Economic Studies Reinforce Efforts to Safeguard Specialty Crops in the United States

M. Fuchs, C. V. Almeyda, M. Al Rwahnih, S. S. Atallah, E. J. Cieniewicz, K. Farrar, W. R. Foote, D. A. Golino, M. I. Gómez, S. J. Harper, M. K. Kelly, R. R. Martin, T. Martinson, F. M. Osman, K. Park, V. Scharlau, R. Smith, I. E. Tzanetakis, G. Vidalakis, and R. Welliver

Plant Disease • 2021 • 105:14-26 • https://doi.org/10.1094/PDIS-05-20-1061-FE

Start clean, stay clean
NCPN
National Clean Plant Network

NCPN-Economic Studies Special Initiative

- NCPN stakeholders, economists, center directors, and program managers convened to discuss the status of existing economic research on clean plants and to decide on the future direction of economic studies.
- This publication is one of the outcomes of the special initiative.
- It reviews recent research outlining economic impacts of diseases of vegetatively-propagated specialty crops and the return on public investment in NCPN centers.

Start clean, stay clean
NCPN
National Clean Plant Network

Plant Disease • 2021 • 105:14-26 • https://doi.org/10.1094/PDIS-05-20-1061-FE

Economic Studies

- Document the economic impacts of diseases caused by graft-transmissible pathogens
- Identify profit-maximizing disease management solutions in the field
- Assess returns to public investment of NCPN centers

Plant Disease • 2021 • 105:14-26 • https://doi.org/10.1094/PDIS-05-20-1061-FE

Economic Studies Reinforce Efforts to Safeguard Specialty Crops in the United States

M. Fuchs[†], C. V. Almeyda, M. Al Rwahnih, S. S. Atallah, E. J. Cieniewicz, K. Farrar, W. R. Foote, D. A. Golino, M. I. Gómez, S. J. Harper, M. K. Kelly, R. R. Martin, T. Martinson, F. M. Osman, K. Park, V. Scharlau, R. Smith, I. E. Tzanetakis, G. Vidalakis, and R. Welliver

Keywords: clean plant center, clean planting material, diagnostics, disease management, disease prevention, economic cost, economic returns, National Clean Plant Network, pathogen-tested plant stocks, specialty crop production

Specialty crops are a vital segment of agriculture in the United States. Specialty crops are fruits and tree nuts, vegetables, culinary herbs and spices, medicinal plants, as well as nursery, floriculture, and horticulture crops (USDA-AMS 2020). In 2017, the value of farm level sales of specialty crops, including fruits, vegetables, and nursery crops, was estimated at close to $65 billion or 38% of total crop sales in the United States. Approximately 240,000 farm operations produced more than 350 types of fruit, vegetable, tree nut, flower, nursery, and other horticultural crops (Johnson 2019).

Most specialty crops are clonally propagated. Clonal propagation ensures that propagated plants grow and produce fruits genetically identical to the original plant stock from which the planting materials are sourced (Bhiwani and Razdan 1996). In addition, most woody specialty crop plants are grown on a rootstock that provides tolerance to pests, diseases, and abiotic factors, confers adaptability to soil type, and impacts vigor, as well as influences fruit yield and quality (Castle 1995; Nimbolkar et al. 2016). Clonal propagation of rootstocks also assures identical genetic horticultural characteristics to the propagated progeny.

Graft-transmissible pathogens including viruses, viroids, bacteria, and phytoplasmas can cause detrimental diseases in clonally propagated specialty crops, such as berries (Martin et al. 2013, 2017; Polashock et al. 2017), citrus (Zhou et al. 2020), fruit trees (Ogawa et al. 1995; Rubio et al. 2017; Sutton et al. 2014), grapes (Fuchs 2020; Wilcox et al. 2015), hops (Pethybridge et al. 2008), roses (Horst and Cloyd 2007), and sweetpotatoes (Clark et al. 2013) (Table 1). If a plant stock (scion or rootstock) of one of these specialty crops is infected with a graft-transmissible pathogen, many of the propagated and grafted progeny will become infected. If pathogens are not identified in plant stocks using robust diagnostic methodologies for subsequent elimination of all propagative units that test positive, infected planting materials will be transferred to the field where they can contribute to disease outbreaks and epidemics. Similarly, top-working, root-grafting, and sometimes the use of contaminated tools (Barbosa et al. 2005) can contribute to the dissemination of graft-transmissible pathogens in the field. In addition, some viruses, phytoplasmas, and bacteria of specialty crops can be transmitted in the field by aerial arthropod vectors such as psyllids, aphids, mealybugs, soft scales, mites, whiteflies, treehoppers, and leafhoppers (Table 1). Some are also pollen-borne or transmitted by ectoparasitic dagger nematodes (Table 1) and viroids are mechanically transmissible, for instance in citrus (Barbosa et al. 2005) and hops (Pethybridge et al. 2008). Once an infection with a graft-transmissible pathogen has occurred, there is no cure in the field and management options are limited, relying primarily on reducing the level of inoculum and eventually controlling vector populations (Almeida et al. 2005, 2013; Clark et al. 2012; Ferguson and Grafton-Cardwell 2014; Fuchs 2020; Gabriel et al. 2020; Gergerich et al. 2015; Gibson and Kreuze 2015; Lee 2015; Maliogka et al. 2015; Martin et al. 2017; Ogawa et al. 1995; Oteza and Benn 2018; Pethybridge et al. 2008; Polashock et al. 2017; Rubio et al. 2017; Uner et al. 2019; Wilcox et al. 2015; Zhou et al. 2020).

Graft-transmissible diseases of specialty crops can be costly at the local, regional, or global scale. A comprehensive literature review recently summarized our collective knowledge on the economic impacts of diseases of specialty crops (Yeh et al. 2019). Here, we build on this review and describe how economic studies have identified profit-maximizing disease management solutions for some diseases. We then discuss collaborative research between agriculture economists, plant pathologists, extension educators, specialty crop growers, and regulators to develop and disseminate integrated recommendations on disease management strategies that resonate with growers. We also analyze studies on returns to investment in clean plant centers that produce, maintain, and distribute pathogen-tested propagative material with a special emphasis on centers of the National Clean Plant Network (NCPN). Finally, we discuss how additional economic studies could further incentivize the use of clean planting material and strengthen efforts to safeguard specialty crops in the United States.

Diseases of Specialty Crops Can Be Costly

Numerous graft-transmissible pathogens infect specialty crops. Some of these pathogens can cause diseases that are costly not only for the specialty crop sector but also for governmental agencies (Yeh et al. 2019). For example, in citrus, the economic impact of Huanglongbing (HLB or citrus greening) caused by *Candidatus* Liberibacter asiaticus is estimated at close to $9 billion from 2006 to 2016 in Florida alone (Court et al. 2017; Hodges and Spreen 2012). The introduction of this invasive disease in Florida in 2005 resulted in a 40% reduction of citrus bearing hectares, a 57% decrease in the number of citrus operations, a 34% decrease in juice-processing

[†]Corresponding author: M. Fuchs; mf13@cornell.edu

Funding: USDA-APHIS (16-8130-0429-CA).

The author(s) declare no conflict of interest.

Accepted for publication 21 August 2020.

Start clean, stay clean

NCPN

National Clean Plant Network

Plant Disease • 2021 • 105:14-26 • https://doi.org/10.1094/PDIS-05-20-1061-FE

Graft-transmissible diseases

- Pathogens: viruses, viroids, bacteria and phytoplasmas
- If infected plant stock is propagated, progeny will be infected
- There is no cure
- Economic studies show graft-transmissible diseases of specialty crops are costly

Start clean, stay clean
NCPN
National Clean Plant Network

Plant Disease • 2021 • 105:14-26 • https://doi.org/10.1094/PDIS-05-20-1061-FE

Citrus: Huanglongbing (HLB/Citrus Greening)

- Florida - Cost $9 billion from 2006-2016
  - 40% reduction in citrus acreage, 57% decrease in citrus operations, 34% reduction in juice processors, loss of 8,000 jobs
- California - $40 million/yr to eradicate and suppress HLB and its vector
- USDA - invested $400 million for HLB suppression in 8 years

Start clean, stay clean
NCPN
National Clean Plant Network

Plant Disease • 2021 • 105:14-26 • https://doi.org/10.1094/PDIS-05-20-1061-FE

Grapevine Diseases

- Leafroll disease causes losses from $25,000 to over $226,000/hectare over a 25-year lifespan of a vineyard in CA
- Grapevine red blotch disease causes losses from $2,200/hectare in WA to $69,500/hectare in CA over a 25-year lifespan of a vineyard
- Grapevine leafroll-associated virus-3 losses estimated at $90 million/year in CA
- Pierce's disease causes losses estimated at $92 million/year in CA

Plant Disease • 2021 • 105:14-26 • https://doi.org/10.1094/PDIS-05-20-1061-FE

Fruit Tree Diseases

- Plum pox virus in PA
  - Eradication program in PA cost $59 million from 1999-2009
  - 810 hectares of orchards and over 2,500 trees destroyed
- Little cherry disease and X-disease in Pacific NW
  - Estimated 12% reduction of cherry production in 2020
  - Losses of 400 hectares of sweet cherry and 300 hectares of stone fruit trees

Start clean, stay clean
NCPN
National Clean Plant Network

Plant Disease • 2021 • 105:14-26 • https://doi.org/10.1094/PDIS-05-20-1061-FE

Benefits of Clean Plant Center Programs: Clean Plant Center Northwest

- Total gross annual benefit to fruit tree growers and nurseries ~$81 million annually or 150 times the cost of establishing and operating the center
- Estimated returns of $2.6 billion over 20 years to apple, cherry, pear, and peach growers in the Pacific Northwest of the United States

Start clean, stay clean
NCPN
National Clean Plant Network

Plant Disease • 2021 • 105:14-26 • https://doi.org/10.1094/PDIS-05-20-1061-FE

Benefits of Clean Plant Center Programs: Foundation Plant Services

- Grower costs and benefits of testing for GLRaV-3 at FPS exceeded $20 million annually for the North Coast of CA; economic returns outweighing costs 10-fold
- The same program has a benefit of $70 million for the rest of the grape growing regions for a statewide benefit of $90 million annually
- Estimated return to investment in FPS based on leafroll ranges from 19:1 to 99:1

Start clean, stay clean
NCPN
National Clean Plant Network

Plant Disease • 2021 • 105:14-26 • https://doi.org/10.1094/PDIS-05-20-1061-FE

Economic Studies

- Incentivize adoption of clean planting material from clean disease-tested stocks
- Demonstrate the economic benefits for NCPN centers
- Provide disease management options that minimize the negative impacts of graft-transmissible pathogens on grower profits
- Contribute to an integrated disease management approach rooted in disease ecology and based on profit-maximizing solutions that resonate with growers

Start clean, stay clean
NCPN
National Clean Plant Network

Plant Disease • 2021 • 105:14-26 • https://doi.org/10.1094/PDIS-05-20-1061-FE

Future Economic Research

"Additional economic studies could further reinforce efforts to produce, maintain, and distribute pathogen-tested propagation material, and to enhance the adoption of clean planting material….to ensure the competitiveness of the United States specialty crop industries in the global market."

Start clean, stay clean
NCPN
National Clean Plant Network

Plant Disease • 2021 • 105:14-26 • https://doi.org/10.1094/PDIS-05-20-1061-FE