiatives.”**

-FBI Scientific Working Group on Microbial Genetics and Forensics (SWGMGF)

“It is now time for the U.S. – and perhaps at some level the world community – to establish an integrated, comprehensive forensic capability to effectively attribute biological weapons...”

– R. Murch, Institute for Defense Analysis, 2003

Plant Pathogen Forensics Working Group

- Solicited and sponsored by IDA
- Charged to
 - Examine current capabilities in plant pathogen forensics
 - Identify gaps and needs
 - Make recommendations for future initiatives
- 12 plant pathologists
 - Workshop – March 2004
 - White paper for IDA
 - APS Symposium – August 2004
 - Review article: *MMBR Vol. 70, p. 450-471*
 - Representation on the FBI - SWGMGF



Addressed FBI – SWGMGF's call for new knowledge and developments in:

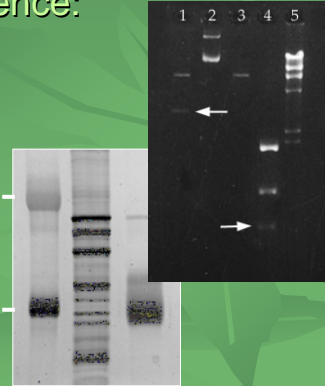
- a) **comparison, standardization and validation of microbial typing methods**
- b) establishing standard procedures for sampling methods, sample size and sample quality
- c) **understanding pathogen genome dynamics, phylogenetics and systematics**
- d) evaluating the influence of mutation, evolution and environment on microbial forensic analysis

AND in:

- e) **exploring the influence of ecology and background clutter on the forensic analysis of microbes**
- f) understanding how post-translational modifications affect forensic typing and discrimination
- g) **development of standard discrimination and match criteria for forensic analyses and attribution**
- h) establishment of an integrated bioinformatics and data analysis system

1. What knowledge and technologies do we already have that can be brought to this new application?

- Bring together elements from established and emerging fields of science:
 - Classical microbiology
 - Microbial genomics
 - Phylogenetics
 - Epidemiology
 - Microbial ecology
 - Bioinformatics
 - Human forensics
 - Plant pathology



2. What gaps and needs remain?

- Two major types of gaps
 - Aspects related to “typical” plant pathology – already doing or planning to do
 - Aspects related specifically to forensic science
 - Integration of these two with each other and with other fields

3. How can we fill those gaps and meet those needs?

- New research initiatives
- Targeted funding programs
- Plant Pathogen Forensics Working Group
 - **APS affiliated**
- Linkages with national/international forensics groups
 - **FBI – Scientific Working Group on Microbial Genetics and Forensics (SWGMPF)**
 - **DHS – National Bioforensic Analysis Center (part of NBACC)**
 - **Others – USDA, CIA, other U.S. government agencies, other scientific societies such as ASM, etc.**
- Develop a coordination mechanism

Issues for Plant Pathogen Forensics



- **100s of plant species, each with many pathogens**
- Some diagnostics still based on time-consuming tests (e.g., reactions on host “differentials”, mating types)
- **Culture collections scattered, inadequate & often lost with retirements**
- Plant pathogen entries in key databases (NCBI, GeneBank, BIOLOG, FAME) very limited
- **Lack of effective molecular detection tags: primers, probes and antibodies**
- Lack of information on pathogen biology

More Issues for Plant Pathogen Forensics

- Diagnostic and detection tools rarely standardized, validated
- Relative effectiveness of different technologies unknown in most cases
- “Best” test generally depends on the tools and databases available for that taxon and closely related taxa
- The “species” concept is becoming cloudy
- **FUNDING FOR PLANT DISEASE RESEARCH IS COMPARATIVELY MINISCULE!**



Corn stunt



Rick Grantham, Artist

National Institute for Microbial Forensics & Food and Agricultural Biosecurity

- Established Fall 2007
 - Oklahoma State University
- Current participants
 - OSU-Stillwater
 - OSU-Center for Health Sciences, Tulsa
- Areas of emphasis
 - Research & technology development
 - Extension & outreach
 - Education & training



NIMFFAB Objectives

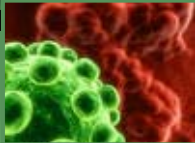
- Provide **strategic planning, vision** and **prioritization** of needs and resources related to plant and food-related microbial forensics and agricultural biosecurity
- **Conduct focused and outcome-oriented research and education** in priority areas of microbial forensics
- Establish a **coalition** of national and Oklahoma investigators conducting research on crop and food biosecurity and forensics



NIMFFAB objectives, *continued*



- Serve as a focal point for **communication, cooperation, funding**
- Deliver outputs to end users in the security community
- Develop **outreach** opportunities for first detectors, Extension educators, producers and the public
- Communicate and work in parallel, locally and nationally, with parallel programs related to animal and human pathogens



Workshop Plant Pathogen Forensics: Filling the Gaps

January 11-13, 2007
Oklahoma City, OK

WORKSHOP

Plant Pathogen Forensics: Filling the Gaps

Planning and attendance:

- FBI Forensics Laboratory
- DHS – NBFAC
- CIA – Bioterrorism Unit
- USDA: APHIS, ARS, CSREES, NPDPN, NPDRS
- National Laboratories: Los Alamos
- Academic community – OSU & nationwide
- Oklahoma agricultural security community



Workshop Objectives

- Bring plant pathology, security and law enforcement communities together
- Develop specific targeted initiatives to
 - formulate **guidelines for decision-making** by security and law enforcement – *Decision Trees*
 - identify and prioritize **most critical needs**
 - **identify research gaps** and develop strategies to address
 - seek **targeted funding programs**

Decision Trees

- Tree branches:
 - *Is a plant disease natural or human-incited?*
 - *What evidence is needed?*
 - *How to collect, transport, store?*
 - *What tests are appropriate?*
 - *How to do them?*
 - *How to interpret them?*



Scenario Based Planning

- **Wheat streak mosaic virus** – vector-borne virus of grain crops
- ***Ralstonia solanacearum* R3B2** – genetically engineered select agent in potatoes
- ***Phytophthora ramorum*** – threat to forests & woody landscape plants
- ***Fusarium oxysporum*** – genetically modified mycotoxin-producing fungus in wheat
- ***Meloidogyne incognita*** – root-knot nematode threat to tomato production

Workshop Outcomes

- Five scenario reports
- Identify features common to all
- Identify situation-unique features
- Develop a draft Decision Tree
- **Planning for a field-based training exercise targeted at law enforcement personnel**
 - OSU, FBI, CIA, DHS, APHIS, NPDN, other?
- **Develop a strategic plan for plant pathogen forensics**



Conclusions

- **Capability in microbial forensics must be part of a balanced plant biosecurity preparedness plan**
 - Part of the NPDRS?
- **Microbial forensics is a new sub-discipline of plant pathology to which we can bring many tools and resources – but more are needed**
- **Building capacity will require dedicated support and collaboration from law enforcement and national protection programs**
 - The National Institute for Microbial Forensics & Food and Agricultural Biosecurity at OSU is just a start
- **It also will require targeted funding and resources**



**Following the
forensic trail.**

*It won't always be
this easy...*