



The Hidden Threat: Emerging Pest Challenges in Global Fruit Production

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Fruit production overall — from backyard produce to export-focused vineyards and tropical fruit plantations — is battling against an escalating array of biological threats. Fueled by a mix of invasive insect species and recently introduced plant pathogens, climate-induced range shifts, and increasing globalization, the resulting outbreaks are economically, ecologically, and socially damaging on a large scale. Here, the major drivers of these emerging pest challenges are outlined, high-risk pests (insects and pathogens) are described, associated production and trade impacts are summarized, current management and policy responses are reviewed, and practical, research and policy options to address this issue are provided. Four summary sheets provide details on priority pests, common introduction pathways, management options, and research gaps to assist growers, extension agents and policy makers in prioritising effort.

Keywords: Emerging pests; Fruit production; Climate change; Invasive species; Biosecurity; Integrated pest management (IPM); Crop protection; Phytosanitary measures; Economic impact

Introduction — why this matters now

Fruits are a staple high-value crop that feeds people, supports rural economies, and serves as the backbone for agro-industries worldwide. Nevertheless, fruit systems are atypically susceptible to biological threats due to (1) many tree and vine crops are long-lived, which constrains the feasibility of rapid replacement; (2) fruit quality is affected by mild adverse conditions; and (3) international trade and travel facilitate easy movement of pests. In recent years we have witnessed increased detections and outbreaks of invasive fruit flies, new vector-borne bacterial pathogens, and polyphagous sap-sucking insects that decrease yield and quality and impose costly control measures. These trends are expected to become more pronounced under climate change due to its potential to increase the suitable habitat for pests and to disrupt their natural enemies.

Emerging pest risk: what are the main drivers

1. Globalization and trade. The globalization of trade in live plant material, fruit packages, and packing materials leads to ever-increasing opportunities for pests and diseases to travel on planes, ships, and trucks.
2. Climate change. Warmer temperatures, changes in precipitation patterns, and more frequent extreme events can influence pest phenology (higher number of generations), geographic ranges, and plant stress, often promoting outbreaks.
3. Monoculture and dense plantings. Uniform, susceptible cultivars used in modern orchards and vineyards provide pests with plentiful, unbroken food.

4. Fewer pesticide tools and regulatory restrictions. The phase-outs of older chemistries for environmental/health reasons take away quick chemical options, and the adoption of integrated pest management (IPM) is patchy.

5. Movement of people & vehicles. Many local expansions have been attributed to hitchhiking eggs or adults on vehicles, packing materials, and personal belongings.

Major emerging pests affecting fruit production

Below are several high-profile or rapidly spreading threats that illustrate different mechanisms of damage and management challenges.

1. Invasive fruit flies (Tephritidae) — *Bactrocera*, *Ceratitis*, *Anastrepha* species

Non-native fruit fly species continue to pose one of the most serious immediate threats to the production and trade of fresh fruit. Upon introduction, they can lead to immediate quarantine action, market closures, and crop losses. In recent years, there has been an increasing number of detections in North America and other parts of the world leading to significant quarantine responses. Epidemics often necessitate emergency aerial baiting, mass trapping and sterile insect technique (SIT) responses.

2. Spotted lanternfly (*Lycorma delicatula*)

Native to Asia, the spotted lanternfly (SLF) has quickly spread across the eastern part of North America and poses a risk to grapes, stone fruit and a number of other specialty crops. SLF feeding: weakens vines and trees, excretes honeydew promoting sooty mold (diminishing fruit quality), and drives growers to ramp up pesticide applications and labor for sanitation and monitoring. Model simulations and economic evaluations indicate substantial potential losses in grape and fruit industries in areas where SLF invades.

3. *Xylella fastidiosa* (vector-borne xylem-limited bacterium)

Xylella fastidiosa is a bacterial pathogen that kills or severely damages olives, almond, citrus, grapes and stone fruits in various subspecies/strains. It has had dramatic effects in southern Europe (notably olive decline), as well as causing disease in the Americas. *Xylella* is transmitted by xylem-feeding insect vectors (including leafhoppers, spittlebugs), making control difficult since there is asymptomatic spread and few curative options, with eradication or large-scale removal often being the only choice in invasion fronts.

4. Brown marmorated stink bug (BMSB) and other pentatomids

BMSB (*Halyomorpha halys*) and other species exert feeding damage on fruit flesh, surface blemishes, and secondary rot that generate losses in marketability. Their wide range of food hosts and capacity to overwinter in houses allow them to be persistent annoyances that are very challenging to eliminate once they are established.

5. Emerging scale insects, mealybugs and psyllids

Certain sap-sucking groups (e.g., mealybugs, scale insects, and psyllids) can vector plant viruses or cause sooty mold via honeydew, reducing fruit quality. Some species have expanded with trade in ornamentals and propagation material.

Table 1. Priority emerging pests, affected fruit types, and regions

Pest / Pathogen	Main affected fruit crops	Typical impacts	Regions of recent concern
Invasive fruit flies (<i>Bactrocera</i> , <i>Ceratitis</i> , <i>Anastrepha</i>)	Citrus, mango, mango, stone fruit, guava, many fleshy fruits	Fruit infestation, trade quarantines, crop loss	Asia, Africa, Americas; repeated detections in USA, Europe.
Spotted lanternfly (<i>Lycorma delicatula</i>)	Grapes, stone fruit, some tree fruits	Sap-feeding, honeydew/sooty mold, yield & quality loss; increased control costs.	Eastern USA, expanding range
<i>Xylella fastidiosa</i> (various subsp.)	Olive, almond, citrus, grapes, stone fruit	Rapid branch dieback, tree death, long-term orchard loss; quarantine removals.	Southern Europe (Italy, Spain), Americas
Brown marmorated stink bug (<i>H. halys</i>)	Apples, pears, stone fruit, grapes	Blemishes, fruit deformation, quality downgrades	North America, Europe, Asia

Mealybugs / scales / psyllids	Citrus, grapes, mango, avocado	Honeydew/sooty mold, virus transmission, quality loss	Global, often via plant trade
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Modes of introduction and spread within the country

Some common pathways are:

- Trade in plants and nursery stock: latent infections or eggs on plants-for-planting.
- Packaging and fruit deliveries: larvae or adults in fruit or packaging material.
- Vehicles and Containers: adults/egg masses as HMs.
- Human traffic: tourists and travel: not to mention people moving egg masses and insects.

It is very much more cost effective to prevent these from entering the country in the first place, through rigorous inspection and risk based surveillance, than it is to mount large scale reactive eradication campaigns.

Effects on production, trade and income

Losses in economy: Direct crop losses, fruit quality downgrading, increased pesticide and labor costs, and loss of export markets for several months due to quarantine measures may result in multi-million or even billion dollar impacts on regions. As an example, the economic analyses for SLF and invasive fruit fly outbreaks demonstrate significant potential losses to the wine and fresh fruit industries in the areas where they are introduced.

Environmental Concerns: The replacement of diverse orchards with emergency interventions, non-target impacts of escalated pesticide application, and landscape alterations following tree removal (e.g., for *Xylella*) reverberate ecologically.

Societal impacts: Specialty fruit growers livelihoods, rural jobs, and community economies can be significantly impacted if production and export are halted.

Management approaches — integrated strategies

No single tool can solve emerging pest problems. Effective responses combine prevention, early detection, rapid response, and long-term management in an integrated framework.

1. Strengthened biosecurity (prevention)

- **Phytosanitary controls for plants-for-planting** (inspection, treatment, certification).
- **Heat or cold disinfestation** and post-harvest treatments where feasible.
- **Public awareness** and “clean-your-vehicle/packaging” campaigns reduce hitchhiking spread.

2. Surveillance and early detection

- Risk-based trapping networks (e.g., for fruit flies, SLF); sentinel orchards and molecular diagnostics to detect low-prevalence pathogens.
- Citizen science reporting paired with official verification increases detection coverage.

3. Rapid response and eradication

- Quarantine, conducting surveys to define boundaries, and applying treatment in focused areas (baiting, sterile insect technique for fruit flies) — the success is largely a matter of speed and coordination. Regional eradication efforts have been successful (e.g., previous responses to invasive fruit flies), but failure could mean that the pest becomes established and requires long-term control.

4. Long-term management (IPM)

- **Cultural control:** sanitation, elimination of alternate hosts (e.g. tree-of-heaven for SLF), good orchard sanitation.
- **Biological control:** classical and conservation biocontrol (parasitoids, predators), and augmentative releases where warranted. There is research under way for many pests.
- **Host resistance:** development of tolerant/resistant cultivars (long-term but sustainable solution).
- **Chemical control:** selective insecticides applied with a rigid rotation; avoid widespread effect on non-targets and development of resistance.
- **Area-wide management:** concerted community/regional efforts (e.g., SIT campaigns against fruit flies) tend to be more successful than isolated farms endeavors.

Table 2. Common pathways and recommended prevention actions

Pathway	Typical examples	Practical prevention actions
Plants-for-planting	Nursery stock carrying eggs or asymptomatic infections	Strict certification, pre-export inspections, mandatory treatments
Fresh fruit consignments	Larvae in fruit, hidden stages	Export quarantine protocols, cold chain management, increased inspection
Hitchhiking on vehicles/containers	Egg masses on outdoor goods, packing materials	Clean packing materials, vehicle inspections, public signage

Case studies

Case study 1. California & invasive fruit fly detections and responses

Since the early 1990s, California has fought exotic fruit flies with quarantines, spraying, trapping and eradication. The above cases illustrate examples where (i) intense effort results in successful eradication of localized populations and (ii) repeated detections highlight the need for ongoing surveillance and public involvement. Prompt action can stop establishment but it needs continuous funding and public cooperation.

Case study 2. Spotted lanternfly and vineyards in the United States

SLF populations have been correlated with deterioration of vineyard health, and regional initiatives involving monitoring, host removal, and outreach are in development. Economics modeling indicates that wine regions could be devastated to the tune of millions of dollars, if SLF is allowed to spread uncontrolled. Public involvement (i.e., “scrape the egg mass”) and host tree management are components of established strategies.

Case study 3 — *Xylella fastidiosa* in Mediterranean fruit trees

In southern Europe, the introduction and spread of *Xylella* subspecies (especially in Puglia, Italy) resulted in massive olive losses, forced tree removals, and intense policy discussions regarding eradication or containment. The *Xylella* story highlights the challenge of controlling a vector-borne bacterial pathogen once it is established, and the tremendous social and economic consequences of large-scale tree removal.

Table 3. Management options

Strategy	Short description	Suitability / Limitations
Quarantine and rapid eradication	Lockdown, surveys, targeted treatments	Best at early detection; resource-intensive; requires coordination
Area-wide SIT (sterile insect technique)	Release of sterile males to reduce reproduction	Effective vs. certain fruit flies; costly, needs technical capacity
Biological control	Introduction/conservation of natural enemies	Promising long-term; requires ecological evaluation for non-target risks
Breeding for resistance	Develop resistant/tolerant cultivars	Sustainable but long timeline and genetic constraints
Chemical control (targeted)	Baits, foliar sprays, trunk injections (pathogens)	Provides immediate relief but risks resistance and non-target harm
Sanitation & cultural control	Remove alternate hosts, prune/remove infected trees	Low-cost; often necessary complement to other measures

Research and innovation priorities

- Rapid diagnostics for early detection.** Affordable and portable pathogen tests and identification kits for insect eggs/larvae reduce detection response times.
- Improved surveillance analytics.** Integration of trap surveillance data, environmental suitability modeling, and citizen reporting to identify the most at-risk locations.

3. **Biocontrol research.** Determine safe and effective natural enemies and develop augmentative strategies for mass-production while assessing ecological risks.
4. **Breeding for resilience.** Screen germplasm for tolerance to pests and abiotic stresses (heat/drought) to have multitress resilience.
5. **Socio-economic studies.** Quantify the costs and farmer decision drivers and barriers to implementing coordinated area-wide control.

Table 4. Research gaps & priority actions

Gap	Why it matters	Priority action
Field diagnostics for <i>Xylella</i> and similar pathogens	Asymptomatic spread enables silent invasions	Invest in portable PCR/isothermal tests, training
Scalable biocontrol options for SLF & fruit flies	Chemical reliance unsustainable	Fund host-specific parasitoid research, release trials
Social mobilization for surveillance	Public reports detect new incursions early	Develop outreach, apps, incentive programs
Predictive models integrating climate change	Range shifts alter risk maps	Fund model development + ground truthing

Discussion — policy and practice recommendations

1. **Prioritize prevention over reaction:** Enhance pre-export measures for plants-for-planting, increase inspection capacity and strengthen controls on imports at risk.
2. **Adopt risk-based surveillance:** Use models to suggest where to place traps and conduct diagnostics within the risk of introduction is highest (ports, nurseries, transportation corridors).
3. **Support area-wide, coordinated responses:** numerous pests need collaboration across the entire landscape; fund multi-stakeholder programs and, where appropriate, compensate growers for mandated removals or quarantine losses.
4. **Invest in research and extension:** Diagnostics, SIT capacity, biocontrol, and breeding need sustained funding; ensure rapid knowledge transfer to growers.
5. **Protect pollinators and natural enemies:** Promote targeted interventions and IPM to avoid broad-spectrum pesticide impacts.
6. **Build social license for difficult measures:** Tree removal and quarantine orders need transparent communication, fair compensation, and stakeholder involvement to maintain public trust.

Conclusion

New pests in fruit systems aren't waiting over the horizon — they are here now and probably coming on strong. The invasive fruit flies, spotted lanternfly and *Xylella fastidiosa* stories demonstrate different routes to crisis, and different response challenges. The good news is that effective prevention, early detection and integrated management can mitigate impacts — but these actions require upfront investment, cross-sector coordination, and science-based policy. For growers, extension agents, and policy makers, the priorities are clear: Stop introductions, detect fast, act decisively, and invest in long-term resilience through research, breeding and ecological management.