



Citrus greening disease:
Incurable, devastating disease of citrus

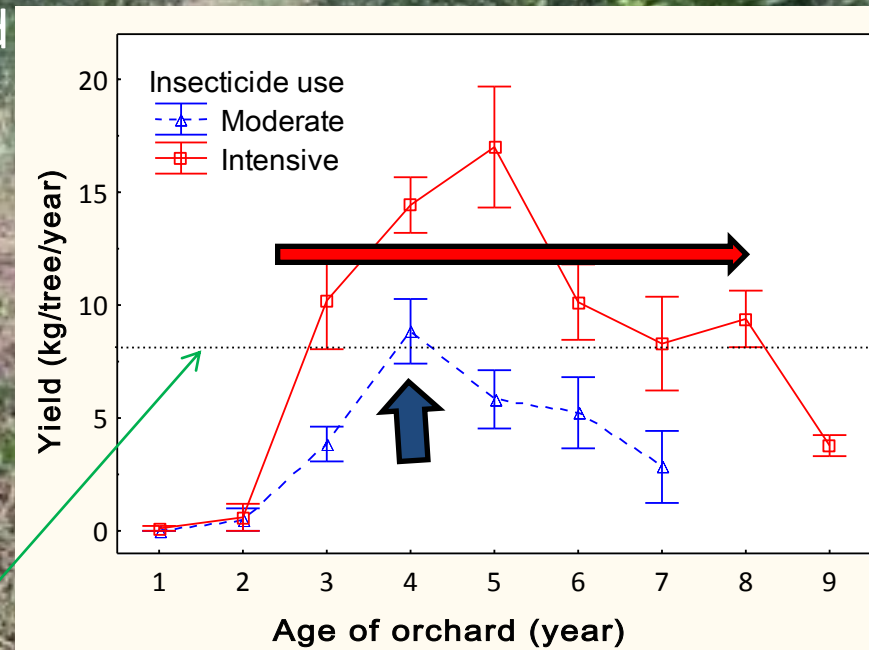
Tree distance and replacement of
citrus greening diseased trees of
King Mandarin for a superfruit

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Nguyen Thanh Hieu, Nguyen Thi Ngoc Truc,
Nguyen Van Son, Nguyen Huy Cuong, Huynh
Thanh Loc, Doan Huu Tien, Kazuyoshi Yuasa,
Takehumi Hayashi, and Katsuya Ichinose

Traditional Cultivation Cycle

- 2 modes in Traditional cultivation
 - Moderate use
 - Once or less a month
 - Intensive use
 - Twice or more a month
- Economic independence from yield
 - Moderate
 - Possible, but only 4th year
 - Intensive
 - Possible, but until 8th year

Yield for economic independence required by averaged growers' family



Annual yield of King in orchards managed by traditional cultivation. Studies by Tien in 2004 – 2005.

King Cultivation in Southern Vietnam

- Three variations
 - Traditional: T
 - SOFRI: S
 - JICA: J
- Tree distance
 - T: < 1.5 m
 - S: 2.5 m
 - J: 4.0 m
- CG-infested tree removal
 - Left until tree death: T
 - Immediately cut and replace: S, J



Which cultivation would give higher yield?

Hyphothetical Orchards

- Size: 30 x 40 m

- T: 494 trees

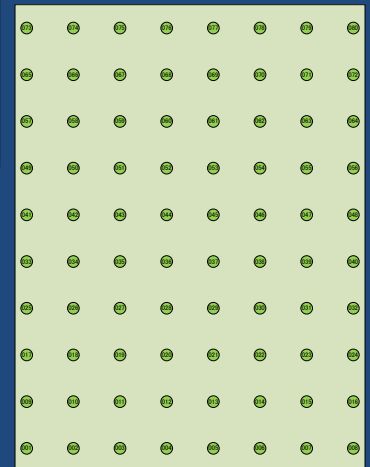
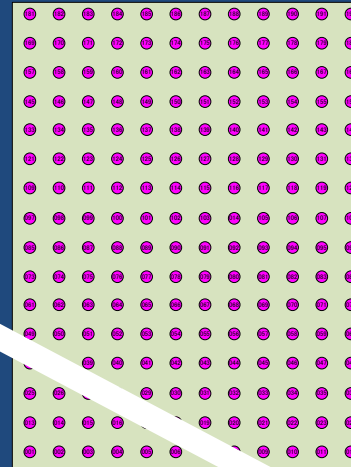
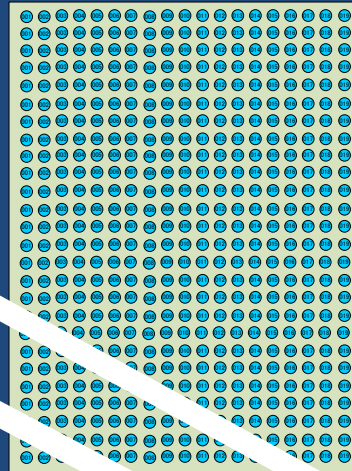
- S: 192 trees

- J: 80 trees



- Yield simulation

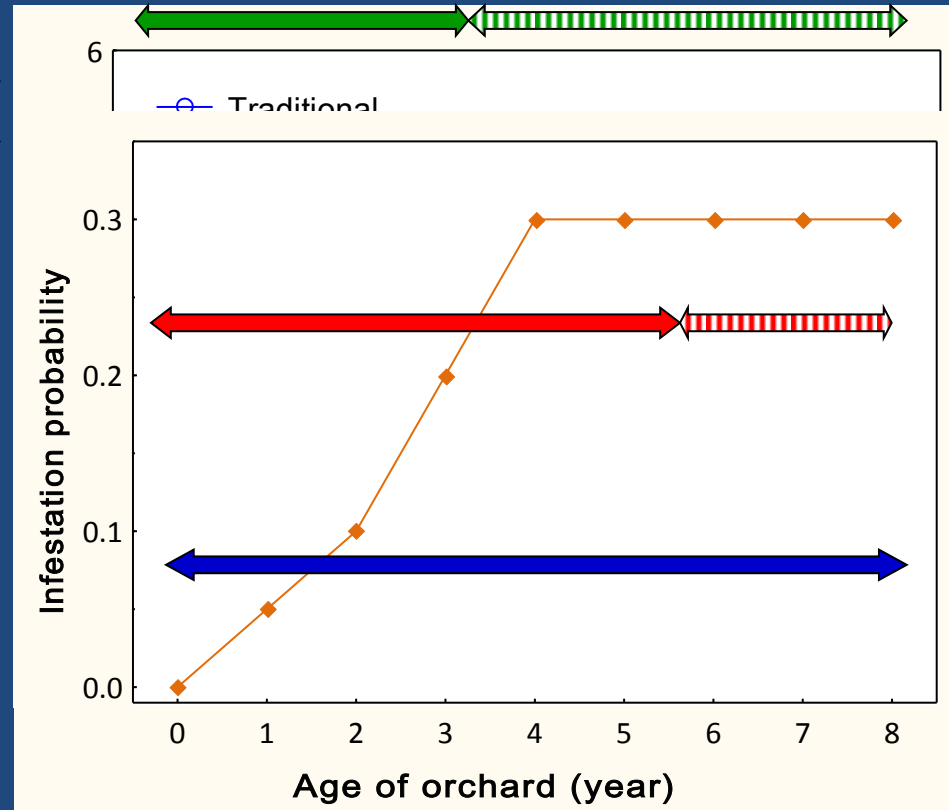
- Models

- Assumptions



Observations & Assumptions

- Yield/tree
 - Observed or 
 - Extrapolated 
 - From Other data
- Total yield/1000 m²
 - $S \approx J > T$: About 2 times
- Effect of greening
 - Same probabilities
 - Cultivation-independent
 - Tree survival: 5 years
 - Yield reduction with time
 - Reduction factor on yield
 - $1/(1 + t)$, t : time (year)



Treatment of Infested Trees in 8 yr Cycle

- Time to cut infested trees
 - At detection
 - 1st – 4th year after planting
 - Not cut
 - 5th or later
- Three variations in treatment
 - Not cut
 - Until death
 - Unconditional tree-cut
 - Cut at infestation
 - Conditional cut
 - Cut until 4th year, no cutting later



Simulation for Hypothetical Orchard

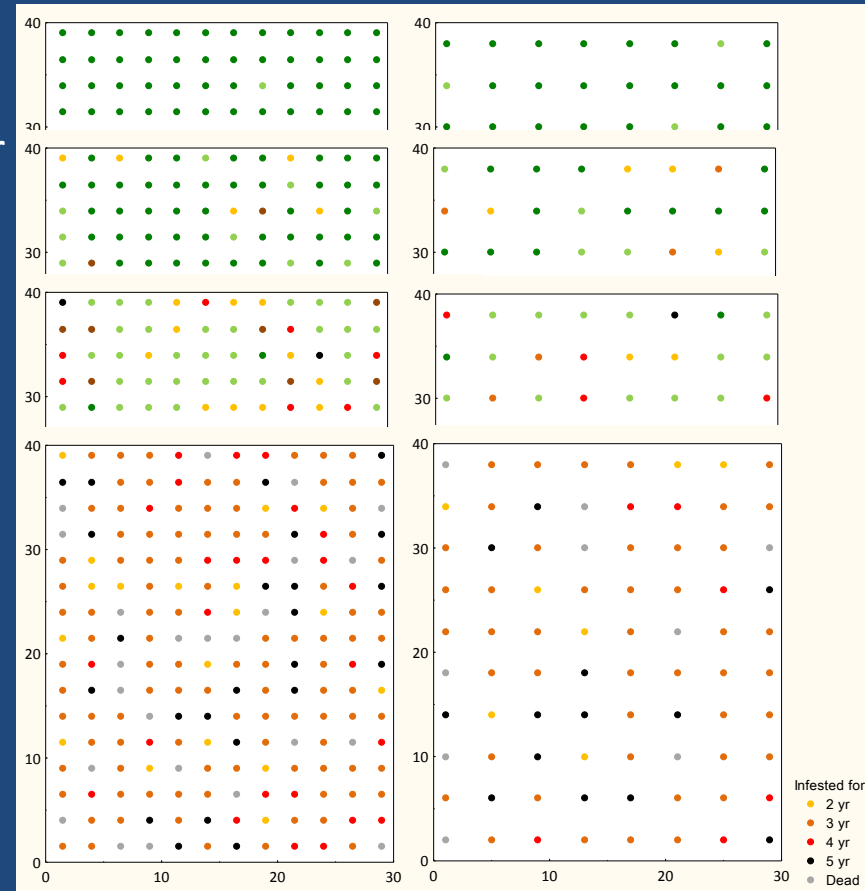
- Infestation and yield
 - Randomisation
 - Random infestation of trees
 - Treatment of cut trees
 - Replacement of new ones
 - Yield
 - Summation
- Example
 - No cutting

1st year

3rd year

6th year

8th year

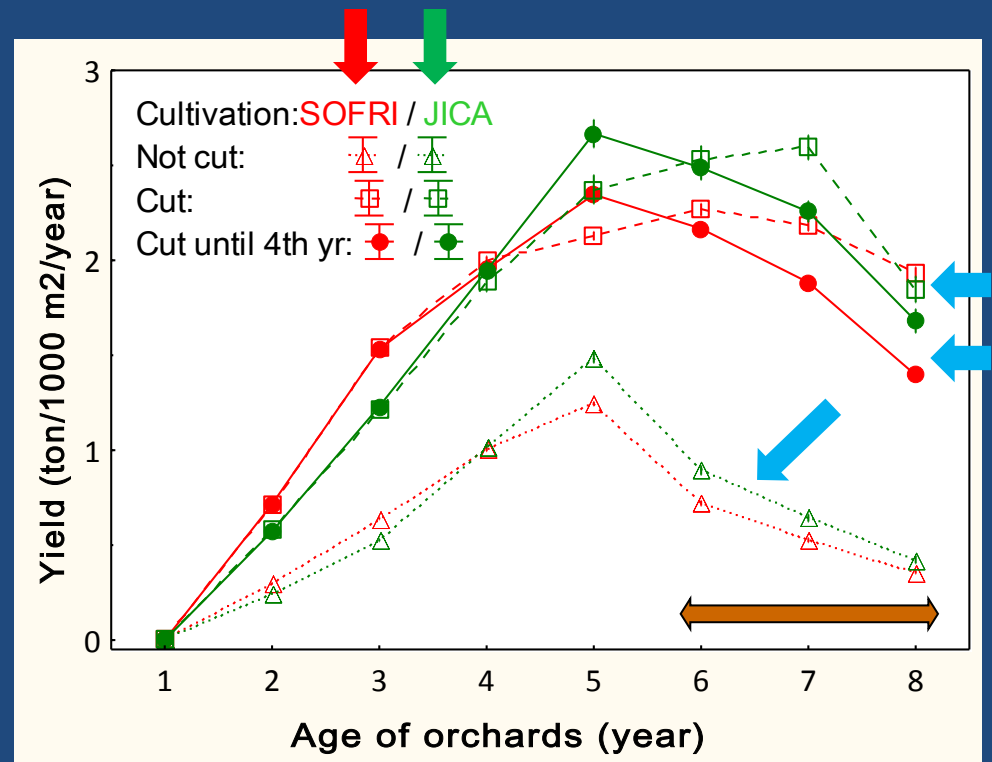


SOFRI

JICA





Simulations for 8 Years Cycle

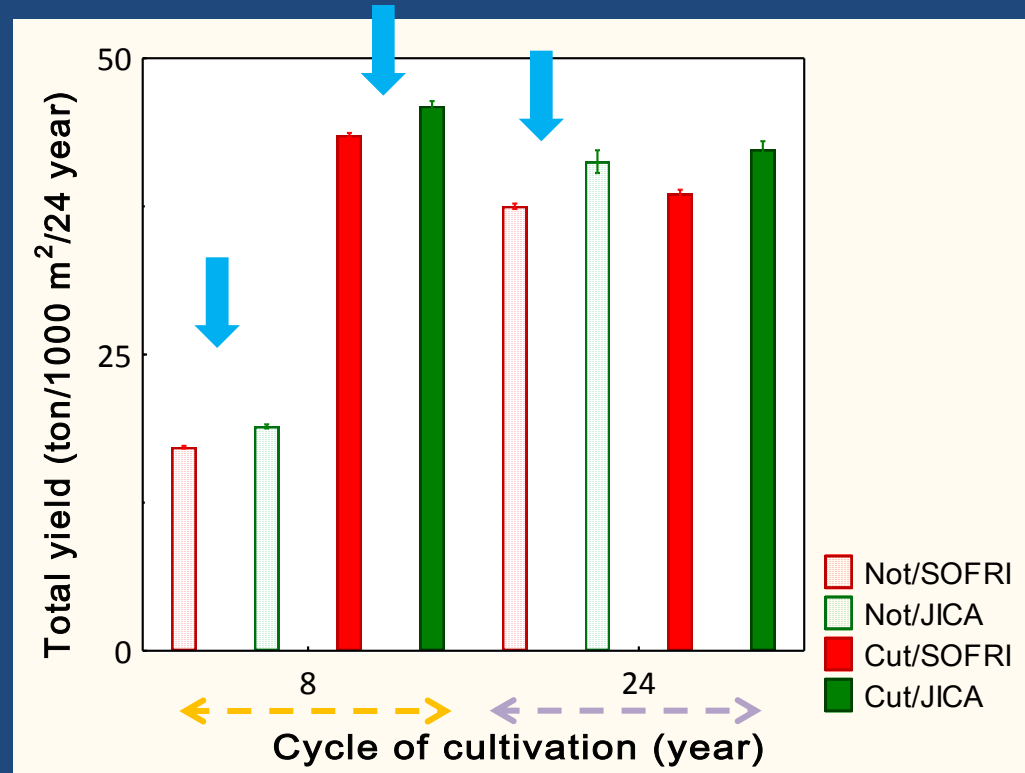
- Combination
 - Cultivation x Tree cut
 - 10 simulations
- Cultivation
 - SOFRI (red)
 - JICA (green)
- Tree cut
 - Not cut until death (Δ)
 - Cut at the detection (\square)
 - Cut until 4th year (\circ)
- Yield
 - SOFRI \approx JICA
 - $\square \approx \circ > \Delta$
- What if you continue over 8 yr?
 - No decline in the last 3 yr
 - and yield would be higher?



Yield in orchards managed by S or J in 8 years cycle, either not cutting CG-infested trees or cutting trees at the infestation detection.

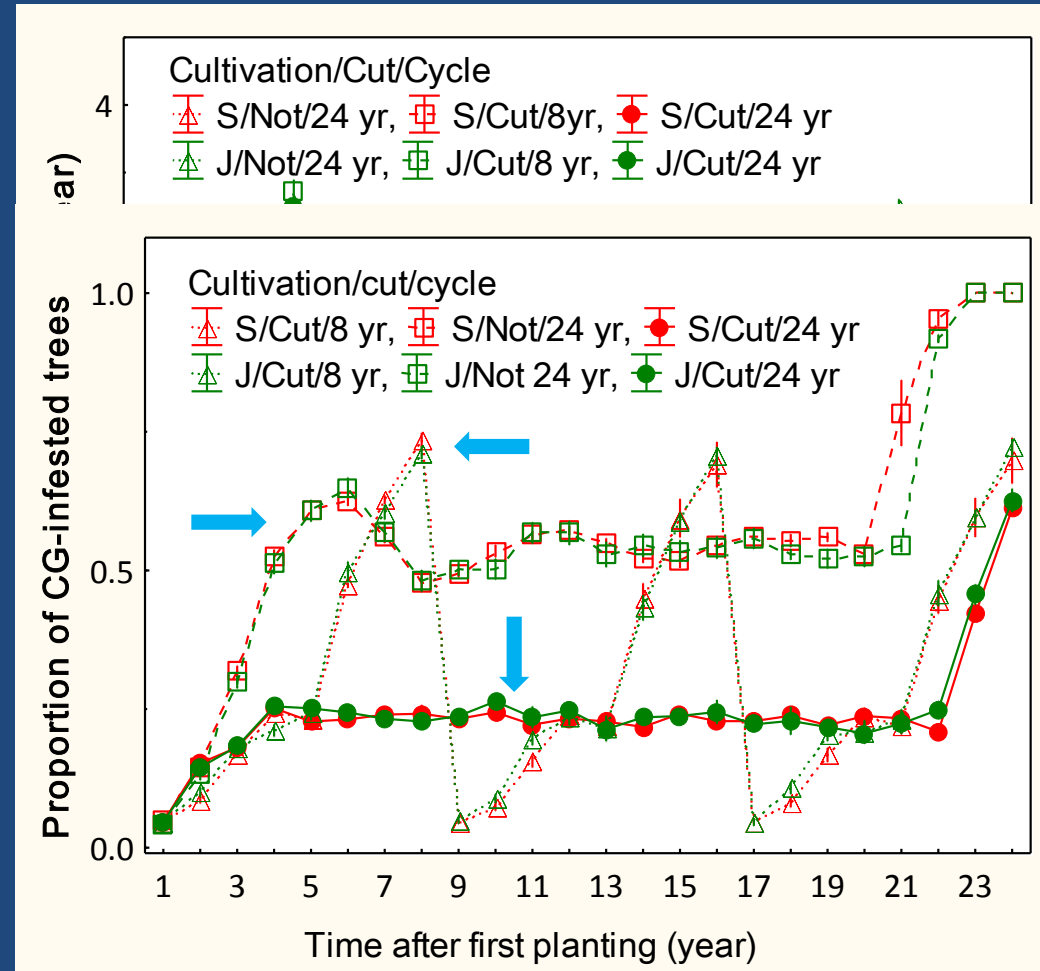
Yield in 24 Years

- Cultivation
 - SOFRI (red)
 - JICA (green)
- Tree cut
 - Not cut
 - Until death 
 - Cut
 - At detection 
- Cultivation cycle
 - 8 years 
 - 24 years 
- Lowest
 - Not cut in 8 yr
- Highest
 - Unconditional cut in 8 yr
- Not cut in 24 cycle
 - Near to the highest



Annual yield & CG Infestation

- Yield
 - 8 yr
 - Cyclic changes
 - 24 yr
 - Higher in the first 8 years
 - Less variable thereafter
- CG infestation
 - 8 yr
 - Cyclic changes
 - 24 yr
 - Constantly higher in Not-cut
 - Lowest in Cut



Lower CG does not necessarily leads to higher yield, vice versa.

Conclusions: Change from Myth to Truth

- Tree distance
 - Either 2.5 m or 4.0 m
 - as you like
- If the highest yield is desired,
 - Select 8 years simulated from models for King:
Without the yield, King can be a Superfruit.
- If better yield is acceptable,
 - Select 24 years cycle
 - Either cut infested trees at detection
 - or leave infested trees until they die.