The economic value of durable disease resistance

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Crop Resistance is useful, but fragile

Potato late blight
(*Phytophthora infestans*)

Tomato yellow leaf curl disease (TYLCV)

Genetic resistance is often overcome quickly after deployment due to pathogen evolution

Canola blackleg
(*Leptosphaeria maculans*)

Root knot nematode
(*Meloidogyne incognita*)

Black rot
(*Xanthomonas campestris*)

What determines resistance durability?

- **Pathogen Evolutionary Potential**
  - Population size
  - Mutation rates
  - Dispersal
  - Mode of reproduction
- **Type of resistance**
  - Qualitative
  - Quantitative
- **Deployment and Farming system**
  - Gene-combinations
    - Stacks
  - Spatial and temporal structure
    - Rotations
    - Mixtures
  - Area sown

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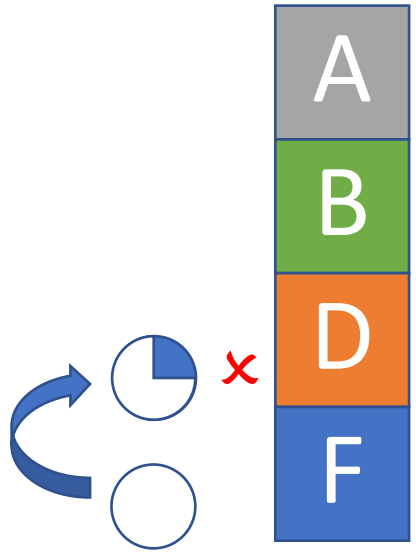
Informed by biology, Implemented by humans

Stacking major resistance genes: pros and cons

- Idea is to create an evolutionary barrier
- Simple to deploy, easy to market



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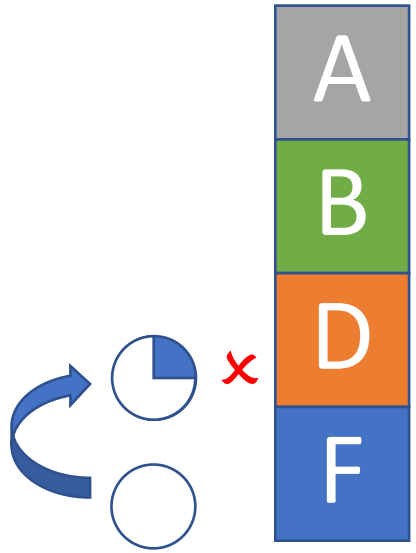

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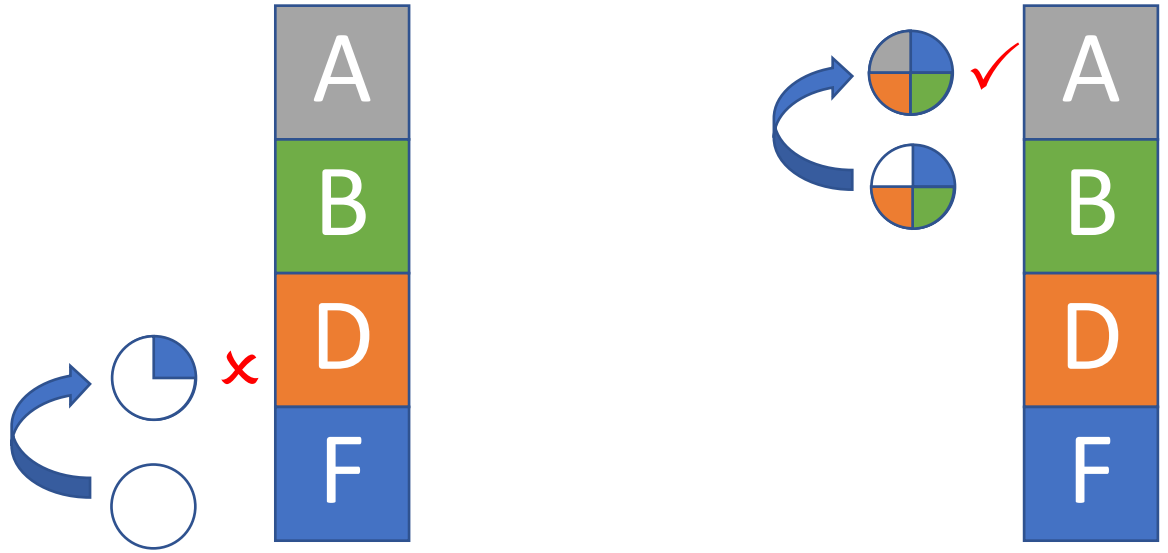
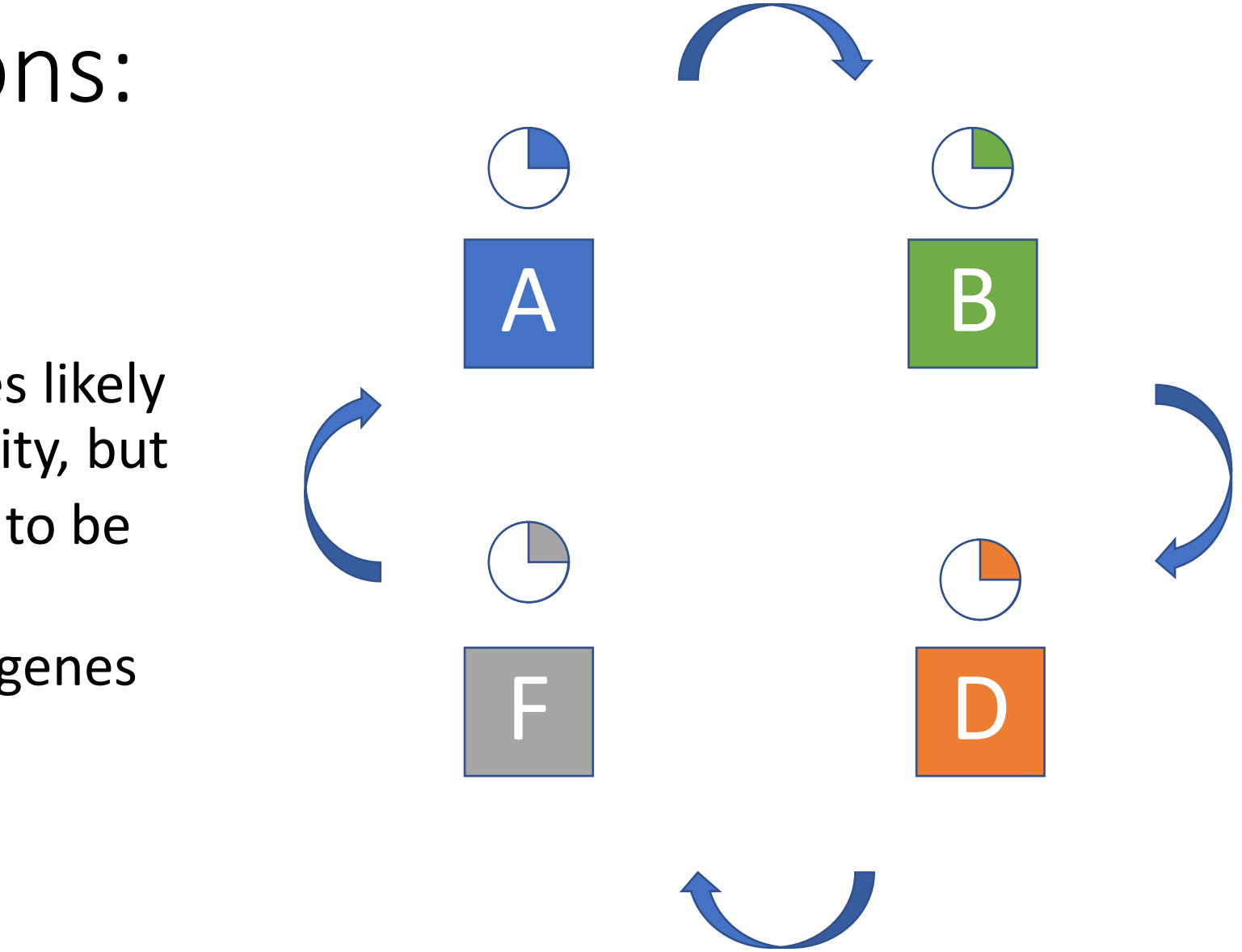
  - Pathogen is asexual
- The breakdown of a stack promotes the emergence of a ‘super pathogen’



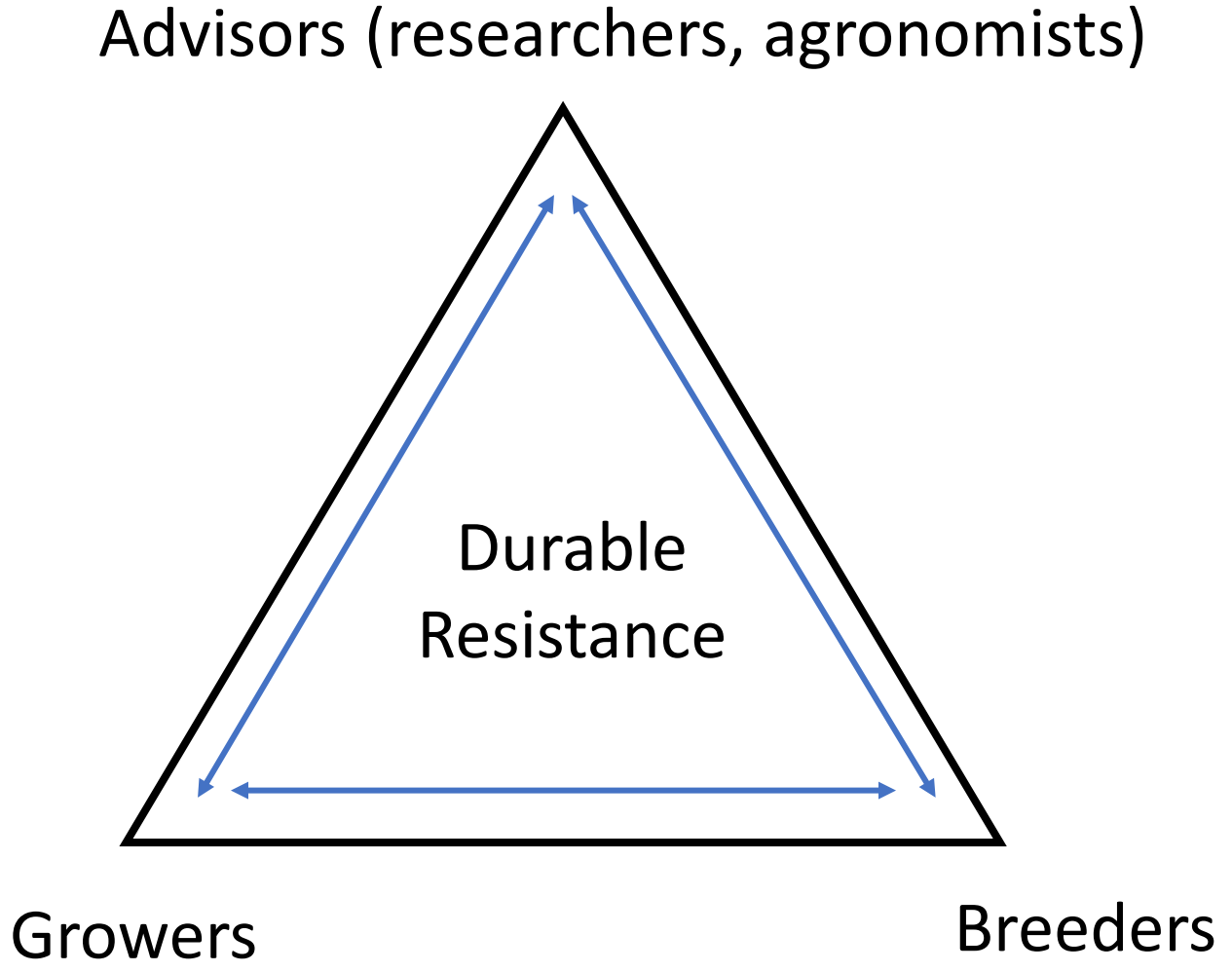
R-gene rotations: pros and cons

- Rotating individual R-genes likely a better option for durability, but
  - Ineffective genes need to be removed
  - Varieties with single R-genes rotated through time



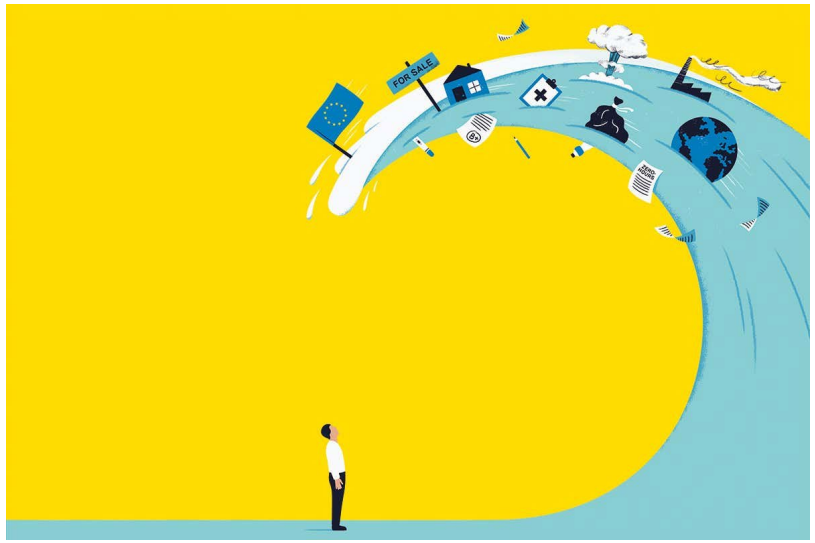
How to ensure more durable resistance?

- Strategies to promote more durable resistance can often be identified
  - Maybe not optimal but better than the status quo
  - Area-wide, more complicated, costly
- Whole of industry approach required
- Genetic resistance undoubtedly has value, but……..
  - Cost vs Benefit of stewardship?



Challenges for the economic valuation of durable resistance

- No formal pricing mechanisms for resistance genes
  - Public goods – unrestricted access, infinitely replicable
  - Not protected by IP or patents
  - *'Tragedy of the commons'*
- Multiple stakeholders with potentially competing interests
  - Who benefits?
  - Who pays?
- Evolutionary processes are complex and uncertain
  - Occur over large spatial and temporal scales



Interacting biological, economic and social uncertainty

Step 1: Place genetic resistance on a firm economic foundation

The socio-economic challenges of managing pathogen evolution in agriculture

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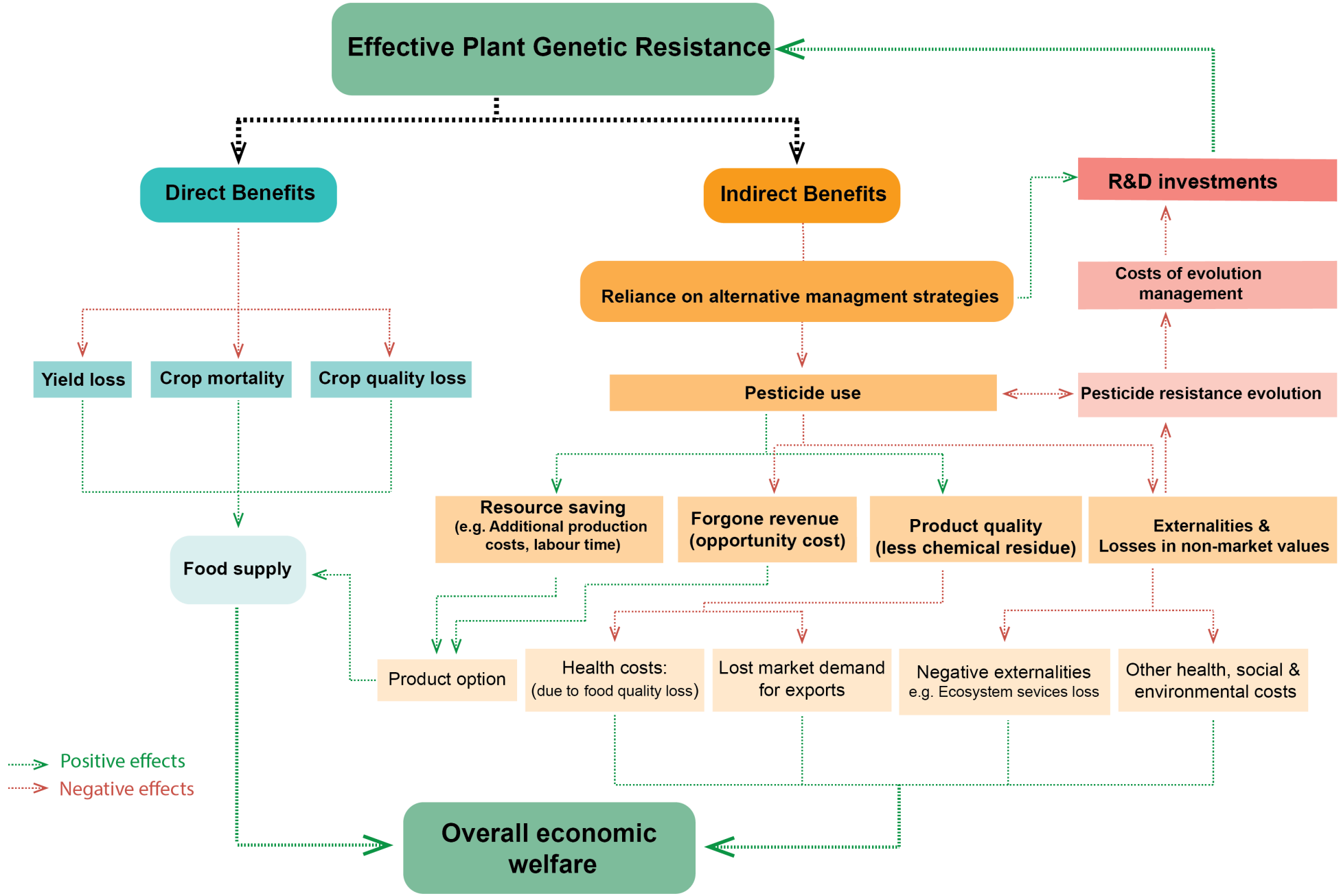
Genetic resistance forms the foundation of infectious disease management in crops. However, rapid pathogen evolution is causing the breakdown of resistance and threatening disease control. Recent research efforts have identified strategies for resistance gene deployment that aim to disrupt pathogen adaptation and prevent breakdown. To date, there has been limited practical uptake of such strategies. In this paper, we focus on the socio-economic challenges associated with translating applied evolutionary research into scientifically informed management strategies to control pathogen adaptation. We develop a conceptual framework for the economic valuation of resistance and demonstrate that in addition to various direct benefits, resistance delivers considerable indirect and non-market value to farmers and society. Incentives for stakeholders to engage in stewardship strategies are complicated by the uncertain timeframes associated with evolutionary processes, difficulties in assigning ownership rights to genetic resources and lack of governance. These interacting biological, socio-economic and institutional complexities suggest that resistance breakdown should be viewed as a wicked problem, with often conflicting imperatives among stakeholders and no simple cause or solution. Promoting the uptake of scientific research outcomes that address complex issues in sustainable crop disease management will require a mix of education, incentives, legislation and social change.


Effective Plant Genetic Resistance
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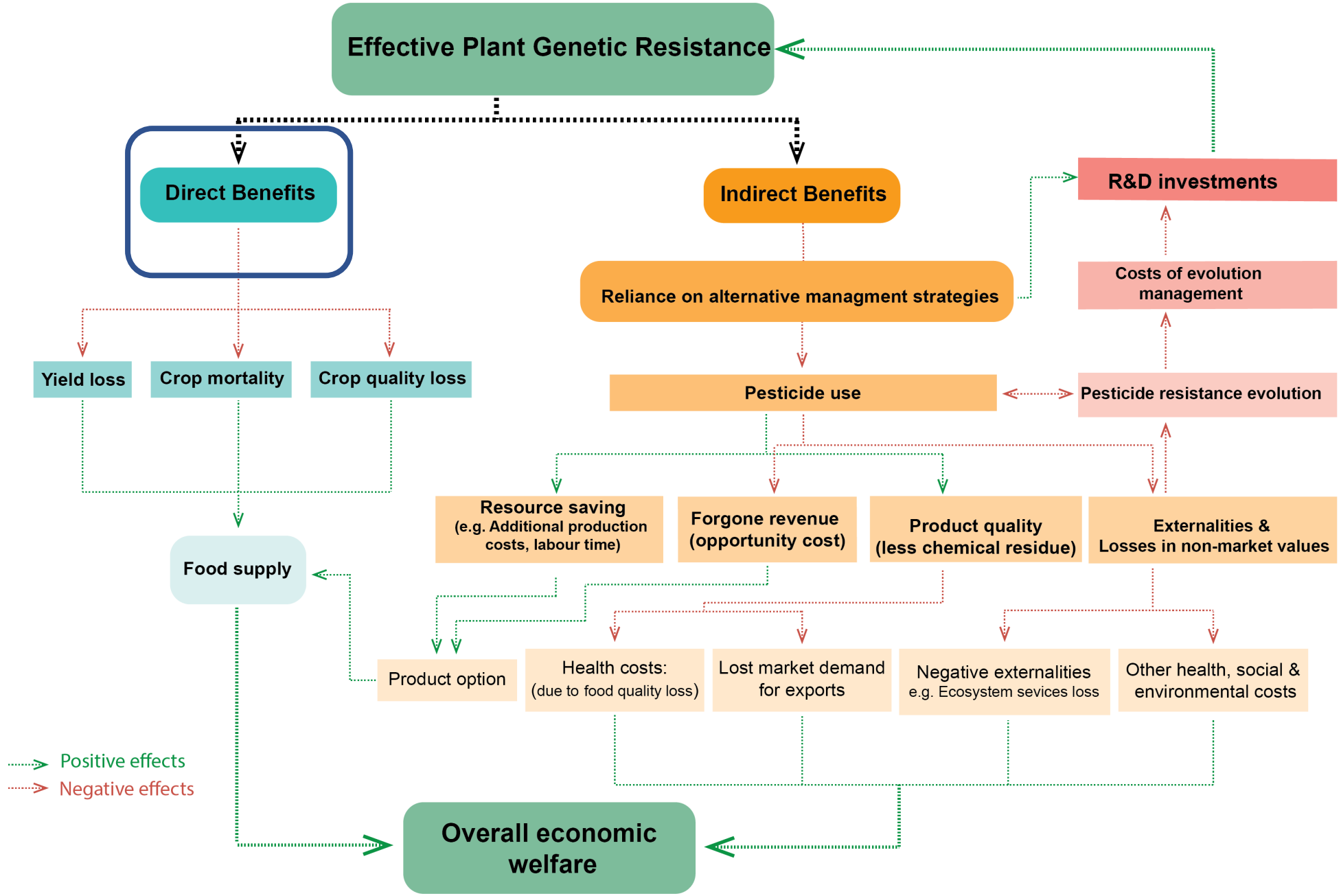
Indirect Benefits
R&D investments
Reliance on alternative managment strategies
Costs of evolution management
Yield loss
Crop mortality
Crop quality loss
Pesticide use
Pesticide resistance evolution
Resource saving
(e.g. Additional production costs, labour time)
Forgone revenue
(opportunity cost)
Product quality
(less chemical residue)
Externalities &
Losses in non-market values
Food supply
Product option
Health costs:
(due to food quality loss)
Lost market demand
for exports
Negative externalities
e.g. Ecosystem sevices loss
Other health, social &
environmental costs
Positive effects
Negative effects
Overall economic
welfare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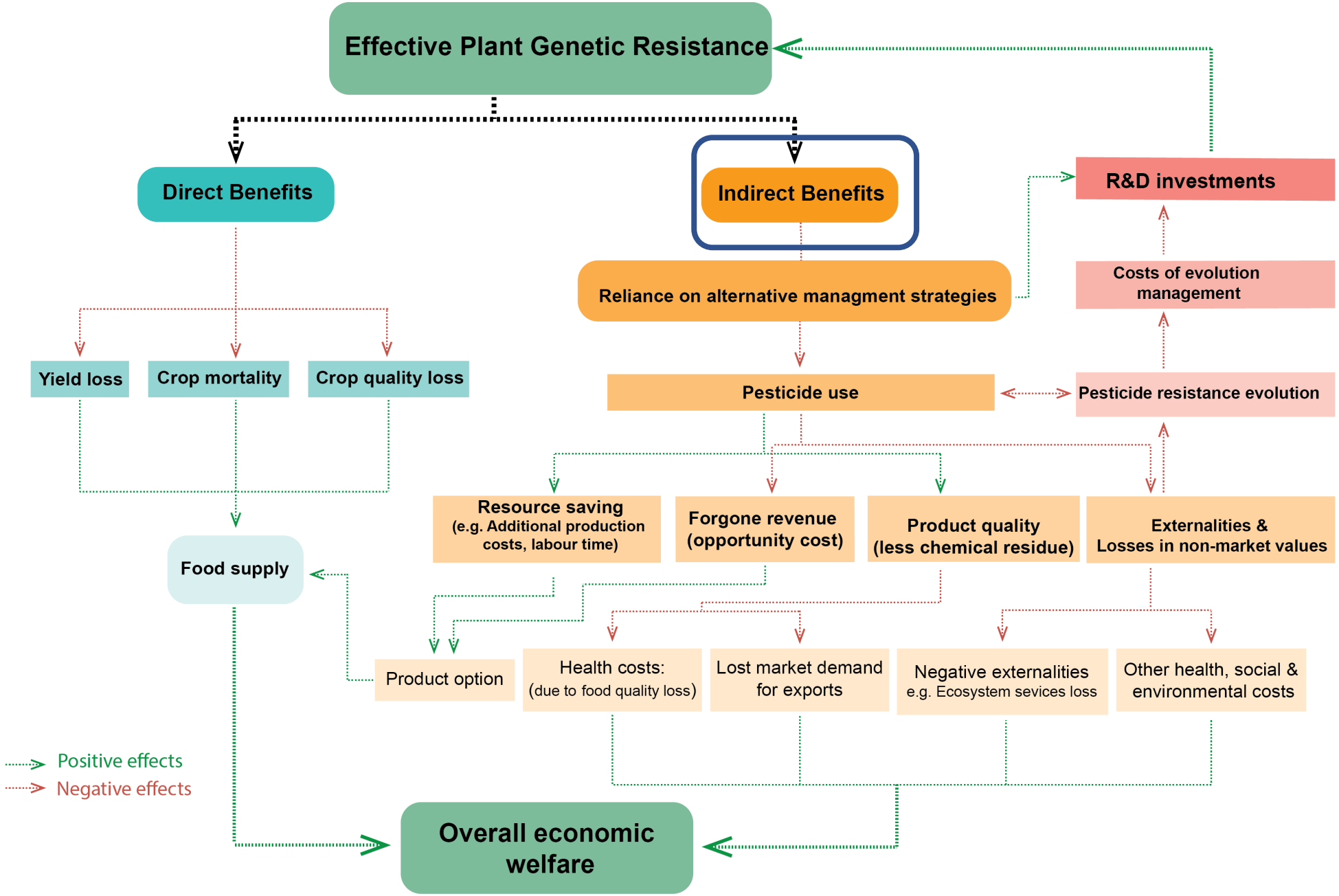
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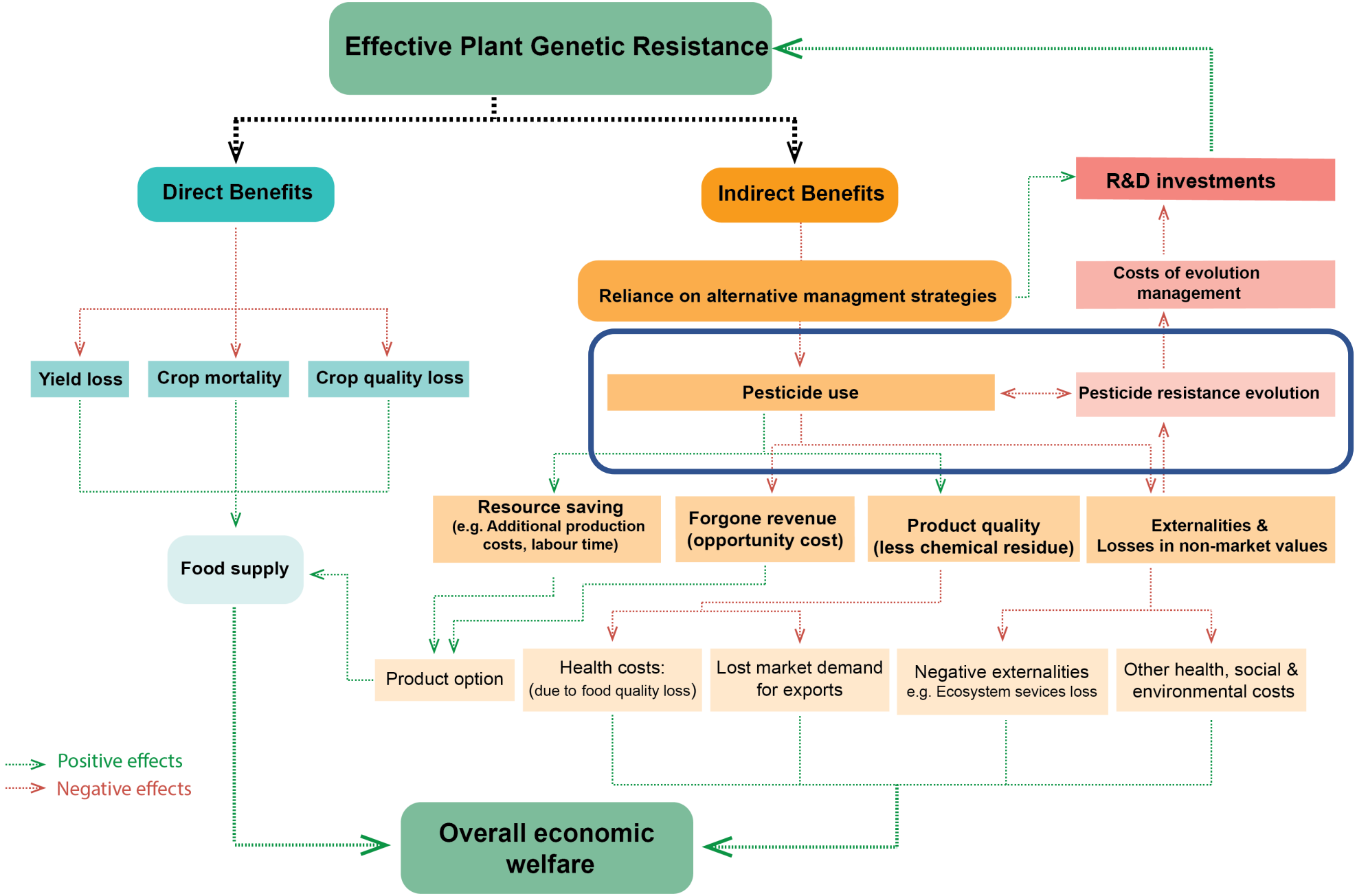
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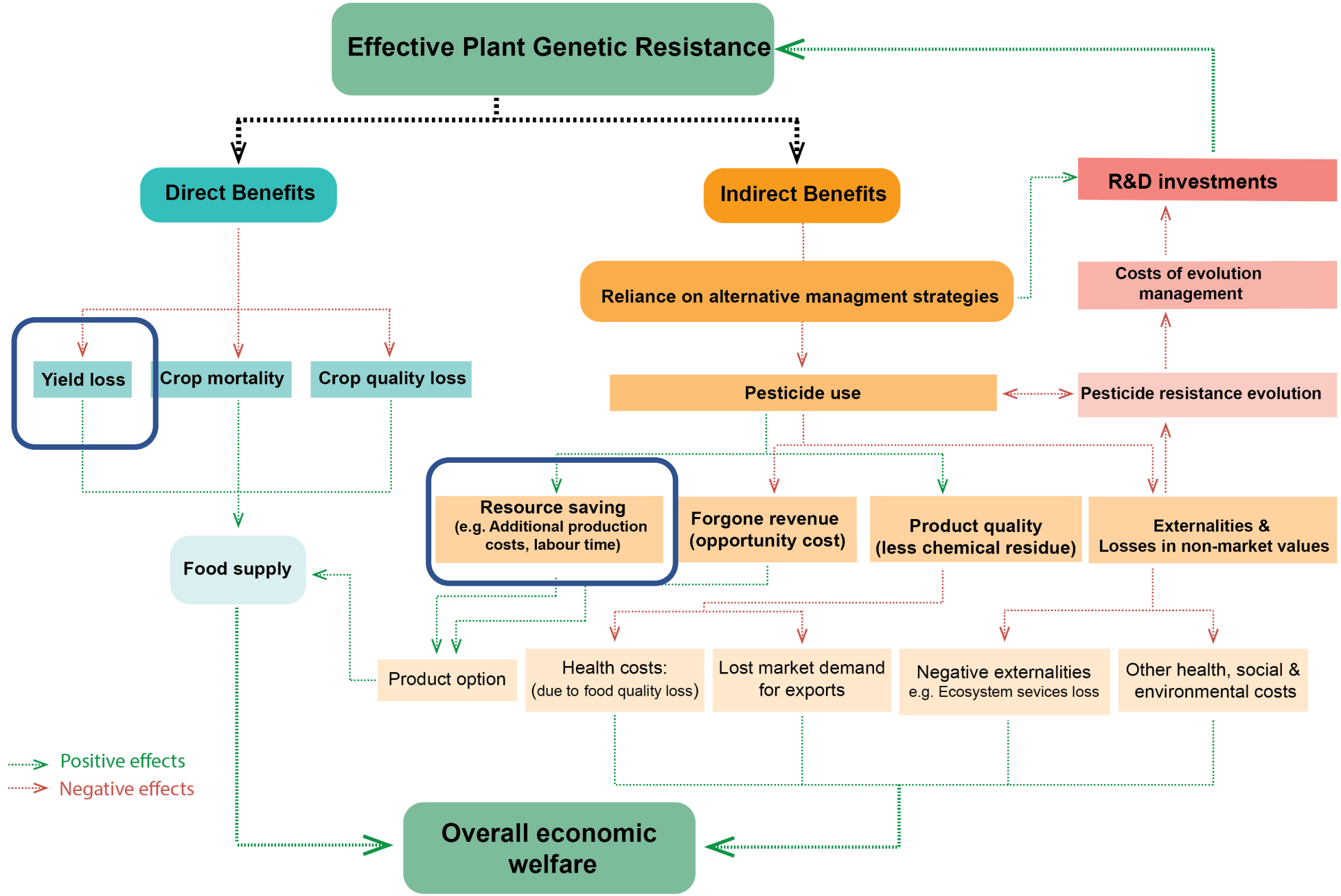
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Some data from Canola and Blackleg

Yield and disease data from:

Summarizing environmental variables
- 16 locations
- 4 states
- 4 years (2013-2016)

Parameters sampled:

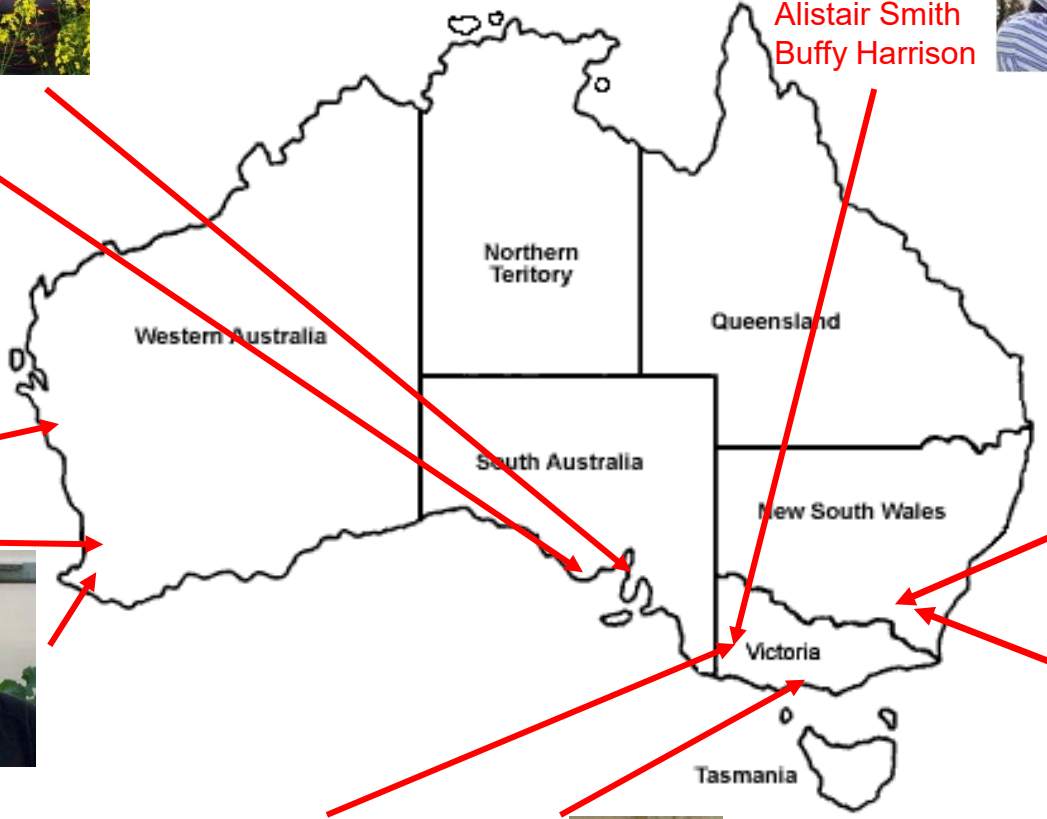
Genetics & cultivation practices variables
- 22 varieties
- 6 genetic resistance rating levels (R ; R-MR ; MR ; MR-MS ; MS ; MS-S)
- Multiple azole fungicide treatments (including “Nil” and “full” control treatments)

data collection

SARDI:
Andrew Ware
Jenny Davidson


MGP:
Steve Marcroft
Biz Sheedy
Alistair Smith
Buffy Harrison



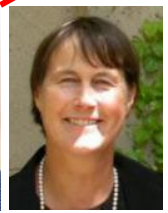
DAFWA:
Ravjit Khangura
Andrea Hills
Ciara Beard



NSW DPI:
Kurt Lindbeck
Audrey Leo


CSIRO:
Susie Sprague





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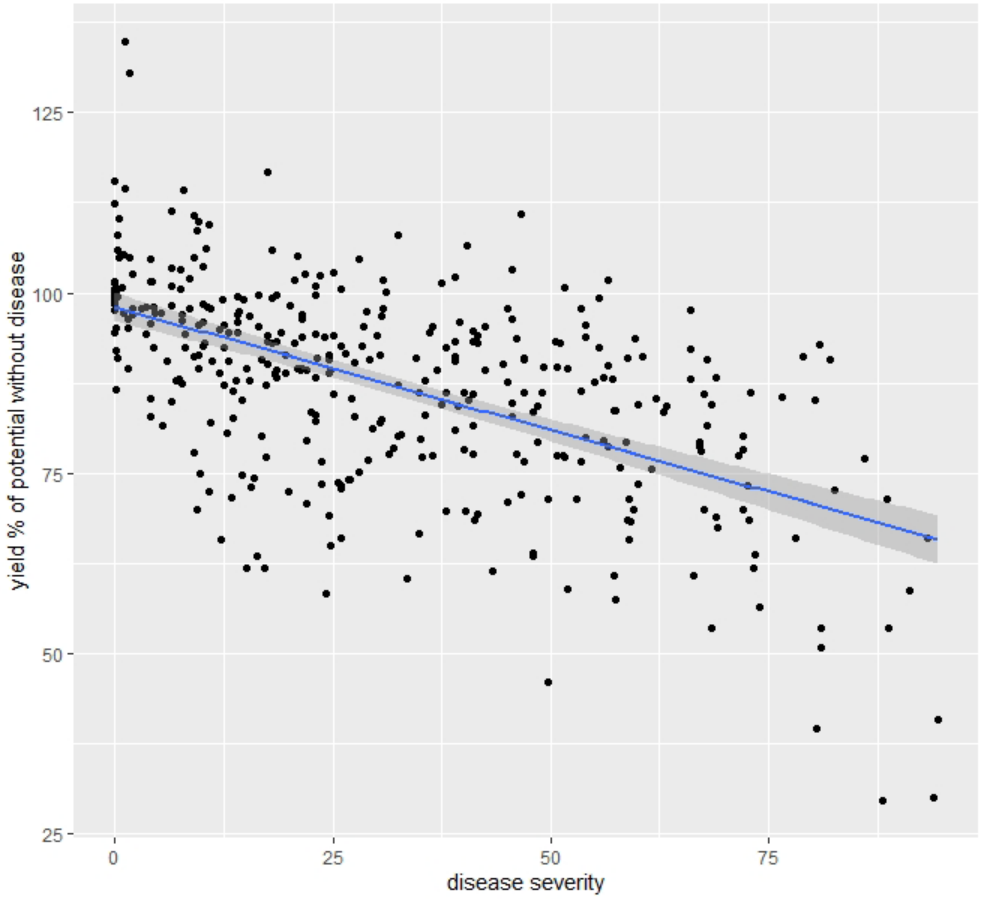
S.J Sprague

Relationship between crown canker severity and yield



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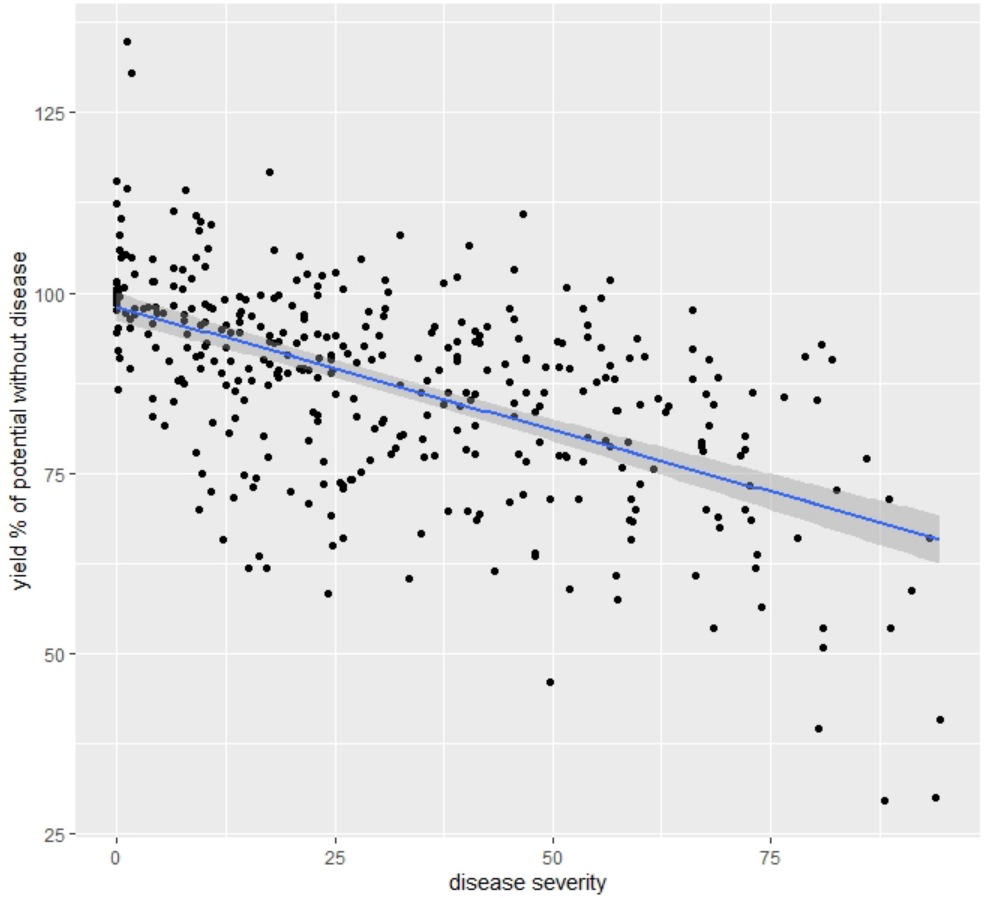
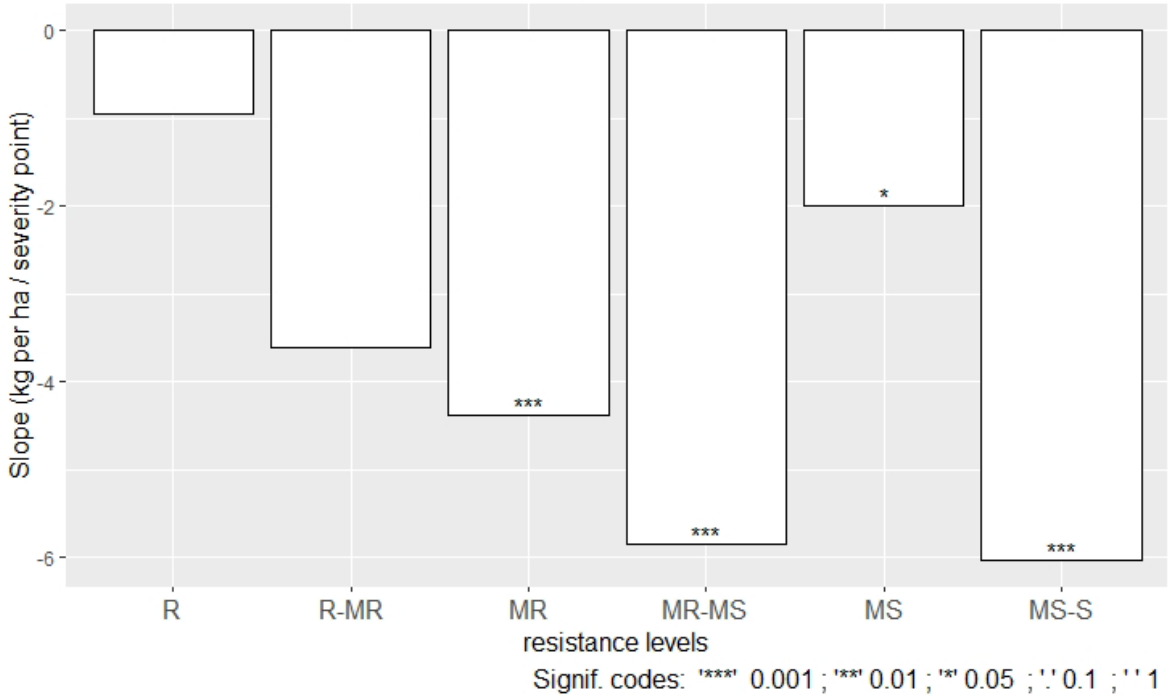
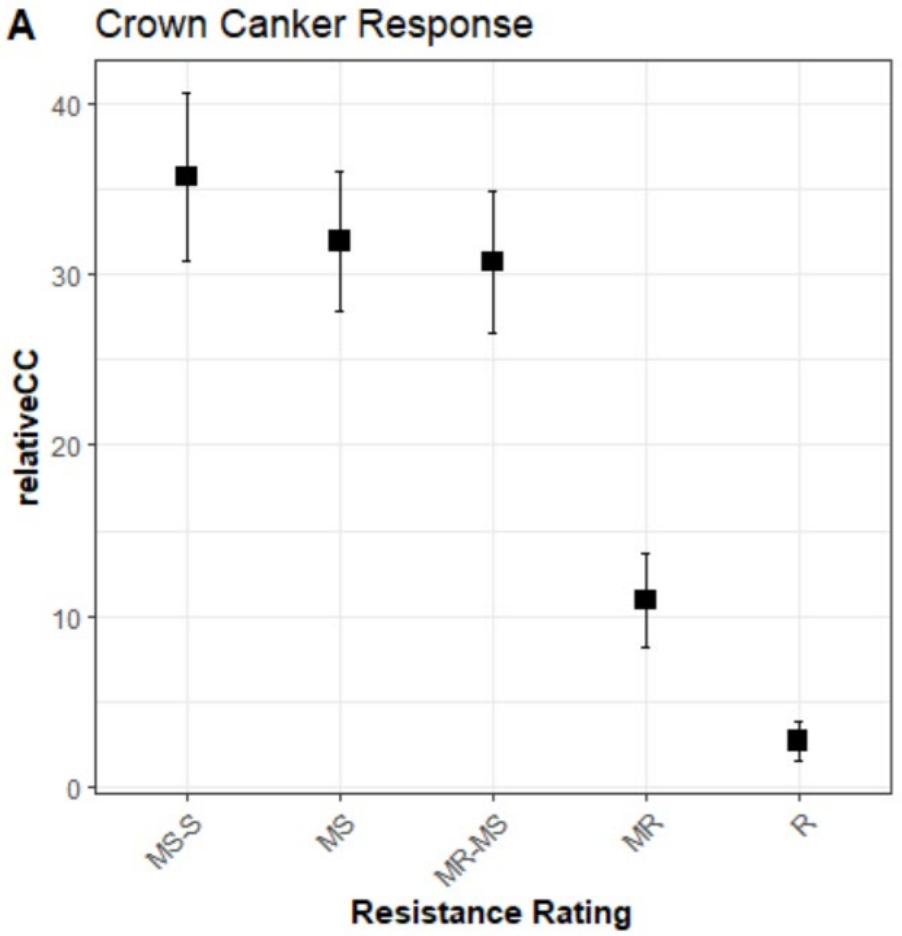




Benefits of resistance to blackleg



No fungicide vs full disease control (Azoles)

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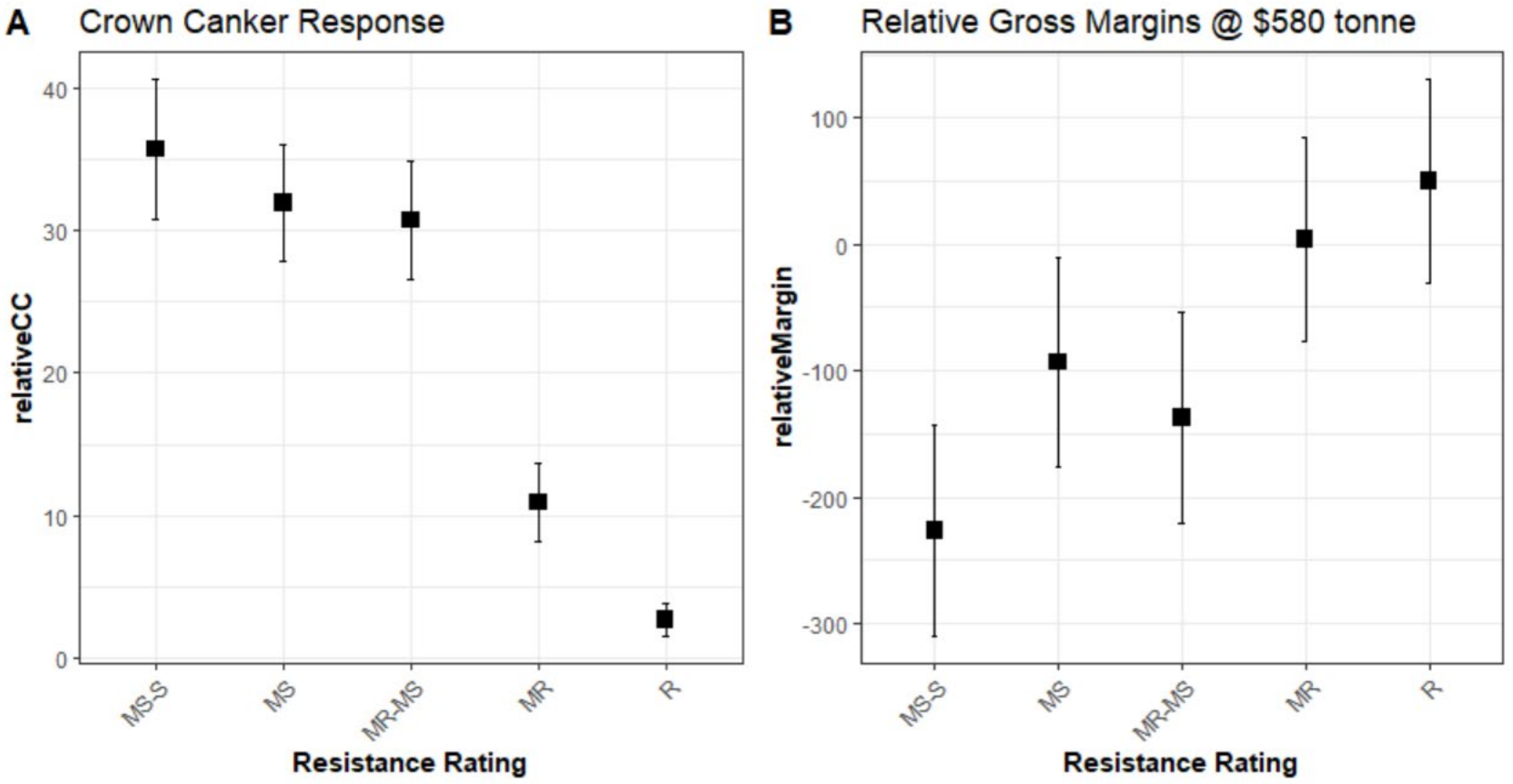

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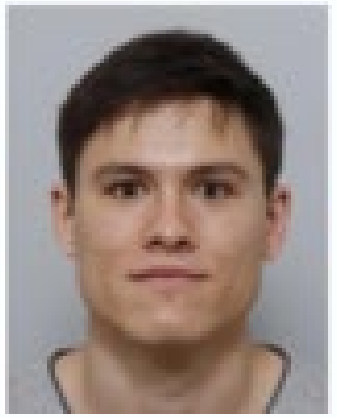
Discussion questions

- Is resistance worthy of stewardship?
- Who benefits from durable resistance?
- Who should pay?
- What are some barriers that affect the potential for cooperation amongst stakeholders?

Acknowledgements



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Challenges for the economic valuation of durable resistance