Breeding to Save Our Ash (From Emerald Ash Borer)

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USFS Northern Research Station Jennifer Koch jkoch@fs.fed.us

Kathleen Knight, Therese Poland, Dave Carey Mary Mason (The Ohio State University) Jeanne Romero-Severson (University of Notre Dame)

USDA



<u>Genetic variation has been the basis for</u> applied tree improvement programs since the early 1950's

EAB first identified in urban/suburban areas

- Horticultural cultivars, i.e. clonal (little genetic diversity)
- Few genotypes planted many, many times

BUT

Natural stands have LOTS of genetic diversity

- Combinations of rare allelic variants may confer level of defense against EAB
- No selective advantage without EAB!
- Other known examples beech bark disease, white pine blister rust, etc.

Definition of Resistance:

(Schneider & Ayres Nature Reviews, 2008, 889-895)

Resistance: the ability of a host to limit pathogen (or insect) growth

Tolerance: the ability of a host to survive a given pathogen/insect load relative to a susceptible tree

Resistant trees live longer than susceptible trees!

Genetically Diverse Population: Range of Phenotypes Types of Resistance



- 2. Quantitative Resistance:
- Polygenic
- Durable
- Tolerant to complete resistance



Resistance Can Provide A SOLUTION!!!



Sustainable Ash Resources in North America

Selection Criteria for "Lingering" Ash

- 1. >95% ash mortality trees 2 years ago
- Tree large enough to have been infested
 @peak EAB infestation (>10cm dbh)
- 3. Healthy canopy
- 4. ~0.1 to 1.0 % of ash trees







EAB Egg Bioassay

Assessed after 8 weeks or 1 year





Coffee filter with eggs affixed to bark



Three grafted replicates of each genotype (2-3 years old)

8 Week Bioassay of Lingering Ash

- Grafted ramets 2-3 years after grafting
- Destructive assessment
 - 8 weeks after egg attachment



- Egg hatched (Y/N)
- Larval outcome
 - L1, L2, L3, L4
 - host-killed
 - dead-other
- Larval weight
- Pupal outcome





Host-killed larva

Live larva

A Sample of the 2012 Results: Green Ash



- Similar 'lingering ash' healthy canopy phenotypes
- Different larval outcomes (high host-killed, low larval weight)

1 Year Bioassay of Lingering Ash

Grafted ramets 2-3 years after grafting

Lingering Ash

Larval outcome: 29% parasitized 37% woodpecker predation 7% exit hole (adult)

Host tree survival rate: 47%

2-fold higher rate of survival!

Susceptible Controls

Larval outcome: 29% parasitized 35% woodpecker predated 17% exit hole (adults)

Host tree survival rate: 26%

*Evidence that biocontrol + resistance needed!

Pyramiding allelic variants of genes that influence different defense responses......

X

Best larval growth inhibition

Highest larval kill





.....results in some progeny with more effective defenses!



EAB & Ash Population Dynamics

Common Garden Study, Novi MI



Rebek et a., 2008 Environ. Entomol. Herms D. 2015. Chp. 3. FHTET-2014-09

Bioassay data correlates with field performance!!!







Urgent Need to Identify and Preserve Lingering Ash

mount a defense response that can extend life for 4-7 years (and counting), but they can still die.





Forest Health Call with K.Knight will provide guidelines to NFs for monitoring and identifying lingering ash. March 7th

Koch Group



Ryan Mark Jennifer Mary Dave Reynolds Miller Koch Mason Carey **Funding:**

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USDA NRI Competitive Grants

Collaborators:

Jeanne Romero-Severson University of Notre Dame **Margaret Stanton** University of Tennessee John Carlson University of Pennsylvania Dan Herms The Ohio State University Jordan Marshall IUPUI Andrew Storer Michigan Tech University Charles Tubesing The Holden Arboretum



Differential Gene Expression in Lingering and Susceptible Green Ash



Lane et al., 2016. BMC Genomics

Dynamic Conservation of Ash (continuation of co-evolutionary process/natural selection)



Defense responses allow ash to survive longer under low EAB pressure. defenses, live even longer.





No evidence supporting dominant single gene resistance

Lingering Ash Selections to Date

| Species | # selected | # accessioned |
|--------------------|------------|---------------|
| White | 8 | 8 |
| Green | 40 | 38 |
| White or Green^ | 6 | 6 |
| Black | 4 | 3 |
| Blue | 1 | 1 |

^some trees intermediate for species phenotypes

Installation of two grafted replicate field trial in 2017 in collaboration with the Holden Arboretum, Kirtland, OH



Selecting Lingering Ash in Natural Forest Areas



Kathleen Knight, US Forest Service Dan Herms, The Ohio State Univ.

SE MI: ~1500 ash trees 14 lingering ash 0.8 % NW OH: ~900 ash trees 1 lingering ash 0.1 % Swan Creek Cluster: ~11,000 ash trees 2010:111 lingering ash 1.0 % 2014:51 remain alive 0.4 % Helicopter survey: Jordan Marshall, IUPUI Andrew Storer, MTU