

Integrating molecular tools into phytosanitary surveillance: Lessons from field implementation across trade pathways

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Issues/challenges

Effective surveillance is a cornerstone of plant health systems and safe trade, as recognized in **ISPM 6 (Surveillance)** under the International Plant Protection Convention. Expanding global trade in fresh commodities and planting material—particularly from tropical and subtropical regions—has increased pressure on National Plant Protection Organizations (NPPOs) to:

- detect regulated pests at an early stage;
- demonstrate the credibility of surveillance outcomes; and
- allocate limited resources efficiently.

At the same time, taxonomic capacity remains uneven across regions. This has driven interest in **molecular diagnostic tools**, such as DNA barcoding and metabarcoding, which offer high-throughput processing, standardized workflows and reduced dependence on specialist taxonomy. These tools are often promoted as scalable solutions for modern surveillance demands. However, their **operational performance under routine field surveillance conditions requires careful evaluation**.

Actions taken

DNA metabarcoding was evaluated in combination with **passive insect trapping** as a surveillance approach linked to trade-related risk pathways. The study was conducted in subtropical crops within a Mediterranean production area associated with international trade.

The evaluation:

- compared metabarcoding results from passive trap samples with outcomes from targeted visual inspections;
- assessed field performance under operational conditions, following prior laboratory validation of protocols and reference databases.

Based on the findings, the surveillance design was reviewed and adjusted. Molecular tools were repositioned within a **risk-based, systems-oriented framework**, integrated with:

- targeted visual inspection;
- pest-specific trapping; and
- surveillance focused on high-risk commodities and entry pathways, in line with **ISPM 14 (The use of integrated measures in a systems approach for pest risk management)**.

Key results

The evaluation revealed a clear contrast between detection methods:

- several pests of regulatory concern were confirmed through visual inspection;
- the same pests were not detected through metabarcoding of passive trap samples.
- Given prior laboratory validation, these results were attributed to **operational and biological factors**, including:
 - low mobility of many regulated pests associated with tropical and subtropical commodities, which remain closely linked to host plants;
 - high levels of non-target biomass in passive traps, diluting target DNA below detection thresholds.

These findings demonstrate that **diagnostic sensitivity alone does not determine surveillance effectiveness**. Sampling strategy, pest ecology and pathway relevance are equally critical.

Conclusions

This experience highlights both the potential and the limitations of molecular diagnostics in phytosanitary surveillance.

Molecular tools offer clear advantages, including:

- high processing capacity;
- standardized identification workflows; and
- support for expanding surveillance demands.

However, their effectiveness depends on **biologically appropriate sampling and risk-based system design**. Key lessons learned include:

- detection probability is strongly influenced by pest ecology and behaviour;
- bulk environmental samples may mask low-abundance target DNA;
- analytical validation must be complemented by **operational validation** under field conditions.

Molecular tools are most effective when:

- embedded within risk-based surveillance planning;
- combined with targeted visual inspection; and
- used alongside pest-specific trapping.

These lessons are directly relevant for NPPOs strengthening surveillance linked to tropical trade. When aligned with biology, pathways and operational realities, molecular tools can meaningfully strengthen plant health systems, reinforcing the principles established in **ISPM 6 (Surveillance)** and **ISPM 14 (The use of integrated measures in a systems approach for pest risk management)**.