Measurement of Risk Reduction Associated with Seed QM Practices

TASC Project Update and Potential Implications for Risk Assessment/Risk Management

Probabilistic Risk-Based Model: *Assessment of Phytosanitary Risk Reduction Associated with Seed Quality Management Practices*

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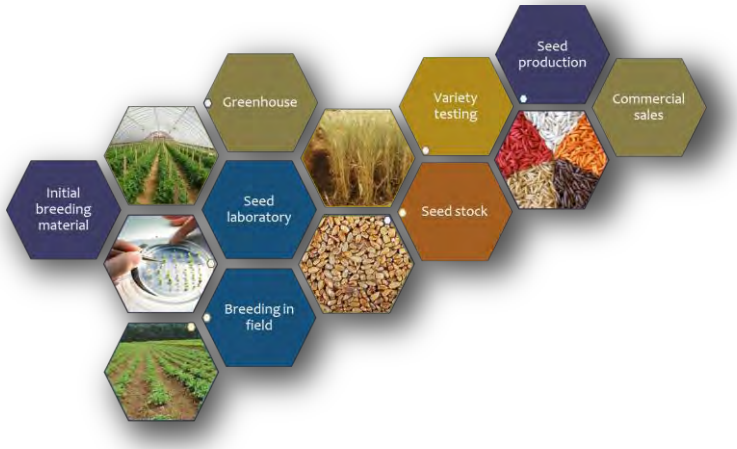

Examples of Applied Probabilistic risk assessment models

1. **Citrus Black Spot:** Probabilistic Risk-based Model for International Citrus Fruit Trade Security
2. **Citrus Huanglongbing (HLB):** Risk-based Residential and Commercial HLB/Asian Citrus Psyllid Survey for California, Texas, and Arizona
3. **US Census/International Travel Survey:** Risk-based Targeted Survey via GIS Mapping to predict points of introduction of Exotic Plant, Animal and Human pathogens
4. **Plum Pox Virus (PPV):** Risk-based Survey Model for early detection and regulatory intervention

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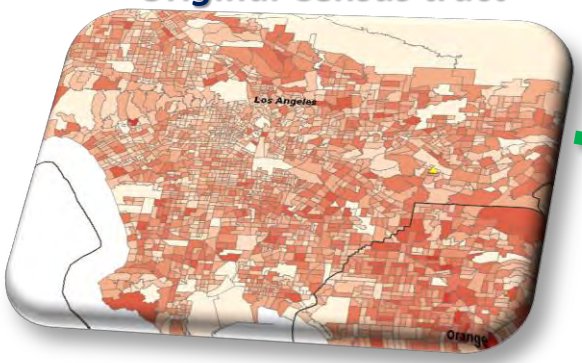
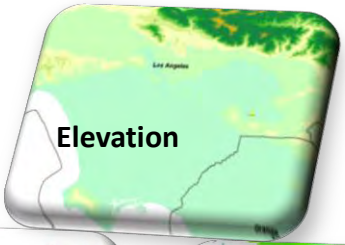
Citrus Huanglongbing (HLB): Risk-based Residential and Commercial HLB/Asian Citrus Psyllid Survey for California, Texas, and Arizona

Original Census tract

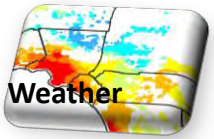


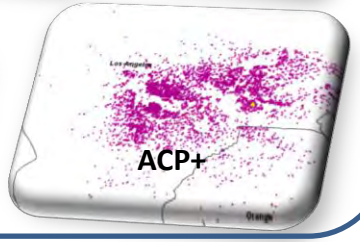
Resulting residential area

Filtering



Risk modeling





Integration

Final risk mapping and survey protocol

www.plantmanagementnetwork.org/edcenter/seminars/Outreach/Citrus/HLB

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Probabilistic Risk-Based Model to Assess Seed *Phytosanitary Risk Reduction*

Motivation

- **Consumers expect healthy, disease-free seeds.**
- **Identify and optimize phytosanitary issues: Costly and damaging to the entire seed industry when are not timely identified.**
- ***Aid in the development of International phytosanitary standards to support a more predictable trade environment.***

Expected Outcomes

- **Method to quantitatively assess how steps in production practices reduce phytosanitary risks.**
- **General framework that can be applied to any seed production system (pathosystem).**
- **Framework on which to develop/justify international phytosanitary standards and possibly revise PRA approaches for seed**

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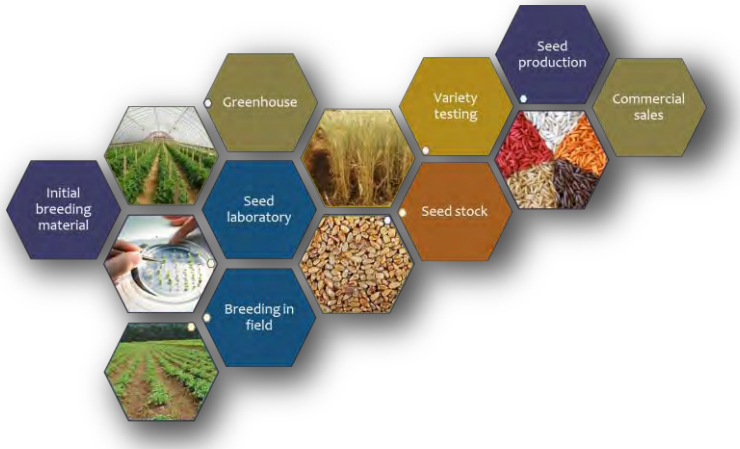

In general follows the Guide to seed quality management practices (*qualitative*)

- Created by ASTA in July 2010.
- Step-wise guidance for developing quality management practices.
- Follows Hazard Analysis and Critical Control Points (HACCP) principles.
- Eight modules from incorporation of a trait into a breeding program through commercial seed production and sale.
- How does following quality management practices affect phytosanitary risk concerns?

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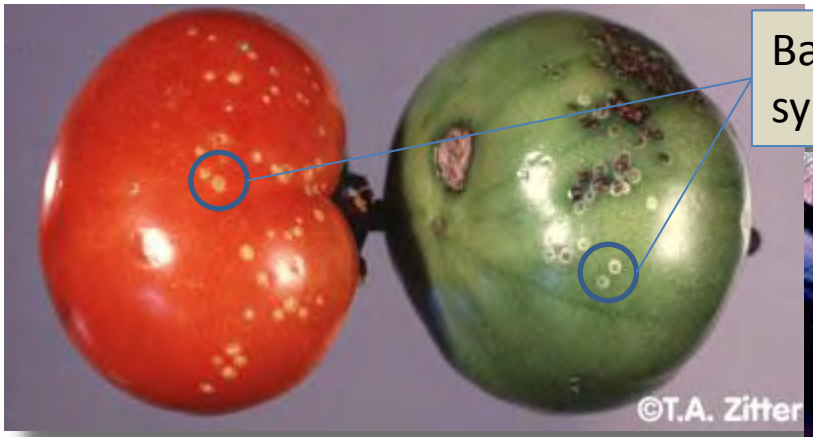
Proposed Risk model Pathosystems - Tomato

1. *Clavibacter michiganensis* subsp. *michiganensis*

Very complex system:
- Multiple tomato production methods.
- **Cmm** can survive for long periods under broad conditions.
- Tomato infected with **Cmm** may remain asymptomatic for some time.



Bacterial canker symptoms on fruit

- Survival possible in soil, plant debris, weed hosts, volunteer plants, and seed.
- Dispersal through wind and water.

2. *Potato spindle tuber viroid* (PSTVd) – *On Tomato*!

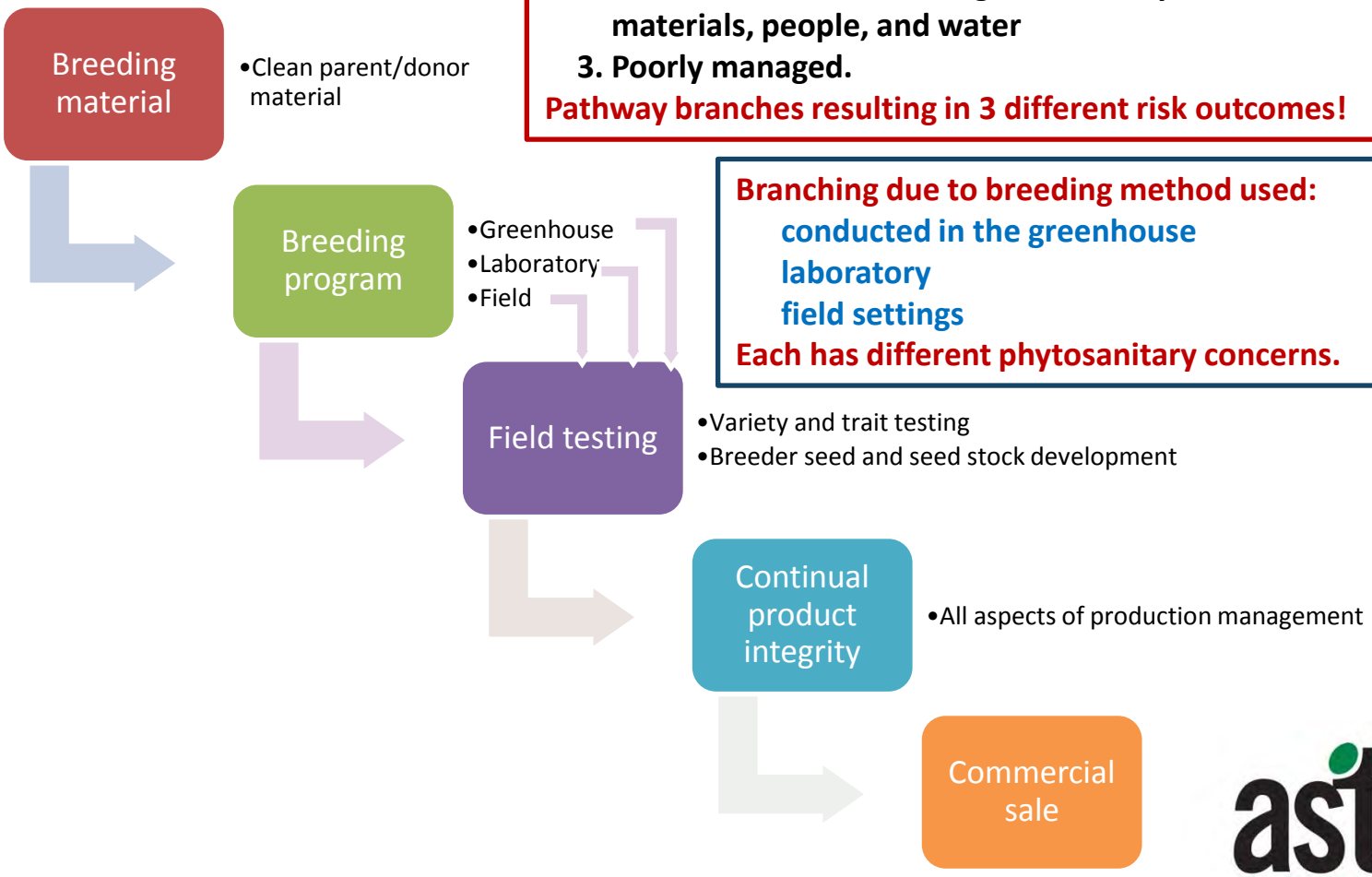
- Mechanical transmission
- Frequency of seed transmission appears uncertain at this time.

General seed production pathway

3 possible greenhouse (SOPs) Pathway branches:

1. **GSPP (good seed and plant practices)**
2. **Non-GSPP, but well managed. Can vary risk due to materials, people, and water**
3. **Poorly managed.**

Pathway branches resulting in 3 different risk outcomes!



Branching due to breeding method used:

- **conducted in the greenhouse**
- **laboratory**
- **field settings**

Each has different phytosanitary concerns.

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Goes beyond HACCP

- Identify steps in the pathway that contribute the highest amount of risk (**sensitivity analysis**).
- Anticipation and contingency planning; ***'what-if'*** scenarios.
  - **Can test any scenario and estimate risk reduction or increase.**
- Discover steps in the pathway that can be adjusted to reduce risk, and the amount of reduction that would be expected due to the change implemented.

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Data Sources

- **Data mining of Published Literature**
  - Much is available
- **Acquire data directly from seed production companies**
  - Some production methods may be specific to individual company
  - Need data resulting from specific method application
- **Where no data is available:**
  - Define precise missing data
  - Design and conduct experiments to fill data gap
  - Analyze data and use to populate model

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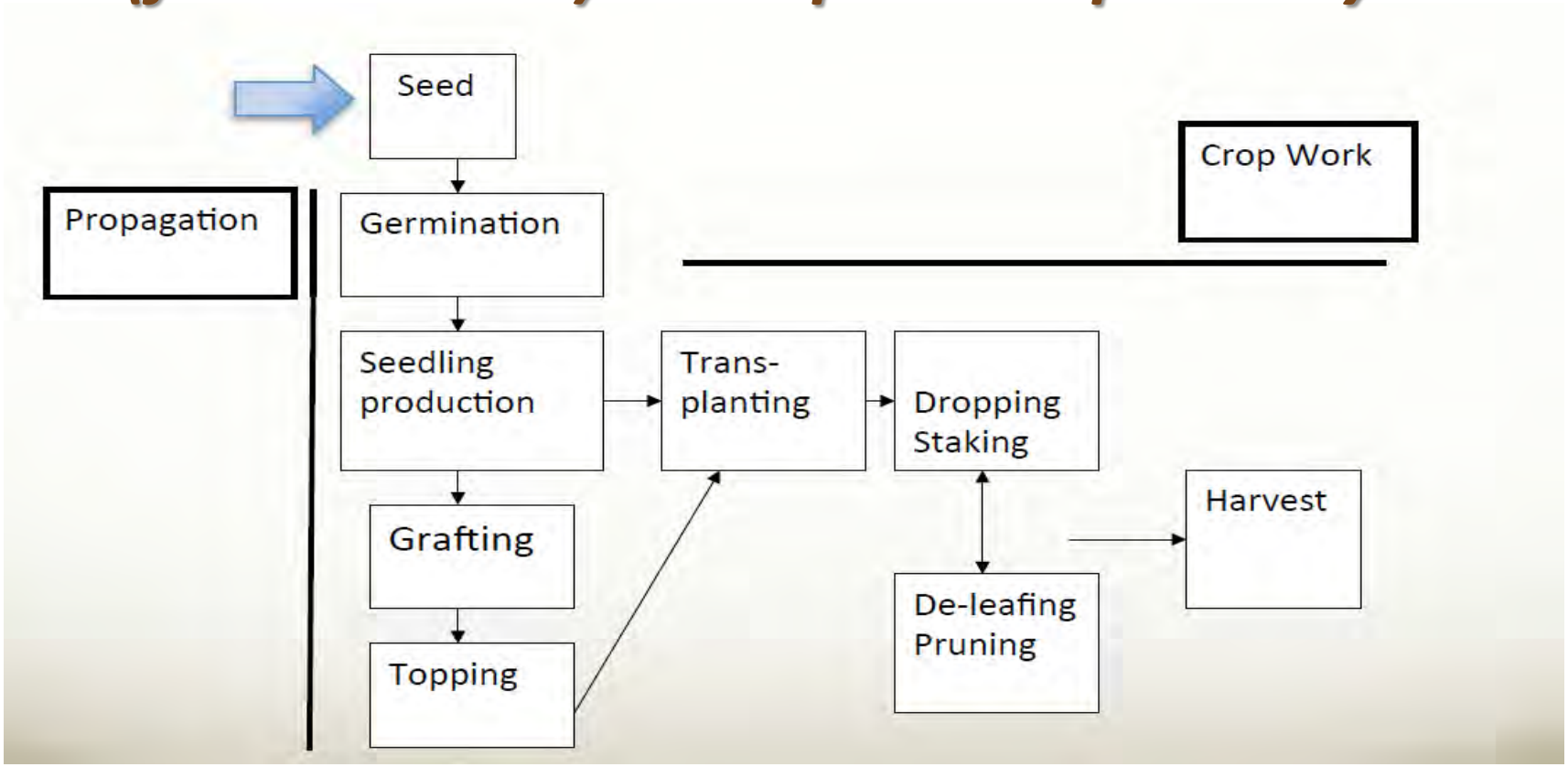
Example: Greenhouse tomato production flow (from website) – one possible pathway



- Individual companies and situations will vary of course.
- We will try to capture these variations

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Example: Known data for Bacterial canker (cmm) control efficacy - extracted from the scientific literature

- Seeds germinate under environmental conditions (warm temperature, high moisture) highly favorable to Cmm
  - >10^6 cfu/g seedling leaves required for epidemic in field
    - Shirakwawa et al. JARQ 25:27

Climatic conditions

Grafting

- Rootstock and scion = double chance of Cmm introduction
- Contaminated hands, tools, clothing spread pathogens during grafting and topping
- Grafting tools readily transmit Cmm but an inoculum threshold approx. 10^2-10^4 cfu/ml may be required

Phytosanitary Risk

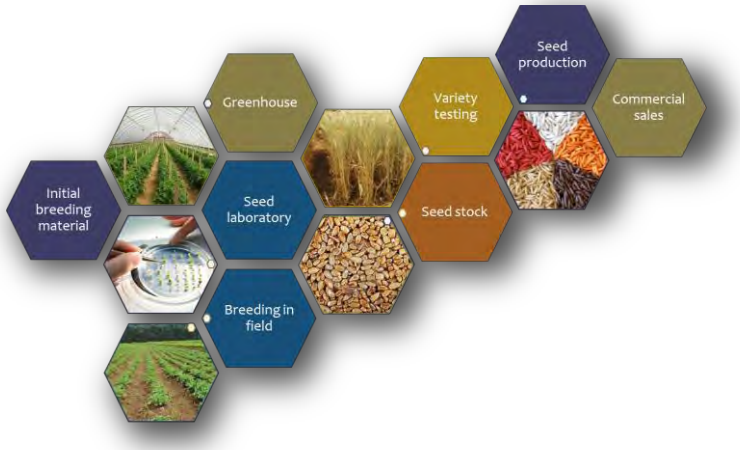
Initial disease level

Seed treatment

- Numbers of Cmm necessary to affect seed health and transmission are small (A. Alvarez)
  - As few as 25 cfu/seed inhibit germination
  - As few as 600 cfu/seed kill seedlings
  - Infestations of seeds within a seed lot are variable
- 1-5 infested seeds in 10,000 sufficient to start epidemic
  - Chang et al. Phytopathology 81: 1276

Seed Treatment Efficacy

Treatment	Cmm-infested seed (%)	Seed Vigor Index
Control	11.8 b	801 ab
Kasugamycin	10.1 bc	603 c
H_2O_2	15.3 a	803 ab
Streptomycin	6.3 d	766 b
Thymol	2.3 ef	747 c
Dry heat	7.6 cd	536 d
Hot water	-	785 b
KleenGrow	0 f	797 ab
Virkon-S	0 f	789 b
NaClO 50°C	0 f	778 b
HCl	0 f	833 a



Methodology:

Risk Modeling to determine risks associated with each step in the pathway

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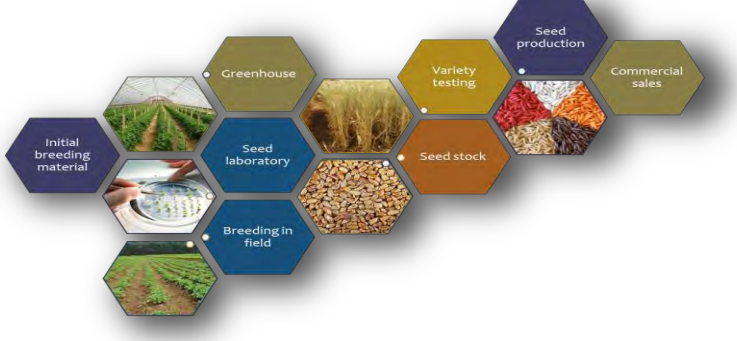

Example: seed production operations - planting preparation

- **Some possible phytosanitary concerns in association with planting for tomato seed stock:**
  - **The nearest distance to a known Cmm infected plant.**
  - **Level of weed control in field, borders, and nearby fields.**
  - **Probability of infested soil.**
  - **Amount of plant debris in area.**
  - **Concentration of Cmm in irrigation water/system.**
  - **Level of contamination/disinfectant of any materials used for planting or pruning.**
  - **Number of times any contaminated material comes in contact with plant material.**
  - **Risks from production workers (hands, clothing).**
- **With supporting data (distributions), each of these scenarios (and many more) can be quantified and included in the risk assessment.**

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Risk-based assessment modules

- ***Eight modules*** are considered from the point of incorporation of seed into breeding program to commercial seed production & sale.

Module 1 – Incorporation of seed into breeding material
Module 2 – Greenhouse or other contained facility
Module 3 – Laboratory or storage facility
Module 4 – Field

Module 5 – Variety & trait testing
Module 6 – Breeder seed & seed stock development
Module 7 – Plant preparation and operations
Module 8 – Commercial seed sales

- Aside from specific aspects of production, we are also interested in quality assurance/control tomato seed production guidelines individual companies utilize.
- Depending on specific protocols and production guidelines, individual modules may collapse to a single risk factor.
- A model will be designed in a way to accommodate various general seed business models & practices, and determine their final seed quality control performance by propagating risk from each module.

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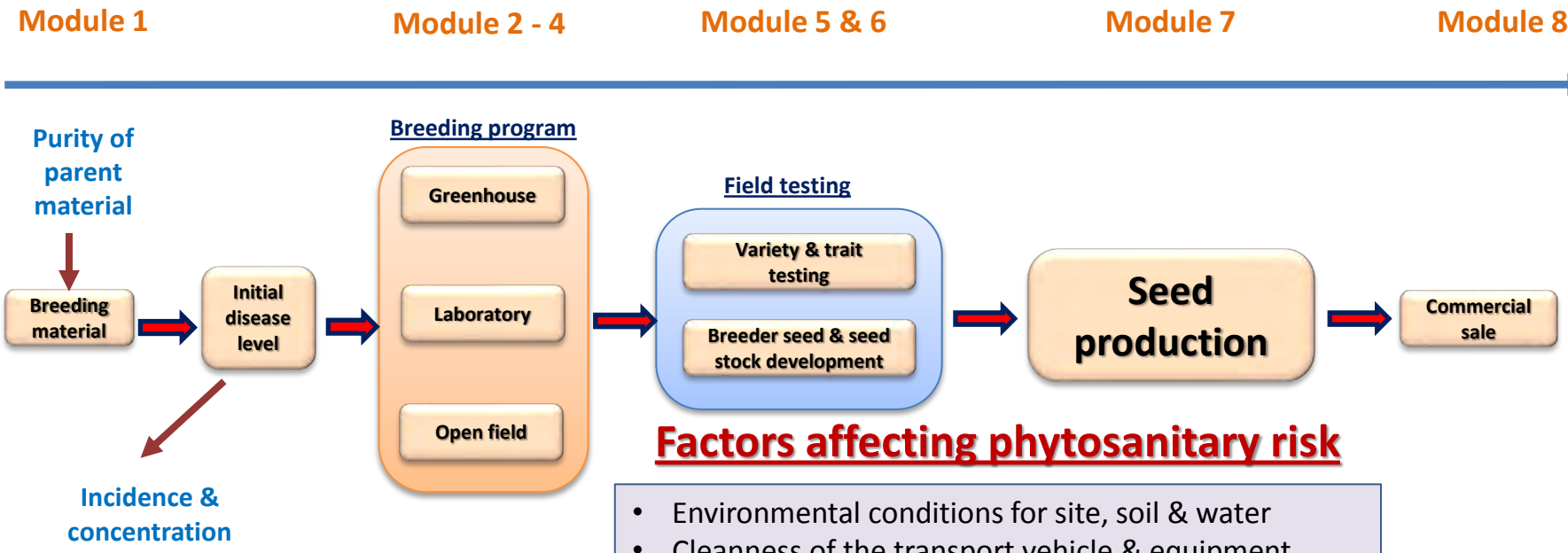
We have begun to translate these modules into an initial model framework: Flow chart for Phytosanitary Risk modelling



Factors affecting phytosanitary risk

- Environmental conditions for site, soil & water
- Cleanness of the transport vehicle & equipment
- GSPP/Non-GSPP managed
- Distance to known infection source
- Disease favorite climate variables controlled or not
- Cultural practice and disease monitor & control
- Harvest & post harvest infestation
- Seed extraction & cleaning
- Seed storage, warehousing & distribution

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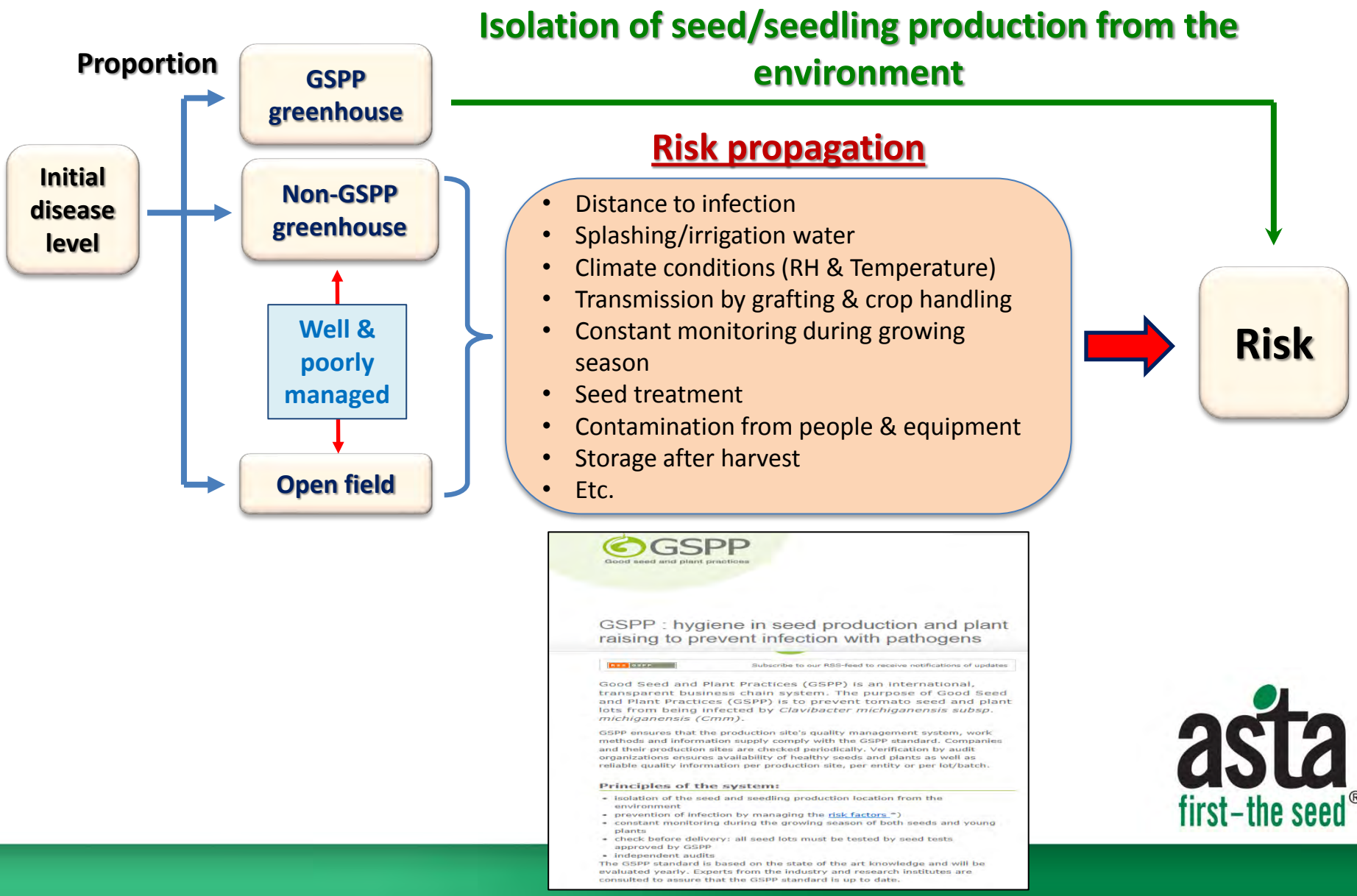
Example Module 2: Tomato, Bacterial canker (cmm)



GSPP
Good seed and plant practices

GSPP : hygiene in seed production and plant raising to prevent infection with pathogens

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Good Seed and Plant Practices (GSPP) is an international, transparent business chain system. The purpose of Good Seed and Plant Practices (GSPP) is to prevent tomato seed and plant lots from being infected by *Clavibacter michiganensis subsp. michiganensis (Cmm)*.

GSPP ensures that the production site's quality management system, work methods and information supply comply with the GSPP standard. Companies and their production sites are checked periodically. Verification by audit organizations ensures availability of healthy seeds and plants as well as reliable quality information per production site, per entity or per lot/batch.

Principles of the system:

- isolation of the seed and seedling production location from the environment
- prevention of infection by managing the risk factors "
- constant monitoring during the growing season of both seeds and young plants
- check before delivery: all seed lots must be tested by seed tests approved by GSPP
- independent audits

The GSPP standard is based on the state of the art knowledge and will be evaluated yearly. Experts from the industry and research institutes are consulted to assure that the GSPP standard is up to date.

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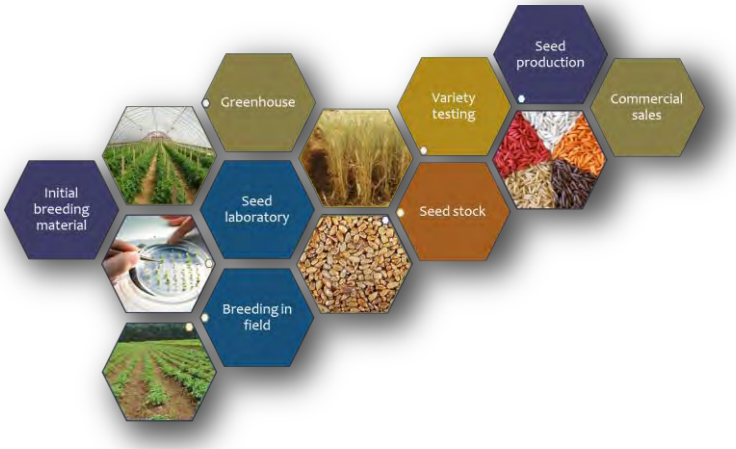

Building the model: Step 1

- **Identify variables to include in the model.**
- **Need to rely on expert opinion, literature, and published/ not published data, proprietary.**
- ***Potential need for 'gap-filling' research!***

Example: 5 variables for Cmm

1. ***Distance to Cmm infected plants***
2. Number of occurrences where pruning tools have Cmm
3. Cmm concentration in irrigation water
4. Plant debris (units) in nearby fields
5. Number of employees that forget to wash their hands

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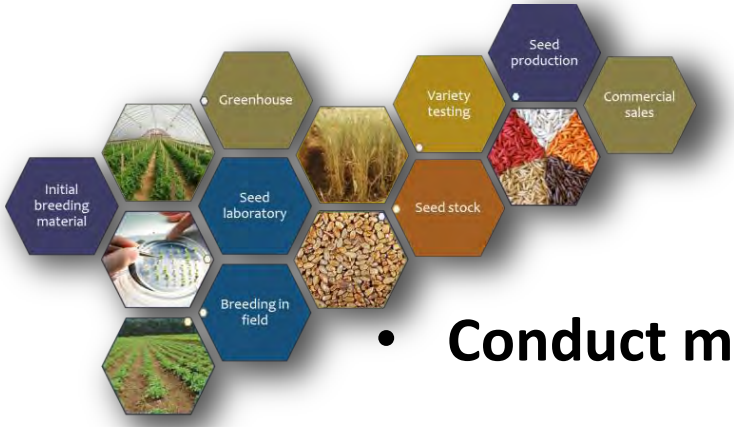

Step 5

- **Conduct multiple iterations and examine results.**

Distance to Cmm infected plants

Number of occurrences where pruning tools have Cmm

Cmm concentration in irrigation water

Plant debris (units) in nearby fields

Number of employees that forget to wash their hands

Risk

Risk = 2.9

Risk = 1.3

Note: Only higher distances chosen

Frequency

0 Risk 5

10,000 iterations = 1.8

Range (0,5)

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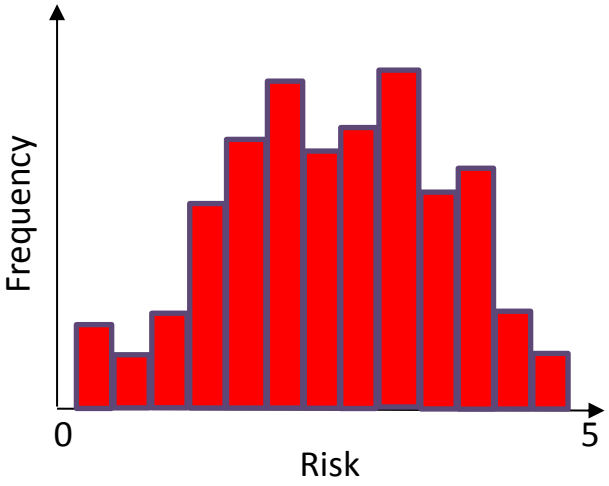
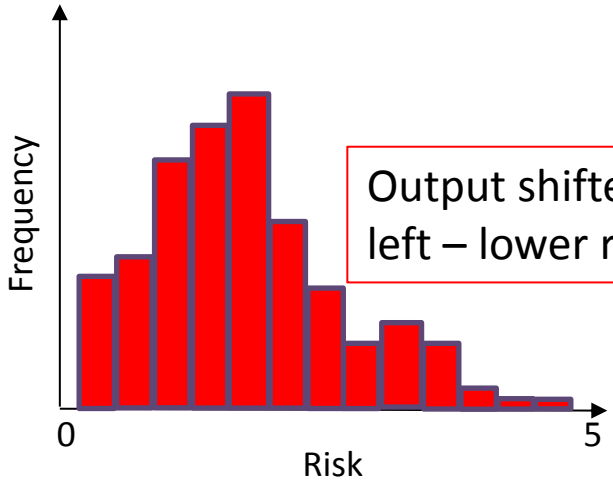
Model application to reduce risk: 'what if' scenarios

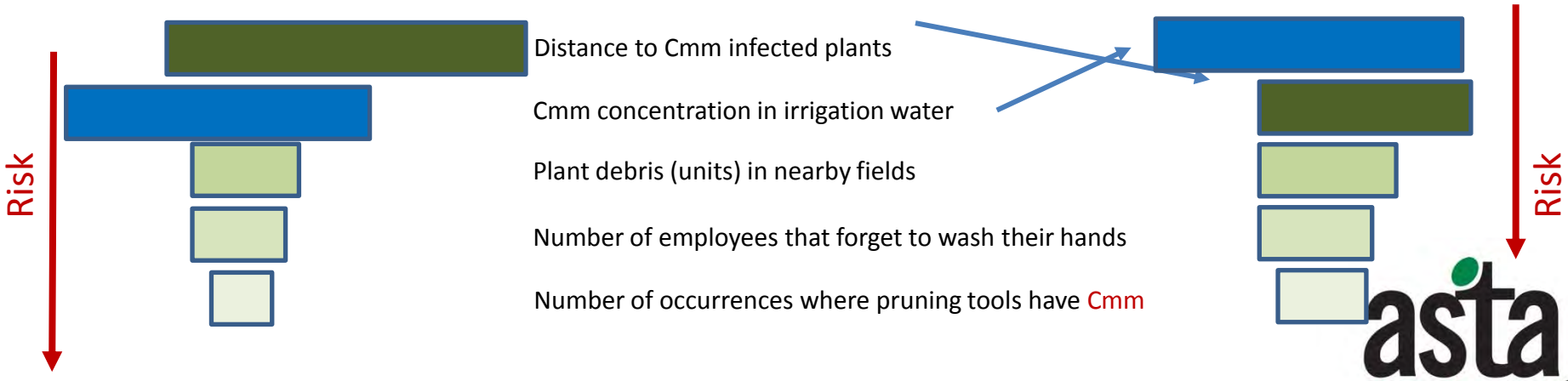
Risk in a **typical** disease pressure environment



Risk in a **low** disease pressure environment



Output shifted to the left – lower risk



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Outcomes

1. **Method to conduct "pathway analysis" with any plant system.**
2. **Method to identify phytosanitary concerns prior to large-scale (high-cost) problems.**
3. **Method to clearly indicate how a company's production practices reduce phytosanitary risks.**
    1. ***Assure regulatory agencies and customers 'How you stack up'!***
4. **Provides and objective "outside" scientific risk assessment. Then members of ASTA can choose to apply the assessment to their own risk management procedures.**
5. **Becomes a framework to develop *International Phytosanitary Standards, revised PRA approaches, and maybe an accreditation system for phytosanitary***

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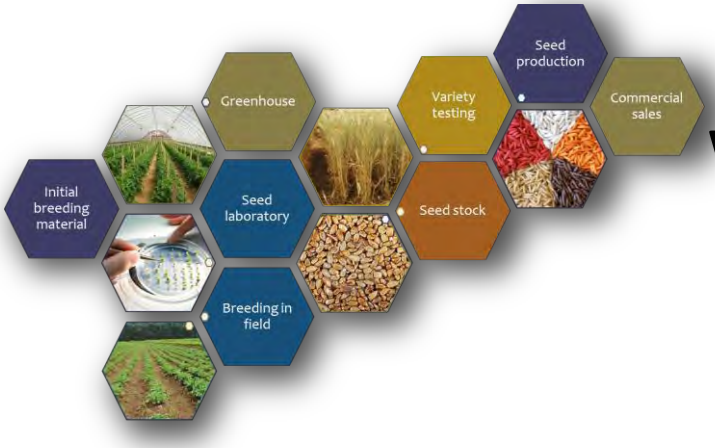

What is needed from seed companies

- **Data for input distributions**
  - **We *understand and appreciate that some data may be proprietary*.**
  - **We do not need to link data to source. Data will become part of a larger set and individual company identity is lost.**
  - **Need to understand the breadth of methods used within each pathway**
  - **Need to ensure we capture all possible steps and possible branches in the pathway**

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Module 3 – Laboratory or storage facility

1) Starting material
    a. Disease incidence of lot/test detection limit
    b. Effectiveness of cleaning method of receiving containers
2) Planting
    a. Is Cmm inoculation testing conducted at the location?
    b. Sanitary level where planting/handling occurs?
    c. # of times/employees forget to wash hands/equipment
    d. Water source concentration of Cmm
    e. Pathogen-free media used?
    f. Plants inspected for Cmm?
    g. Growing media and ground covers changed since last crop?
    h. Climate controlled?
        i. Temperature
        ii. Relative humidity
        iii. # hours leaf wetness per day (and after sunset)
    i. Irrigation method (overhead, drip…) coupled with volume of water during each watering
    j. Level of weed control
    k. Amount of plant debris in area
    l. During roguing, number/level of adjacent asymptomatic plants also removed
    m. Method of culling/plant disposal
        i. Piled without burying
            1. Distance of cull pile to greenhouse/production site?
        ii. Burying/composting plants
            1. Distance of cull pile to greenhouse/production site?
        iii. Others? (incineration?)
    n. Seed treatment?
        i. Hot water/dry heat
        ii. Acetic acid
        iii. Other
    o. Shipment of starting material
        i. Transport vehicles inspected/cleaned to be sanitary?
        ii. Type of transport vehicle (open, closed, controlled environment…)
        iii. Transport vehicles climate controlled (free of instances of compromised climate control integrity?) and free of moisture pockets?
        iv. Distance shipped coupled with impenetrability of shipping container to outside environment (resistance to being contaminated with Cmm)
        v. Distance of ground transportation through an area known to have Cmm hosts/infection?
        vi. Effectiveness of cleaning regime upon receipt

Information Needed from Seed Production Companies

- First we are meeting with key industry representatives to better understand the QM systems being used.
- A questionnaire has been prepared to circulate to seed companies to capture the data.

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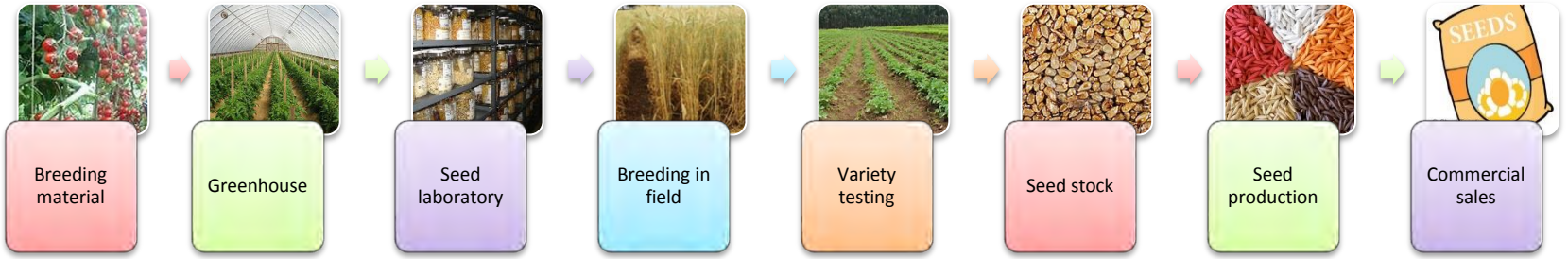
Risk assessment of seed production:

From breeding to sale

Thank You for you time and attention!



= What Risk?

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