Assessing adoption drivers of a VOC sensor technology for pest and pathogen detection: Insights from a survey among European nurseries

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Biosecurity in the EU

- **Global trade networks** facilitate the movement of plants and plant products: a major pathway for the introduction of plant pests and pathogens (Chapman et al., 2017)
- **Border control posts**: Verifying pest-free status and compliance with the phytosanitary certificate scheme (Regulation (EU) 2017/625; Regulation (EU) 2016/2031)
- Inspection frequency is determined on a **risk basis** (European Commission, 2019, 2017)
- Upon entry, the phytosanitary certificate is **replaced** by a plant passport = free movement within the "internal market" (European Commission, 2016)

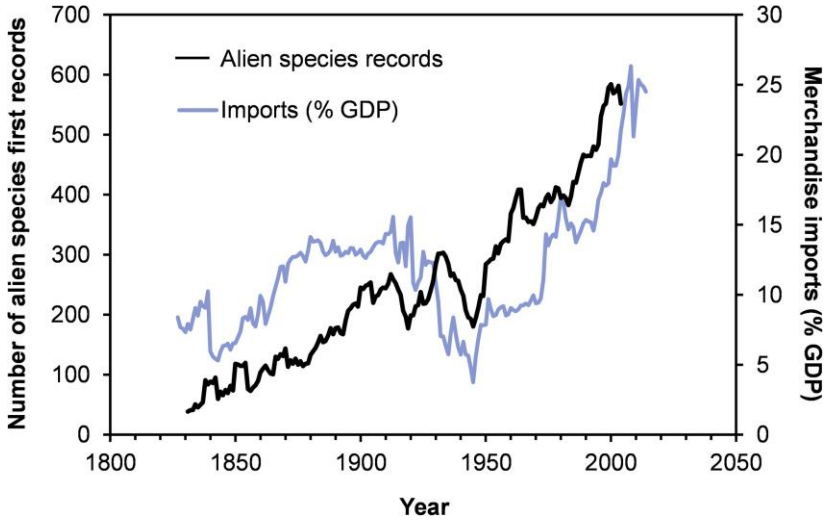

Figure 1. Global trade and invasions over time (Hulme, 2021)

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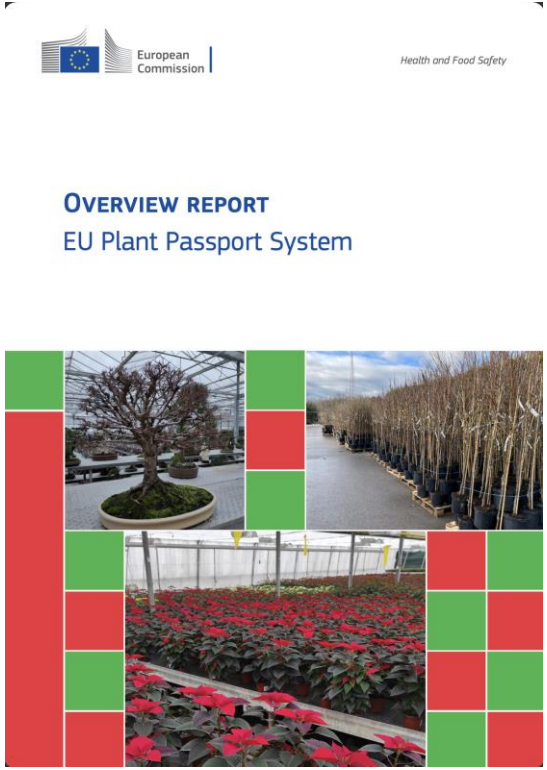
Biosecurity in the EU

- Sampling intensity and implementation of the plant passport system **vary** among MSs
- *"Plants moved with plant passports **without a proper guarantee of pest freedom**, which is a risk for spreading pests"!*
- Phytosanitary assurance depends on actors involved in plant trade **post-border entry**
- **Nurseries have a direct interest in disease-free plant material**, as infections carry economic and reputational costs (Alonso Chavez et al., 2016)



Source: European Commission, 2025

Phytosanitary inspections

- Regular monitoring is a key practice for early detection and damage mitigation in nurseries (Keskitalo et al., 2018)

Nurseries typically evaluate the phytosanitary status of incoming consignments via:

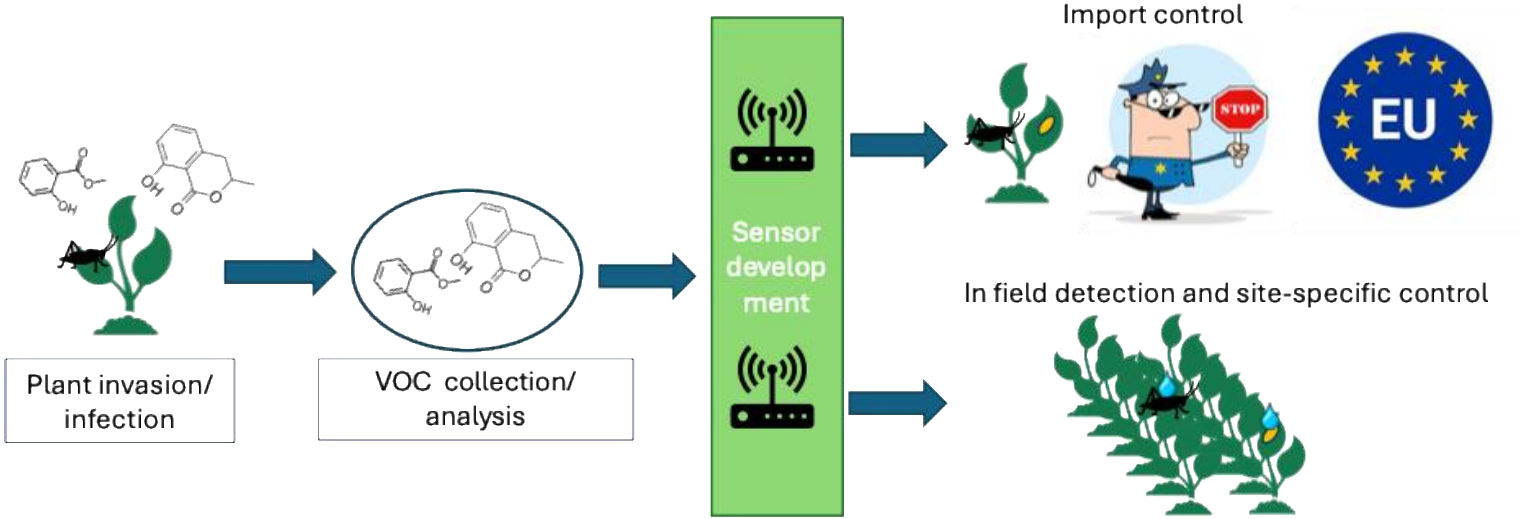
Visual inspection
Rapid but limited accuracy

Rapid and accurate?

Laboratory testing
Often slower, more costly, and require destructive sampling

(Combes et al., 2025; Esfandi et al., 2024; Baldi & La Porta, 2020; Martin & Tzanetakis, 2014; Parke & Grünwald, 2012)

PurPest concept



Objective, survey design, and data

- The main objective was to elicit the preferences of European nursery operators for adopting a novel pest and pathogen detection technology, the VOC sensor.
- The survey instrument was structured into five sections:
    a. Nursery characteristics
    b. Discrete choice experiment
    c. Experience with invasive pests and pathogens
    d. Perceptions on detection methods and responsibility/trust among plant health actors
    e. Sociodemographic characteristics of the respondent
- 420 completed questionnaires: Germany (130); France (110); Italy (100); Romania (80)

Respondent characteristics

Table 1. Socio-demographic characteristics of respondents in the sample.

		Total	Italy	Romania	Germany	France
Gender	Female	39.0%	43.0%	33.8%	38.5%	40.0%
	Male	60.2%	57.0%	63.8%	60.8%	60.0%
	Other / Prefer not to say	0.7%	0.0%	2.5%	0.8%	0.0%
Age	18-24	7.1%	6.0%	0.0%	9.2%	10.9%
	25-34	21.4%	21.0%	26.3%	20.8%	19.1%
	35-44	27.6%	29.0%	42.5%	21.5%	22.7%
	45-56	27.6%	28.0%	22.5%	30.0%	28.2%
	55-64	13.6%	14.0%	7.5%	15.4%	15.5%
	65+	2.6%	2.0%	1.3%	3.1%	3.6%
Education	No formal qualifications	4.8%	7.0%	1.3%	6.9%	2.7%
	High school or lower	27.4%	31.0%	18.8%	26.2%	31.8%
	Bachelor's degree or equivalent	34.5%	27.0%	48.8%	30.8%	35.5%
	Master's degree or equivalent	25.5%	27.0%	27.5%	24.6%	23.6%
	Doctoral degree (PhD)	6.7%	8.0%	3.8%	8.5%	5.5%
	Other	1.2%	0.0%	0.0%	3.1%	0.9%
Association membership	Yes	77.6%	91.0%	15.0%	93.1%	92.7%
	No	22.4%	9.0%	85.0%	6.9%	7.3%
Financial position	Very good (room for investments)	14.5%	16.0%	5.0%	18.5%	15.5%
	Good (sufficient reserves)	28.1%	32.0%	27.5%	31.5%	20.9%
	Medium (profitable but with considerable debt)	33.8%	33.0%	32.5%	32.3%	37.3%
	Low (profitability varies, high indebtedness)	5.7%	3.0%	12.5%	3.1%	6.4%
	Bad (structurally loss-making)	3.8%	4.0%	1.3%	3.1%	6.4%
	I don't want to answer	14.0%	12.0%	21.3%	11.5%	13.6%

Nursery characteristics

Table 2. Nursery characteristics of the sample.

		Total	Italy	Romania	Germany	France
Role	I am the owner	81.4%	79.0%	87.5%	80.8%	80.0%
	I am the general manager	15.2%	19.0%	2.5%	18.5%	17.3%
	Other	3.3%	2.0%	10.0%	0.8%	2.7%
Years in operation	Less than 3 years	12.6%	11.0%	21.3%	9.2%	11.8%
	3-10 years	31.4%	26.0%	50.0%	26.2%	29.1%
	11-20 years	31.7%	32.0%	17.5%	37.7%	34.5%
	More than 20 years	24.3%	31.0%	11.3%	26.9%	24.5%
Nursery size (unit area)	Less than 2 ha	11.4%	7.0%	26.3%	5.4%	11.8%
	From 2 to 4.9 ha	28.6%	31.0%	23.8%	31.5%	26.4%
	From 5 to 9.9 ha	30.7%	27.0%	28.8%	33.1%	32.7%
	From 10 to 19.9 ha	24.3%	27.0%	13.8%	26.9%	26.4%
	More than 20 ha	5.0%	8.0%	7.5%	3.1%	2.7%
Nursery size (number of employees)	Micro-sized enterprise (0-9 employees)	17.6%	11.0%	37.5%	16.9%	10.0%
	Small-sized enterprise (10-49 employees)	42.9%	35.0%	42.5%	43.8%	49.1%
	Medium-sized enterprise (50-249 employees)	33.1%	46.0%	16.3%	32.3%	34.5%
	Large-sized enterprise (250+ employees)	6.4%	8.0%	3.8%	6.9%	6.4%

What type of plants do you primarily produce or sell at your nursery? (select all that apply)

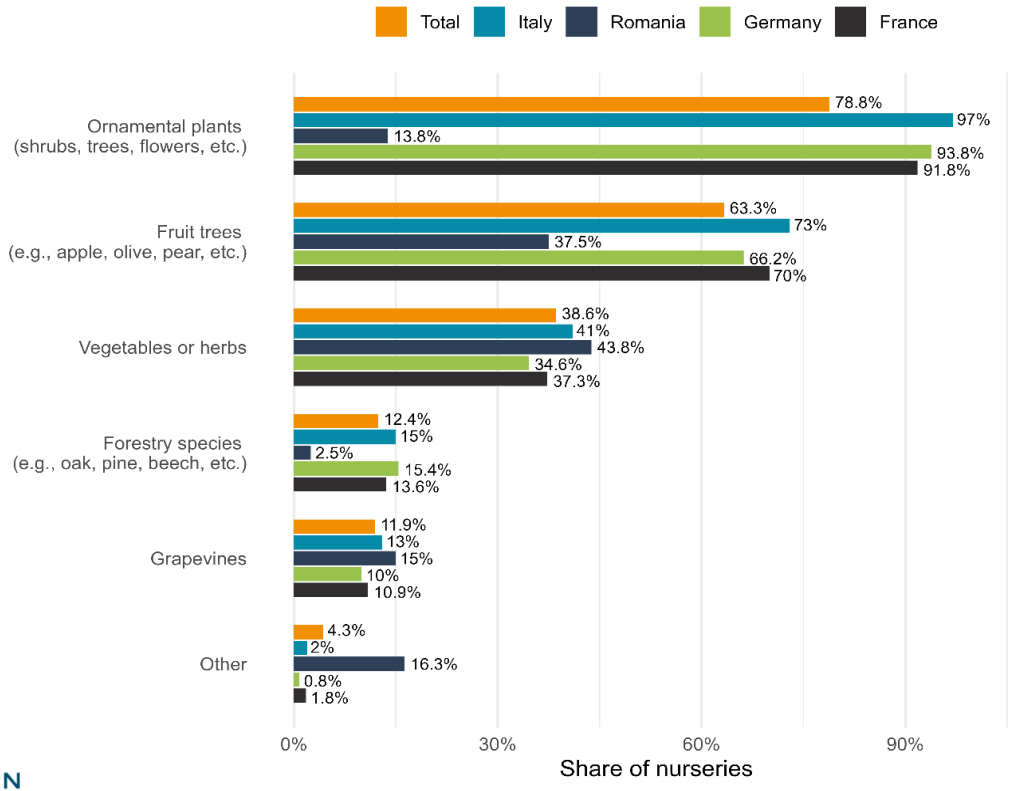


Figure 2. Type of plants cultivated or sold by surveyed nurseries.

Do you export/sell plants or plant products? (select all that apply)

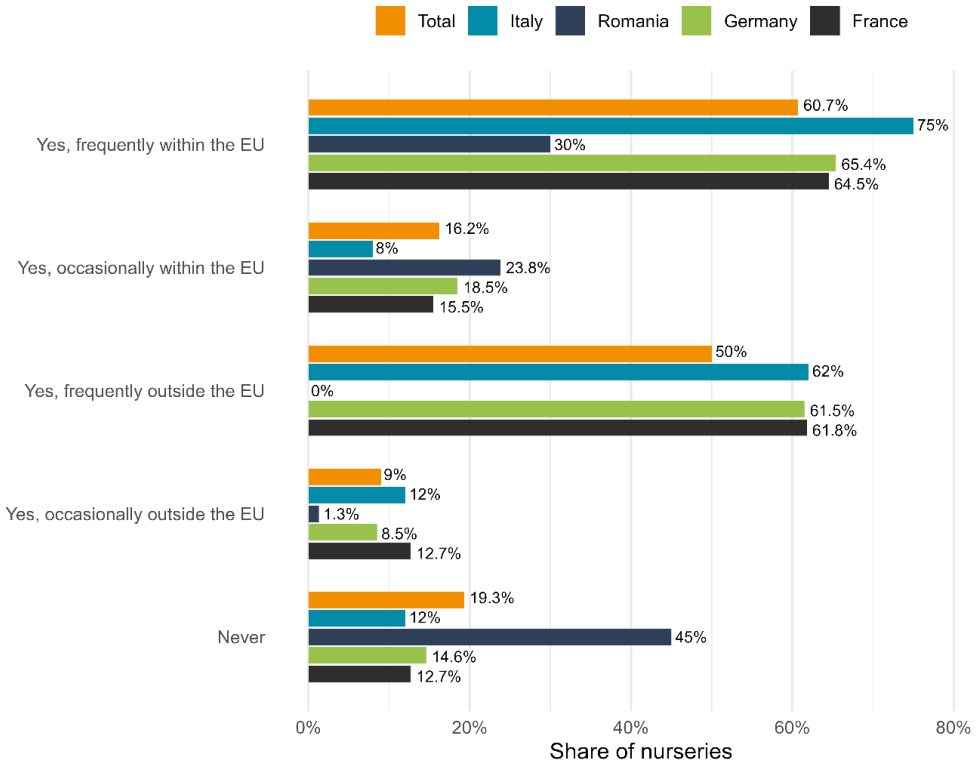


Figure 3. Nursery involvement in plant trade.

Has your nursery ever experienced problems related to invasive pests or pathogens?

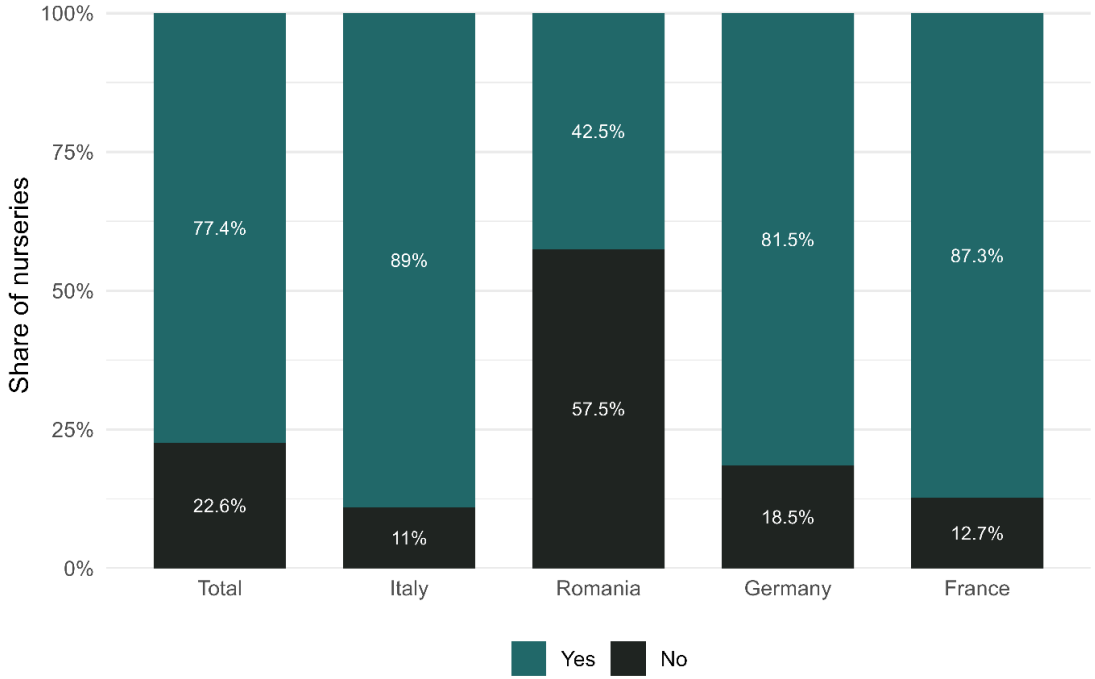


Figure 4. Experience with invasive pests or pathogens among surveyed nurseries.

Do you perform inspections on incoming plant consignments at your nursery?

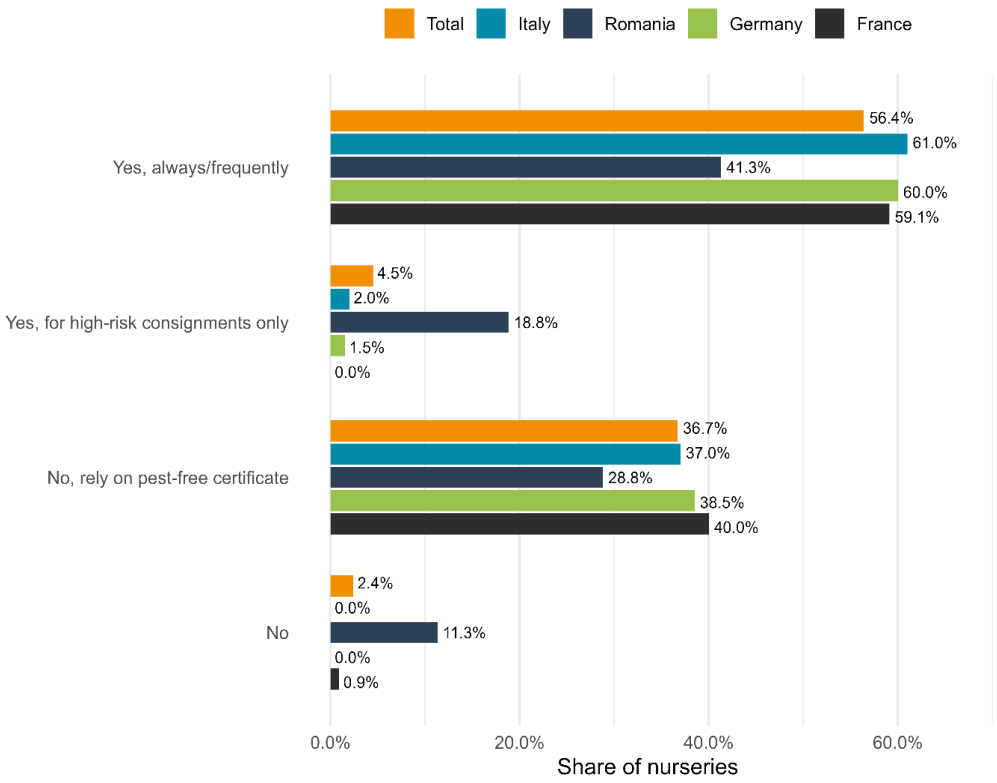


Figure 5. Inspection frequency for incoming consignments among surveyed nurseries.

If yes, what method(s) do you use to perform the inspection? (select all that apply)

Table 3. Methods used by surveyed nurseries to perform inspections on incoming plant consignments.

	Total	Italy	Romania	Germany	France
Visual inspection (nursery staff)	95.7%	100.0%	89.6%	92.5%	100.0%
Laboratory diagnostics (in-house)	9.8%	7.9%	14.6%	11.3%	6.2%
Laboratory diagnostics (outsourced)	76.6%	93.7%	6.3%	90.0%	95.4%
No specific method	0.4%	0.0%	2.1%	0.0%	0.0%
Other	1.6%	0.0%	4.2%	2.5%	0.0%

For each of the questions below, select the response that best characterizes how you feel about the statement.

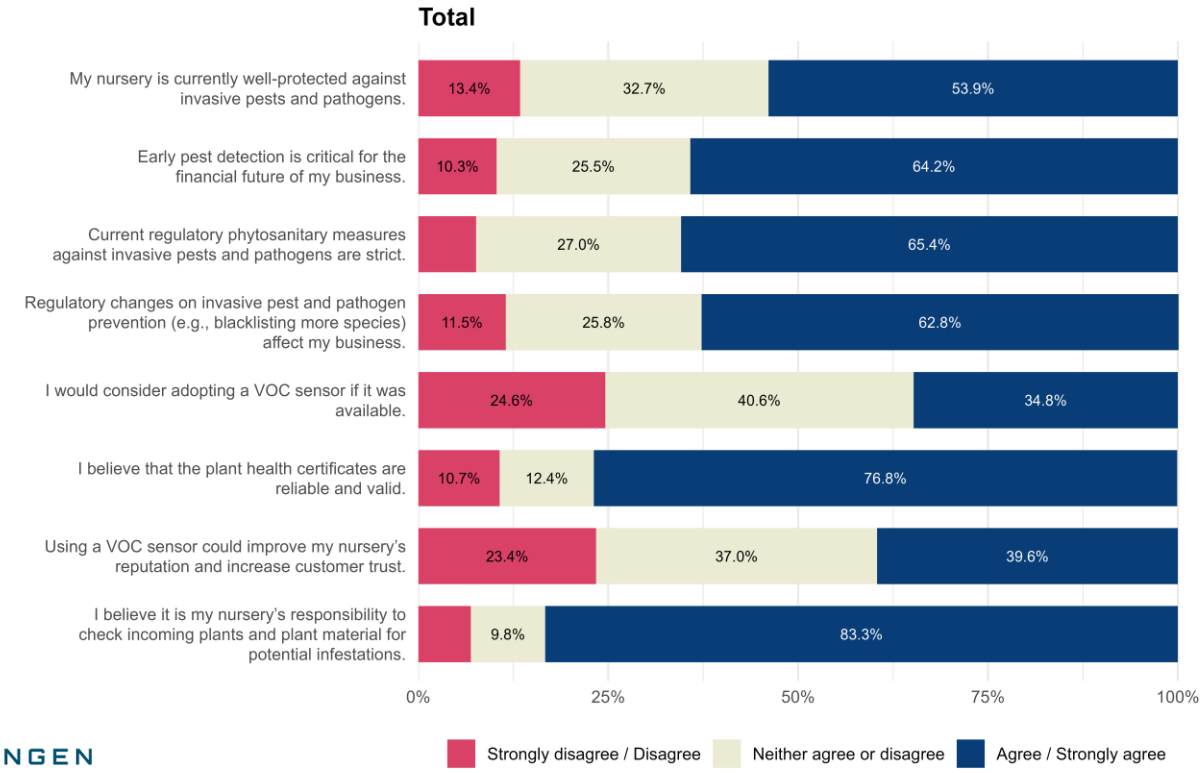


Figure 6. Opinions and attitudes of nursery operators in the total sample.

In your opinion, thinking about the current situation, how responsible is each of the following actors for ensuring that plants and plant material are free from pests and pathogens?

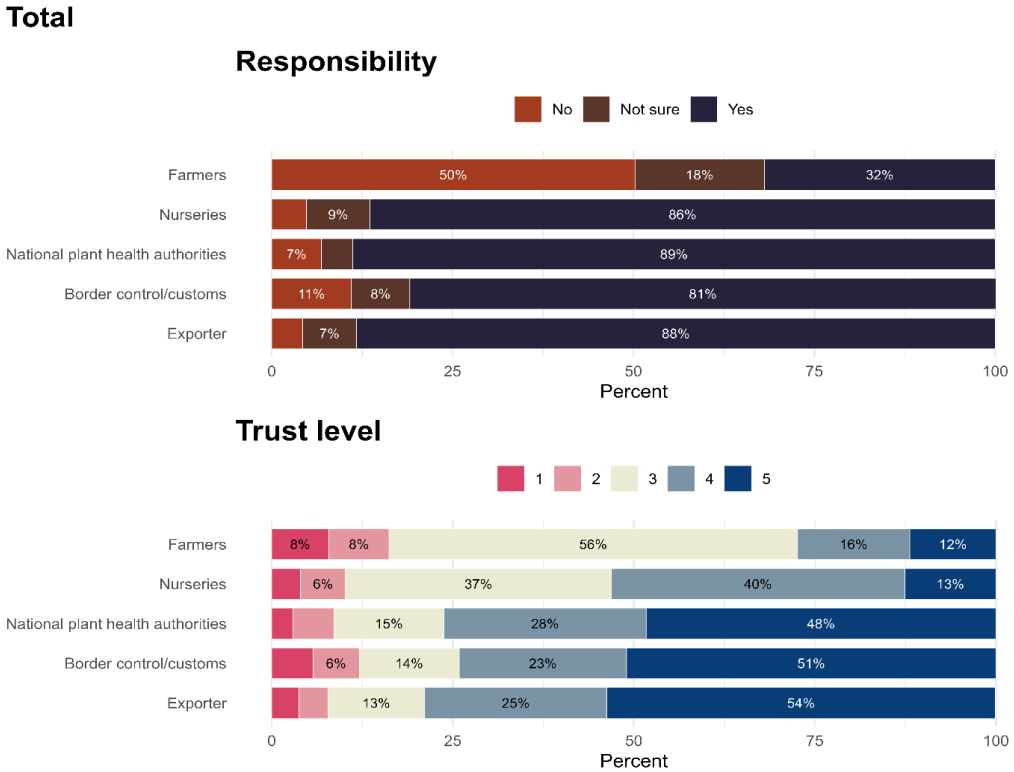


Figure 7. Perceptions of responsibility and trust in different actors for ensuring that plants and plant products are free from pests and pathogens, across the total sample.

In your opinion, where should most of the responsibility for pest and pathogen prevention lie in the future? (select all that apply)

Table 4. Views on where most responsibility for pest and pathogen prevention should lie in the future.

	Total	Italy	Romania	Germany	France
Exporter	76.1%	83.8%	47.5%	82.3%	82.7%
Border control/customs	67.3%	80.8%	25.0%	73.8%	78.2%
National plant health authorities	75.9%	79.8%	55.0%	82.3%	80.0%
Nurseries	36.8%	31.3%	57.5%	33.8%	30.0%
Farmers	22.0%	16.2%	63.8%	11.5%	9.1%
Other	1.4%	0.0%	0.0%	0.0%	5.5%

Discrete choice experiment

Please consider each option carefully and choose the one that would best fit your nursery's needs. There is no right or wrong choice. However, we ask you to answer as realistically as possible, as if these options were available to you.

Attribute	Option 1	Option 2	Current practice (status quo)
Time to receive results	4 hours	1 hour	Would rather stay in the current situation
Detection reliability	70%	85%	
Cost per inspection	€4	€2	
Certification potential	Yes	No	
Ownership of the technology	Outsourced	Co-owned	
Your choice	○	○	○

Figure 8. Example of a choice card (English version).

Preliminary results

Table 6. Mixed logit model results by country.

	Italy	Romania	Germany	France
	Coefficients (Std. err.)			
Time to receive results	-0.298***	-0.202**	-0.007	-0.187***
	(0.044)	(0.084)	(0.038)	(0.043)
Detection reliability	0.023***	0.014	0.024***	0.009**
	(0.005)	(0.010)	(0.004)	(0.004)
Cost per inspection	-0.134***	-0.114***	-0.104***	-0.096***
	(0.020)	(0.033)	(0.017)	(0.018)
Certification potential	0.148	0.605**	-0.342***	0.241***
	(0.096)	(0.288)	(0.093)	(0.088)
Ownership (Purchased)	-0.195	0.240	-0.164	-0.041
	(0.132)	(0.195)	(0.109)	(0.119)
Ownership (Co-owned)	0.025	-0.253	0.095	0.111
	(0.126)	(0.233)	(0.113)	(0.116)
ASC (alternative-specific constant)	0.404	1.628	-0.799*	0.797*
	(0.460)	(1.206)	(0.411)	(0.423)

The model was estimated using StataNow/BE 18.5. *, **, and *** denote significance at the 0.10, 0.05, and 0.01 level, respectively. The mixed logit models are based on calculations with 1000 Halton draws.

Conclusions

- Nurseries recognize the importance of **early detection**
- **Inspections** are primarily visual, supported by lab tests
- **Responsibility** is mainly assigned to exporters, NPPOs, and border control
- High **trust** in existing plant health certification schemes
- Clear **need** for complementary, on-site detection tools
- **Performance** of the sensor is important, but **economic feasibility** remains the most influential determinant of adoption

Find out more!

https://www.purpest.eu/

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Discrete choice experiment

Table 5. Attributes and attribute levels used in the discrete choice experiment.

Attribute	Description	Attribute levels
Time to receive results	Time required to obtain inspection results	1 hour; 2 hours; 4 hours
Detection reliability	Likelihood of correctly detecting infested plant material	70%; 85%; 95%
Cost per inspection	Costs of inspecting one batch (independent of batch size and ownership)	€2; €4; €6; €8; €10
Certification potential	Ability to certify consignments as additionally inspected and pest-free	Yes; No
Ownership of the technology	Arrangement through which the VOC sensor is provided	Purchased; Co-owned; Outsourced