

Crop protection status and actions in Portugal

A national synthesis

Final Report

Section I – National context: pests, diseases, pesticide sales and regulatory framework

Section II – Levers and barriers for prevention and agroecology

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Declaration on the use of artificial intelligence

The authors used AI (Claude, Anthropic) to aid with database raw construction and error checking, data cleaning and final text editing. All AI-generated outputs were cross-checked by the authors, who stand for the reliability of the work presented here.

1. Section I – Crop protection status and pesticide use in Portugal

1.1 Introduction

Plant pests and pathogens remain one of the main constraints on agricultural productivity: yield losses to pests and diseases are estimated at 10–40% for the major food crops worldwide (Savary et al., 2019), and climate warming is expected both to increase insect-driven losses and to shift pest ranges towards higher latitudes (Bebber et al., 2013; Deutsch et al., 2018). Mainland Portugal combines Atlantic conditions in the north-west with a Mediterranean climate in the interior and south, a gradient that shapes the phytosanitary pressure on its main perennial cropping systems – vineyards, olive groves, pome, stone and citrus orchards, and nut crops. Humid springs favours diseases, whereas warmer and drier summers are expected to modify the phenology of both host and pest (Fraga et al., 2012). The reliance of these systems on chemical protection carries well-documented environmental costs, including the persistence of residues in agricultural soils, the risk of pollution of adjacent waters and the presence in food products (Silva et al., 2019; Tang et al., 2021).

Directive 2009/128/EC made the general principles of integrated pest management (IPM) mandatory for professional users, placing monitoring, forecasting and warning at the core of crop protection decisions (Barzman et al., 2015; Lamichhane et al., 2016). Warning and decision-support systems translate field and weather observations into timely, region-specific recommendations and are among the most effective tools to replace calendar spraying (Rossi et al., 2012; Pertot et al., 2017). In Portugal, this function is performed by the *National Agricultural Warning Service (SNAA)*, coordinated by the *General Directorate for Food and Veterinary of Portugal (DGAV)* and operated by Regional Warning Stations (*Estações de Avisos, EA*) that issue periodic warning circulars. This section characterises the national context by (i) building a structured database from the SNAA circulars for 2023–2025 to describe the main pest and disease of six major crop groups, (ii) summarising the trends in pesticide sales, and (iii) outlining the regulatory framework set by the National Action Plan for the Sustainable Use of Plant Protection Products.

1.2 Methodology

1.2.1 Database construction

The warning circulars (PDF) issued between 2023 and 2025 were collected, on September 4th, 2026, from the *National Agricultural Warning Service (Serviço Nacional de Avisos Agrícolas (SNAA))* consultation portal (snaa.dgav.pt), which indexes each circular by year, date, warning station, crop and target organism. Because the index under-reports the content of the documents, every circular was read in full. Data retrieval was performed with the assistance of Claude AI (Anthropic): the PDFs were downloaded, their text extracted with a column-aware layout procedure (scanned documents by optical character recognition), and each crop section was parsed against a closed vocabulary of crops and harmful organisms. The database follows a tidy structure with one record per crop–enemy pair and circular, holding the identifier, date, warning station, crop, common name as printed, scientific name and type (pest, disease, weed or abiotic). Records flagged as uncertain or biologically inconsistent, and all reported errors were reviewed and corrected by the authors against the original circulars. Crops were aggregated into 12 crop groups, of which six were selected for this report: vines (grapevine), olive, nut crops, citrus, pome fruit, and stone fruit. The final dataset holds 1,542 records from 230 circulars issued by 10 warning stations; 1,427 records refer to pests or diseases (73 distinct organisms).

1.2.2 Data treatment

Data were processed in R (R Core Team, 2025), analysis was restricted to descriptive statistics: absolute and relative frequencies per year, crop group and type, and share of the dominant organism. The counting unit was the number of distinct circulars citing an organism in a given crop group and year, so that repeated mentions within one circular count once. Grapevine trunk diseases reported under separate names (esca, eutypa dieback, Petri disease, black-foot and *Botryosphaeria* dieback) were merged as a single category, “Grapevine trunk diseases” (Gramaje et al., 2018). The data are presented for the selected years 2023, 2024 and 2025 as pie charts per year and crop group, with pests and diseases of the same crop side by side (Annex I, Figures A1–A6).

1.3 Results and discussion

The coverage of the warning network expanded over the period, from 32 circulars issued by 7 stations in 2023 to 81 (10 stations) in 2024 and 117 (10 stations) in 2025, and in 2023 a single station (EA da Bairrada) contributed with 60% of the records. Differences between years therefore partly reflect reporting effort, and the results are interpreted as the relative composition of the warnings rather than as absolute pest pressure. Diseases dominated warnings in every year (56–59% of records), against 32–37% for pests (Table 1).

Table 1. Number of warning circulars reporting pests (P) and diseases (D) in the six selected crop groups, and most cited organism, in 2023–2025.

Crop group	2023 P / D	2024 P / D	2025 P / D	Most cited pest	Most cited disease
Vines (grapevine)	11 / 23	29 / 52	44 / 74	<i>Lobesia botrana</i>	<i>Plasmopara viticola</i>
Olive	11 / 14	12 / 24	25 / 31	<i>Bactrocera oleae</i>	<i>Venturia oleaginea</i>
Nut crops	0 / 1	8 / 10	9 / 7	<i>Dryocosmus kuriphilus</i>	<i>Cryphonectria parasitica</i>
Citrus	5 / 1	15 / 14	18 / 21	<i>Ceratitis capitata</i>	<i>Phytophthora</i> spp.
Pome fruit	17 / 15	30 / 34	51 / 51	<i>Cydia pomonella</i>	<i>Venturia inaequalis</i>
Stone fruit	2 / 3	8 / 14	11 / 24	<i>Ceratitis capitata</i>	<i>Taphrina deformans</i>

Source: SNAA warning circulars (DGAV); authors' database.

Vines were the most frequently addressed crop (Fig. A1), with downy mildew (*Plasmopara viticola*) and powdery mildew (*Erysiphe necator*) together accounted for 50–58% of the disease citations each year, followed by black rot (*Guignardia bidwellii*, 15–19%) and grapevine trunk diseases (8–13%). Flavescence dorée, a quarantine phytoplasma, rose from one to seven circulars, while its vector, the American grapevine leafhopper (*Scaphoideus titanus*), was cited in 5, 8 and 12 circulars, reflecting the mandatory vector-control measures (Chuche & Thiéry, 2014). The European grapevine moth (*Lobesia botrana*) was consistently the main pest (39–43%), with a growing share of the European grape leafhopper (*Empoasca vitis*, 17% to 27%).

In olive (Fig. A2), olive leaf spot or peacock's eye (*Venturia oleaginea*) was the dominant disease (45–49%; Buonauro et al., 2023), followed by olive anthracnose (*Colletotrichum* spp.), which rose from 18% to 29–30% and is known to degrade yield and oil quality (Talhinhas et al., 2018); *Cercospora* leaf spot appeared in 2024 and reached 21% in 2025. *Xylella fastidiosa* was cited in five circulars in 2023, one in 2024 and none in 2025 (Schneider et al., 2020). The olive fruit fly (*Bactrocera oleae*) remained the main pest (36–52%; Daane & Johnson, 2010), followed by the olive moth (*Prays oleae*).

Pome fruit showed the most balanced profile (Fig. A5): apple scab (*Venturia inaequalis*) accounted for 47–67% of the disease citations (Bowen et al., 2011), with loquat scab (*Fusicladium eriobotryae*) a further 4–14%, followed by Nectria canker (*Neonectria ditissima*, 13–19%); fire blight (*Erwinia amylovora*) appeared in 2024–2025, while codling moth (*Cydia pomonella*, 25–32%), the European red spider mite (*Panonychus ulmi*), aphids and the Mediterranean fruit fly (*Ceratitis capitata*) led the pests. In stone fruit (Fig. A6), leaf curl (*Taphrina* spp., 30–44%), brown rot (*Monilinia* spp.) and Coryneum blight (shot-hole) dominated, and the spotted-wing drosophila (*Drosophila suzukii*) emerged in 2025 (25% of pest citations; Asplen et al., 2015). Citrus warnings (Fig. A4) were led by *Phytophthora* brown rot (52–54%, reported as downy mildew), and by anthracnose and *C. capitata* (33–41%); aphids were the only pests cited in 2023, and the regulated African citrus psyllid (*Trioza erythrae*) and South African citrus thrips (*Scirtothrips aurantii*) were reported from 2024. Nut-crop warnings (Fig. A3) concerned mostly chestnut: chestnut blight (*Cryphonectria parasitica*, 42% of the 2024 disease citations; Rigling & Prospero, 2018), ink disease (*Phytophthora cinnamomi*), chestnut brown rot (*Gnomoniopsis castaneae*) and the chestnut gall wasp (*Dryocosmus kuriphilus*, 56% of pest citations).

Overall, each crop's warnings are dominated by a few fungal and oomycete diseases, consistent with the predominance of fungicides in national sales (Section 1.4). Two further features stand out: the weight of regulated organisms (flavescence dorée and its vector, *X. fastidiosa*, fire blight, *T. erythrae*, chestnut gall wasp), which require coordinated area-wide rather than farm-level responses, and the transversal role of polyphagous pests such as *C. capitata*, cited in citrus, pome and stone fruit and, in 2025, in vines.

1.4 Pesticide sales in Portugal

Sales of plant protection products in Portugal reached 8,359 t of active substance in 2024, 16.4% below 2015 and 40.4% below 2011, but 2.7% above in 2023 (Eurostat, 2026; APA, 2026; Figure 1). Fungicides and bactericides remained the largest category (4,401 t; 52.7%), despite decreases of 8.5% relative to 2023 and 31% relative to the 2020 peak (6,402 t). Herbicides represented 24.9% (2,078 t; +11.6% relative to 2023) and insecticides and acaricides 10.5% (874 t), the latter increasing by 36% in 2024 after a minimum of 278 t in 2021; molluscicides and growth regulators accounted for less than 0.5%. The fungicide share is well above the EU average (40% in 2024; Eurostat, 2026) and mirrors the disease-dominated profile of the warnings, notably the weight of grapevine downy and powdery mildew. Data for 2025 were not yet available.

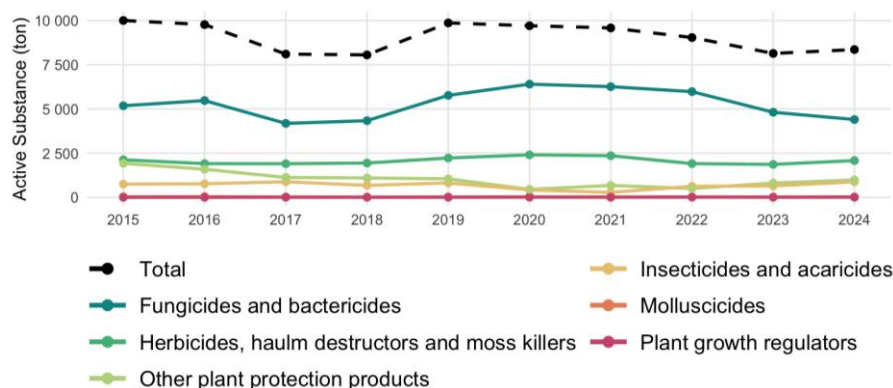


Figure 1. Sales of plant protection products in Portugal by category, 2015–2024 (ton of active substance).

Source: Eurostat. Access September 10th, 2026; data available till year 2024.

1.5 National Action Plan for the Sustainable Use of Plant Protection Products

Directive 2009/128/EC was transposed by Law n.º 26/2013, which created the National Action Plan for the Sustainable Use of Pesticides (*Plano de Ação Nacional para o Uso Sustentável de Produtos Fitofarmacêuticos* (PANUSPF)). The first plan (2013–2018; Ordinance n.º 304/2013) was revised for 2018–2023 (Ordinance n.º 82/2019), and the second revision, for 2025–2030, was approved by Ordinance n.º 119/2026/1, of 19 March, after a one-year interruption linked to the withdrawn proposal for an EU Sustainable Use Regulation (DGAV, 2026). The plan keeps two transversal axes – research, innovation and technology transfer; and training, awareness and information – and three strategic axes: protection of human health, protection of the environment, and promotion of sustainable agricultural and forestry production, monitored through 88 indicators. Under the third axis, the adoption of the general principles of IPM is supported by the single electronic field notebook (2024), IPM indicators in official controls (2023), updated IPM technical guidelines and economic thresholds for the main pests and diseases, and a dedicated measure (Measure 19) to modernise the SNAA and broaden the scope of agricultural warnings, with the number of SNAA subscribers as an indicator.

1.6 Treatment advice in the warning circulars: pesticides and alternatives

To complement the frequency of pests and diseases, the treatment advice given in each warning was examined for the six crop groups (Annex II). Of the 1,465 warnings (one circular × crop × pest or disease), 1,296 contained treatment text. Advice to apply a plant protection product was found in 72% of these warnings (930) and advice without pesticides in 33% (430). Both types were combined in 22% of the warnings (291), whereas alternatives alone were given in only 11% (139); the remaining warnings contained only monitoring or risk-estimation instructions, or no measure. Between 2023 and 2025 the share of warnings with pesticide advice fell from 77% to 69–72%, and the share with alternatives rose from 24% to 35%, while the number of warnings with treatment text more than tripled (from 196 to 676; Table A1c).

Differences between crop groups were marked (Figure 2; Tables A1a–A1c). Over the three years, pesticide advice was most frequent in stone fruit (81% of the warnings), pome fruit (77%) and citrus (77%), and least

frequent in nut crops (42%). Nut crops were the only group in which alternatives (48%) outnumbered pesticide advice, mainly through cultural measures and the release and conservation of the parasitoid *Torymus sinensis* against the chestnut gall wasp. Citrus combined frequent pesticide advice with the highest share of alternatives (52%), including releases of *Tamarixia dryi* against the African citrus psyllid and water and drainage management against *Phytophthora*. About one third of the warnings for olive (37%) and vines (33%) included alternatives, and pome fruit had the lowest share (24%).

Fungicides and bactericides were the dominant pesticide group, cited in 599 of the 930 warnings with pesticide advice (64%), followed by insecticides and acaricides (311; 33%). Herbicides (12 warnings) and other products (18, mostly weather-related or general notes) were rare, and no molluscicides or plant growth regulators were recommended (Table A2). Fungicides prevailed in vines (136 against 43 insecticide warnings in 2025), olive, stone fruit and citrus, in line with the weight of fungal diseases in the circulars. Pome fruit was the exception: insecticide and acaricide advice exceeded fungicide advice in 2023 (26 against 17) and 2025 (80 against 59), driven by codling moth, pear psylla and San José scale.

Among the alternatives, cultural and prophylactic measures were by far the most cited (297 of the 430 warnings; 69%), chiefly pruning and pruning-wood management, canopy management and removal of infected material. Organic-farming products other than copper and sulphur (paraffin oil, kaolin, azadirachtin, pyrethrins, fatty acids) appeared in 124 warnings (29%), biological control in 68 (16%; mostly microbial agents such as *Trichoderma*, *Bacillus* and *Saccharomyces* in vines), and biotechnical methods such as mating disruption or mass trapping in only 16 (4%). Overall, the circulars work mainly as decision support for timing chemical treatments, and present alternatives as preventive complements rather than substitutes. This agrees with the knowledge and technical-support barriers reported in Section II and with the aim of PANUSPF Measure 19 to broaden the scope of the agricultural warnings.

These figures are indicative. A warning recommending a treatment without naming the product was counted as pesticide advice, copper and sulphur were counted as pesticides although they are authorised in organic farming, and only a short excerpt of each warning was classified, so alternatives are probably under-counted.

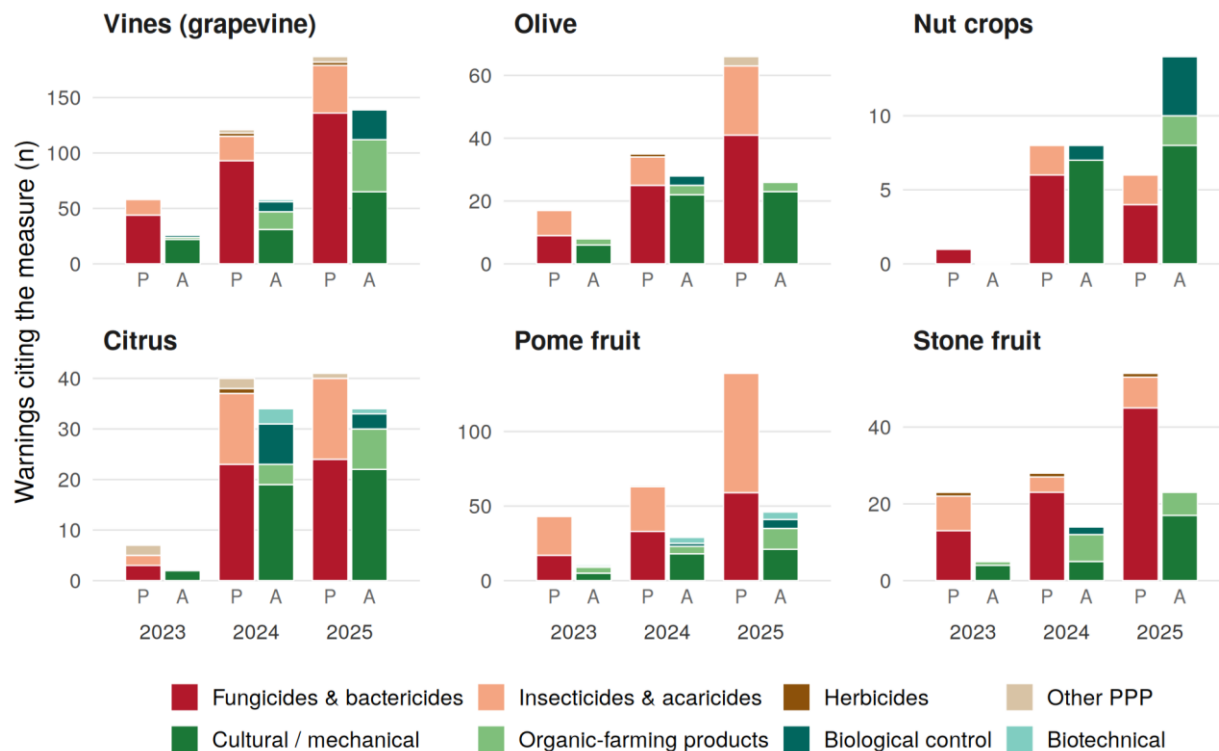


Figure 2. Treatment advice in the warning circulars by crop group and year, 2023–2025: pesticide groups (P) and alternatives without pesticides (A), number of warnings. A warning can cite more than one group; y scales differ between crop groups.

Source: SNAA warning circulars; see Annex II.

2. Section II – Levers and barriers for prevention and agroecology

2.1 The national online meeting

The national synthesis was built collectively in an online participatory meeting held in September 2026 under the title “Crop Protection in Portugal: Alternatives and Actions”. The call attracted 48 registrations, 33 people joined the session, 22 followed at least 90% of it, and 19 answered the final questionnaire on barriers. Registrations covered the whole national crop protection system: agricultural technicians (17 of the declared roles), researchers (14), trainers (9), consultants (9), farmers (5) and association officers, coming from the advisory sector (AAPIM, 10 registrations), higher education and research (16, from the agrarian schools of Viseu, Santarém, Coimbra, Portalegre and Beja and from the Centre for Functional Ecology of the University of Coimbra), public administration (DGAV, DGADR, GPP, two CCDR and two municipalities, 9), the interprofessional centre COTHN-CC, the industry association CropLife Portugal, the NGO League for the Protection of Nature, a wine cooperative, farms and a certification body. Farmers were the smallest group, so the results below express mainly the view of advisers, researchers and administration.

Participants worked in six groups. Each group described one or more cropping systems, the crop, the pest or disease of concern, the preventive or non-chemical technique that could replace or reduce the use of synthetic pesticides, and the constraints/barriers that hold that technique back; the six group tables were consolidated into 22 records. The session closed with a questionnaire in which the 19 respondents distributed 100 points across three sets of barriers previously identified during the discussion.

2.2 Crops, pests and diseases addressed by the participants

The six groups recorded 21 crop–enemy–technique combinations across annual and perennial systems (Table 2). Perennial crops were represented by vine (downy mildew and *Lobesia botrana*), pome fruit (codling moth), apple (aphids) and pear (pear psylla); annual crops by oat (septoria and weeds), maize (soil insects), cereals (aphids and weeds), and horticultural crops by lettuce (*Fusarium* and downy mildew), cucumber and sweet pepper (aphids), and tomato in the open field and in greenhouses (*Tetranychus urticae* and whitefly). Fungal and oomycete diseases were raised mainly for vine, oat and lettuce, while insects and mites dominated the remaining systems. Group 3 described its crops and techniques separately but reported a single set of constraints for all of them, which is shown once in the table and referred to as “(as above)” in the rows that follow; group 1 noted that it had not had time to present the constraints of one of its three options for vine.

2.3 Alternatives to pesticide use proposed

The techniques proposed fall into seven families. Biological control was the most frequent (five records: parasitoids in cucumber, releases of natural enemies in apple, pear and greenhouse tomato, and conservation of natural enemies in sweet pepper), followed by cropping-system measures (five records: crop rotation and intercropping in oat, false seedbed against weeds, rotation with legumes in maize, and wider spacing to aerate the vine canopy) and by host resistance (four records: tolerant or resistant varieties in vine and lettuce, and resistant plants in maize). Ecological infrastructures were proposed in winter cereals, greenhouse tomato and apple, where ground cover was described as an infrastructure rather than as a weed problem. Semiochemicals appeared twice, as mating disruption against codling moth and against *L. botrana*; biopesticides and natural substances twice, with citrus essential oils in vine and nettle extract against spider mite; and precision technology once, with robotic weeding in cereals. Beyond the crop-specific records, group 4 made a general point that applies to all crops: the lever is not a single substitute technique but the combined use of several protection means, and what is missing is knowledge of how they complement each other – a view echoed by its own robotic weeding record, reported as needing complementary methods such as herbicides.

Table 2. Summarised. Cropping systems, targets, alternative approaches and barrier types reported by the six working groups (G = group).

G	Cropping system	Target pest / disease	Alternative approach	Barrier types reported
1	Oat	Septoria leaf blotch	Crop rotation; intercropping	Yield loss · Operational
	Oat	Weeds	False seedbed	Yield loss · Operational
	Vine	Downy mildew	Resistant varieties; canopy management; plant-derived products	Market acceptance · Yield loss
2	Maize	Soil insects	Resistant plants; natural enemies; rotation with legumes	Efficacy · Operational · Economic risk
3	Cucumber	Aphids	Parasitoid releases	Economic · Knowledge and advice · Market acceptance · Availability
	Pome fruit	Codling moth	Mating disruption	
	Lettuce	<i>Fusarium</i> ; downy mildew	Resistant varieties	
4	Cereals	Weeds	Robotic weeding	Operational
	Apple	Aphids	Natural enemy releases; conservation biological control; ecological infrastructures	Knowledge and advice · Economic risk · Slow response
5	Winter cereals	Aphids	Ecological infrastructures	Knowledge and advice
	Pear	Pear psylla	Natural enemy releases	Economic risk · Slow response
	Tomato (greenhouse)	Whitefly	Natural enemy releases; ecological infrastructures	Knowledge and advice
6	Sweet pepper	Aphids	Conservation biological control	Knowledge and advice
	Tomato	<i>Tetranychus urticae</i>	Biopesticides and natural substances	Economic risk · Efficacy
	Vine	<i>Lobesia botrana</i>	Mating disruption	Regulatory · Operational

Barrier types: Economic (cost of implementation and transition, cost-benefit) · Economic risk (risk borne by the farmer) · Yield loss · Operational (technical difficulties, machinery, irrigation, complementary methods) · Knowledge and advice (training, technical follow-up, decision support) · Market acceptance and valorisation · Availability of the alternatives · Efficacy · Slow response of the biological agents · Regulatory (authorisation of the products)

2.4 Constraints reported with each technique

The constraints recorded next to the techniques (Table 2; full wording in Table A3, Annex III) are consistent across groups. Economic constraints come first: cost of implementation and of the transition, cost-benefit and risk for the farmer, yield reduction, and the absence of a price premium for the resulting product, to which the cucumber group added the lack of support under the Common Agricultural Policy. Knowledge and advisory constraints come second: lack of training, need for closer technical follow-up and for more field visits, and difficulty in obtaining decision support, explicitly mentioned by three groups. Agronomic constraints follow: no effective resistance to maize soil insects, lack of natural enemies, slow response of released auxiliaries, need to adapt machinery and irrigation, and the need for complementary methods where robotics alone is insufficient. Market and regulatory constraints close the list: lack of consumer acceptance of resistant or tolerant varieties, limited availability of alternatives, and slow, country-dependent authorisation of pheromone products.

2.5 Barriers ranked by the participants

In the final questionnaire, the 19 respondents distributed 100 points within each of three sets of barriers (Figures A7–A9, Annex IV). In the first set the non-recognition and valorisation of the production systems and of the products obtained from them received 35 points, ahead of cost and economic risk for the farmer (27), yield reduction (23) and the availability, regulation and suitability of the alternatives (15). In the second set, the need for technical support with more field visits received 27 points, followed by technical difficulties of operationalisation (25), lack of resistant varieties or cultivars (19), lack of consumer knowledge and valorisation of the products obtained (16) and lack of market acceptance of resistant or tolerant species and cultivars (13). In the third set, risk aversion received 27 points, followed by lack of knowledge (23), the need

to accept protection responses that only work in the long term (22), complementarity between protection means (16) and the scarce availability of alternatives on the market (12).

Read together, the three sets place the heaviest weight on economics and market recognition (35, 27 and 23 points in the first set, and 16 and 13 in the second), followed by knowledge and advisory capacity (27, 25 and 23 points), by the behavioural dimension of risk and time horizon (27 and 22) and, last, by the availability and regulation of the alternatives themselves (15 and 12). The ranking mirrors the constraints written in the group tables, which gives some internal consistency to the exercise, and it shows that the participants did not consider the alternatives to be technically unavailable so much as economically unrewarded and insufficiently supported.

The two exercises can also be checked against each other, since the group tables were filled in before the questionnaire was answered. Every barrier scored in the questionnaire has a counterpart in the tables: non-recognition and valorisation of the products (35 points) matches the valorisation of the final product raised by group 3 and the market difficulties recorded by group 1; cost and economic risk (27) matches groups 3 and 6; yield reduction (23) matches groups 1 and 2; availability and regulation of the alternatives (15 and 12) matches the market availability noted by group 3 and the authorisation of pheromones noted by group 6; technical support with more field visits (27), operational difficulties (25) and lack of knowledge (23) match the follow-up, machinery adaptation and knowledge constraints reported by groups 2, 3, 4, 5 and 6; lack of resistant varieties (19) matches the absence of effective resistance to soil insects in maize; consumer knowledge and market acceptance (16 and 13) match the vine record of group 1; risk aversion (27) and the long-term nature of the responses (22) match the fear of economic loss and the slow response of natural enemies reported by groups 4 and 5; and complementarity between protection means (16) matches the general point made by group 4. Two constraints written in the tables have no counterpart in the questionnaire: the lack of natural enemies able to regulate maize soil insects, and the absence of support under the Common Agricultural Policy. The answers are therefore concordant in content, and differ only in weight, since the tables mention knowledge and technical support most often whereas the questionnaire placed market recognition and economic risk first.

3. Conclusions – the warning circulars and the barriers reported

Section I presents the main crop protection pest and diseases collected from warnings issued by SNAA and the evolution on the use of pesticides at the national level over the period of 3 years. The database built from the SNAA circulars holds 1,542 records from 230 circulars issued by 10 warning stations in 2023–2025, of which 1,427 refer to 73 pests and diseases. Coverage grew over the period, from 32 circulars and 7 stations in 2023 to 117 circulars and 10 stations in 2025, and one station accounted for 60% of the 2023 records, so the differences between years express reporting effort as much as phytosanitary pressure and are read here as composition, not as trends in pest pressure. That analysis of the selected warnings proves to be narrow and stable, as small number of recurrent fungal and oomycete diseases set the rhythm of intervention in each perennial crop, which is consistent with the weight fungicides still hold in national sales.

Section II resulted from participants' knowledge and perceptions about the existence of alternatives to pesticide use for some pests and diseases and the barriers for pesticides alternative implementation. The six working groups produced 21 crop–enemy–technique records covering both perennial crops (vine, pome fruit, apple, pear) and annual or protected crops (oat, maize, cereals, lettuce, cucumber, sweet pepper and tomato). The alternatives proposed concentrate on biological control (five records), cropping-system measures (five), host resistance (four), ecological infrastructures (three), semiochemicals (two), biopesticides and natural substances (two) and robotic weeding (one); one group stressed that the lever is the combined use of several means rather than a single substitute. Results from the meeting show that the obstacle to alternatives is not the absence of solutions, but the implementation process is ahead. For every system discussed, participants named options they consider workable, all of them placed the difficulty downstream: in the economic return, in the recognition of the product obtained, and in the technical capacity needed to operate the technique in the field.

This is coherent with the nature of the alternatives proposed, which are knowledge-intensive and slow-acting compared with a chemical treatment. Such methods require planning, observation and patience, which explains why risk aversion and the long-time horizon of the responses weighed so heavily, and why the demand for training and closer technical follow-up was expressed together with the techniques themselves. The agreement between what the groups wrote and how they later scored the barriers indicates stable priorities for the barriers. Furthermore, the implication is that policies confined to making alternatives available will not, by themselves, move adoption. Valorisation of the resulting products and support through the transition are what the participants identify as decisive.

These two sections rest on independent sources: the circulars as the warning results were not presented or discussed during the meeting, and the participants chose their crops and organisms freely, so no causal relation can be drawn between them. However, two observations can be made as several of the organisms discussed by the groups in perennial crops: grapevine downy mildew, *Lobesia botrana*, codling moth, aphids and pear psylla; are also among the most frequently cited in the circulars, so both sources point to the same small set of recurrent problems, which supports prioritising alternatives for them.

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Annex I – Pie charts of pests and diseases per crop group (2023–2025)

Each panel shows, for one crop group and year, the relative frequency of the pests (left) and diseases (right) cited in the SNAA warning circulars; slice = number of circulars citing the organism.

Figure A1. Vines (grapevine)

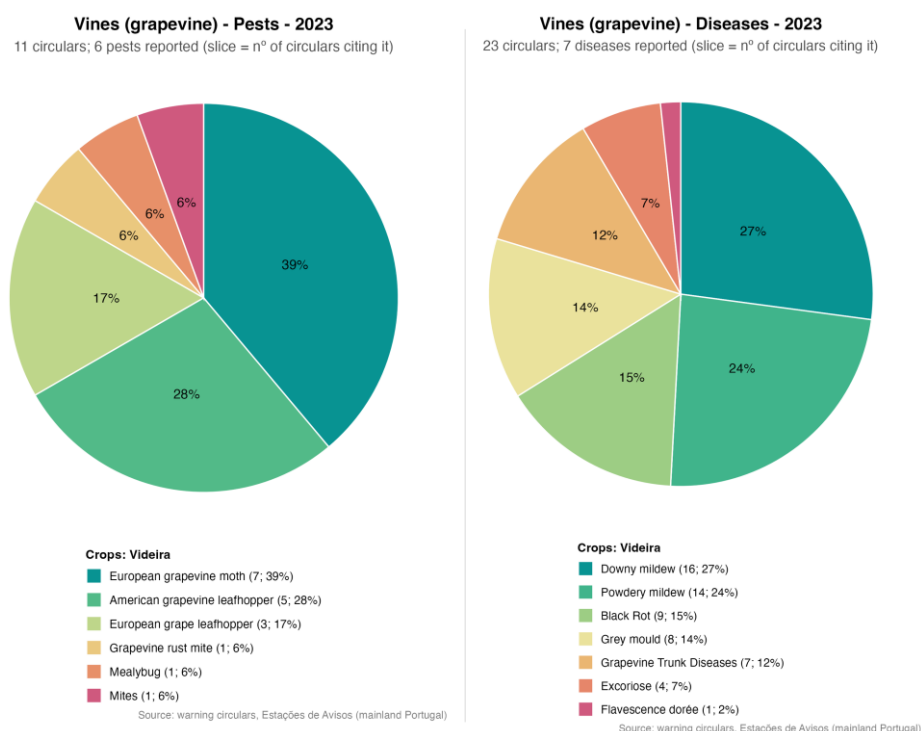


Figure A1a. Vines (grapevine), 2023 – pests (left) and diseases (right).

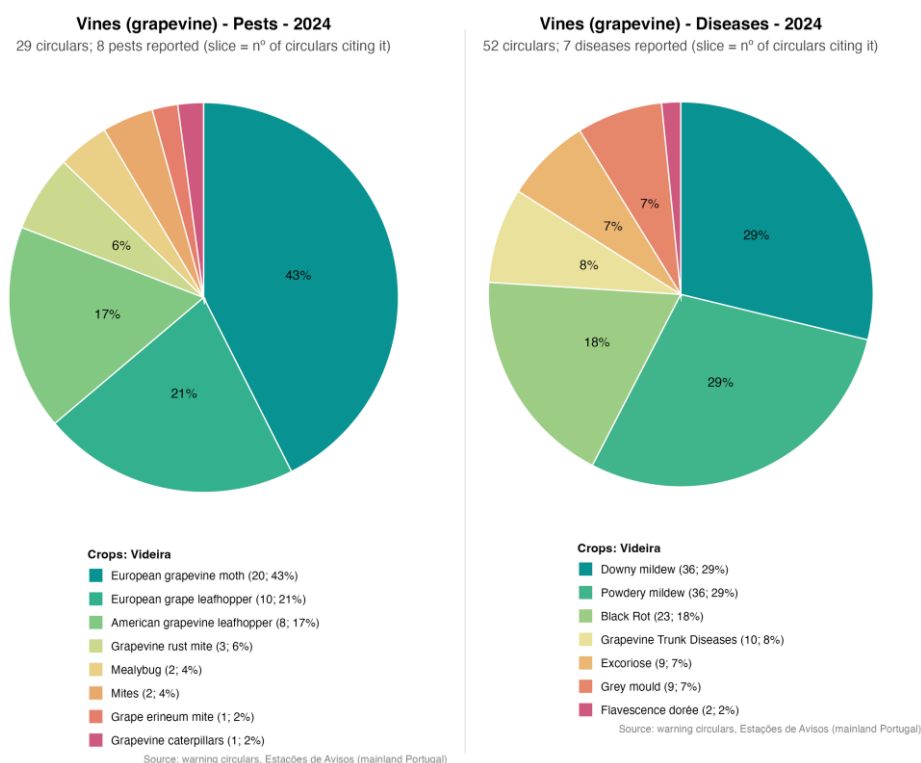
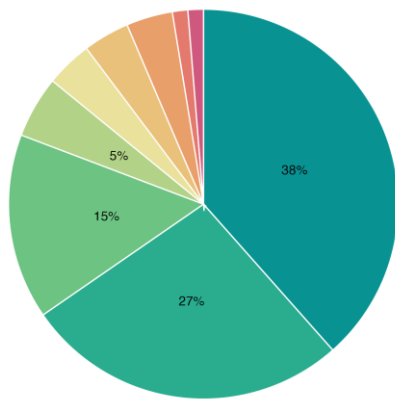


Figure A1b. Vines (grapevine), 2024 – pests (left) and diseases (right).

Vines (grapevine) - Pests - 2025
44 circulars; 9 pests reported (slice = n° of circulars citing it)

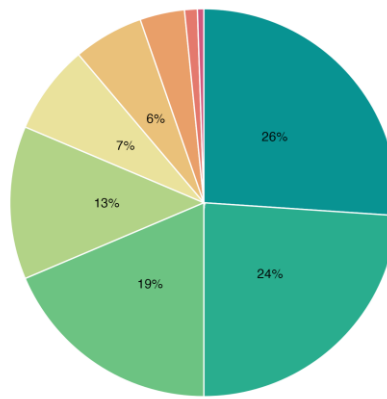


Crops: Videira

- European grapevine moth (30; 38%)
- European grape leathopper (21; 27%)
- American grapevine leathopper (12; 15%)
- Grape erineum mite (4; 5%)
- Grapevine rust mite (3; 4%)
- Mealybug (3; 4%)
- Mites (3; 4%)
- Grapevine yellow spider mite (1; 1%)
- Mediterranean fruit fly (1; 1%)

Source: warning circulars, Estações de Avisos (mainland Portugal)

Vines (grapevine) - Diseases - 2025
74 circulars; 9 diseases reported (slice = n° of circulars citing it)



Crops: Videira

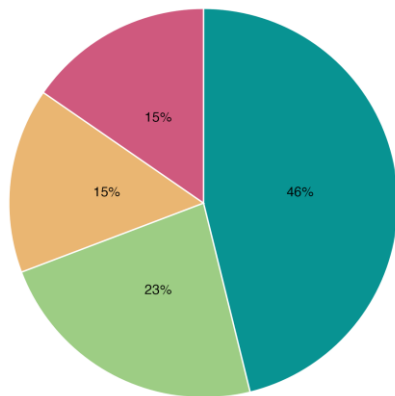
- Downy mildew (49; 26%)
- Powdery mildew (45; 24%)
- Black Rot (35; 19%)
- Grapevine Trunk Diseases (24; 13%)
- Grey mould (14; 7%)
- Excoriose (11; 6%)
- Flavescence dorée (7; 4%)
- Anthracoze (2; 1%)
- Honey Fungus (1; 1%)

Source: warning circulars, Estações de Avisos (mainland Portugal)

Figure A1c. Vines (grapevine), 2025 – pests (left) and diseases (right).

Figure A2. Olive

Olive - Pests - 2023
11 circulars; 4 pests reported (slice = n° of circulars citing it)

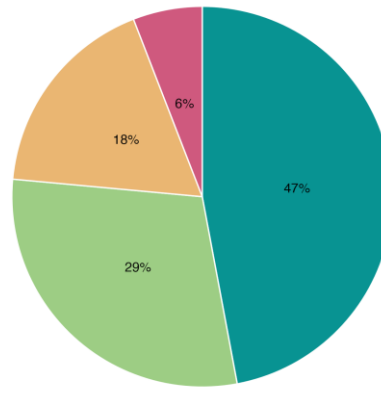


Crops: Oliveira

- Olive fruit fly (6; 46%)
- Olive bark beetle (3; 23%)
- Olive moth (2; 15%)
- Olive psyllid (2; 15%)

Source: warning circulars, Estações de Avisos (mainland Portugal)

Olive - Diseases - 2023
14 circulars; 4 diseases reported (slice = n° of circulars citing it)



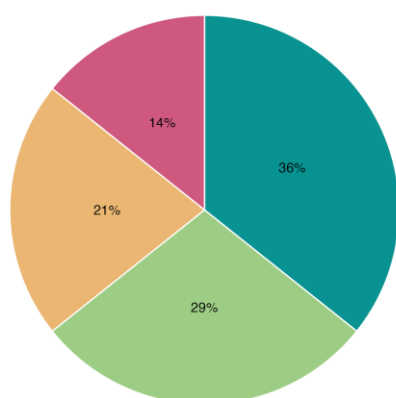
Crops: Oliveira

- Peacock's eye (8; 47%)
- Xylella fastidiosa (5; 29%)
- Olive anthracnose (3; 18%)
- Anthracoze (1; 6%)

Source: warning circulars, Estações de Avisos (mainland Portugal)

Figure A2a. Olive, 2023 – pests (left) and diseases (right).

Olive - Pests - 2024
12 circulars; 4 pests reported (slice = n° of circulars citing it)

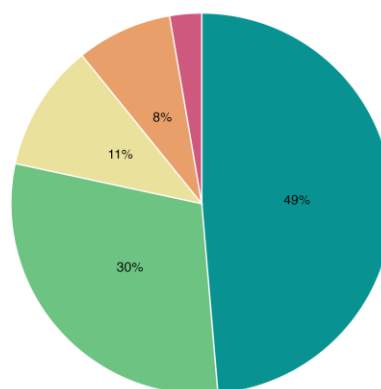


Crops: Oliveira

- Olive fruit fly (5; 36%)
- Olive moth (4; 29%)
- Olive bark beetle (3; 21%)
- Olive psyllid (2; 14%)

Source: warning circulars, Estações de Avisos (mainland Portugal)

Olive - Diseases - 2024
24 circulars; 5 diseases reported (slice = n° of circulars citing it)



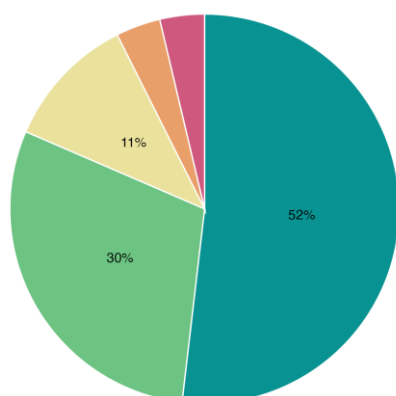
Crops: Oliveira

- Peacock's eye (18; 49%)
- Olive anthracnose (11; 30%)
- Cercospora leaf spot (4; 11%)
- Olive knot (3; 8%)
- Xylella fastidiosa (1; 3%)

Source: warning circulars, Estações de Avisos (mainland Portugal)

Figure A2b. Olive, 2024 – pests (left) and diseases (right).

Olive - Pests - 2025
25 circulars; 5 pests reported (slice = n° of circulars citing it)

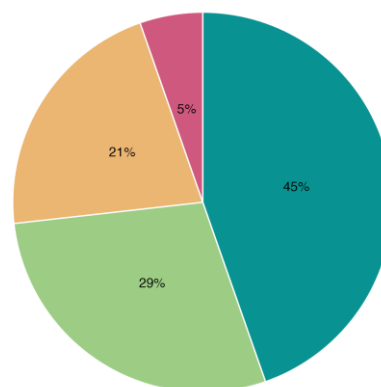


Crops: Oliveira

- Olive fruit fly (14; 52%)
- Olive moth (8; 30%)
- Olive bark beetle (3; 11%)
- Mealybug (1; 4%)
- Olive psyllid (1; 4%)

Source: warning circulars, Estações de Avisos (mainland Portugal)

Olive - Diseases - 2025
31 circulars; 4 diseases reported (slice = n° of circulars citing it)



Crops: Oliveira

- Peacock's eye (25; 45%)
- Olive anthracnose (16; 29%)
- Cercospora leaf spot (12; 21%)
- Olive knot (3; 5%)

Source: warning circulars, Estações de Avisos (mainland Portugal)

Figure A2c. Olive, 2025 – pests (left) and diseases (right).

Figure A3. Nut crops

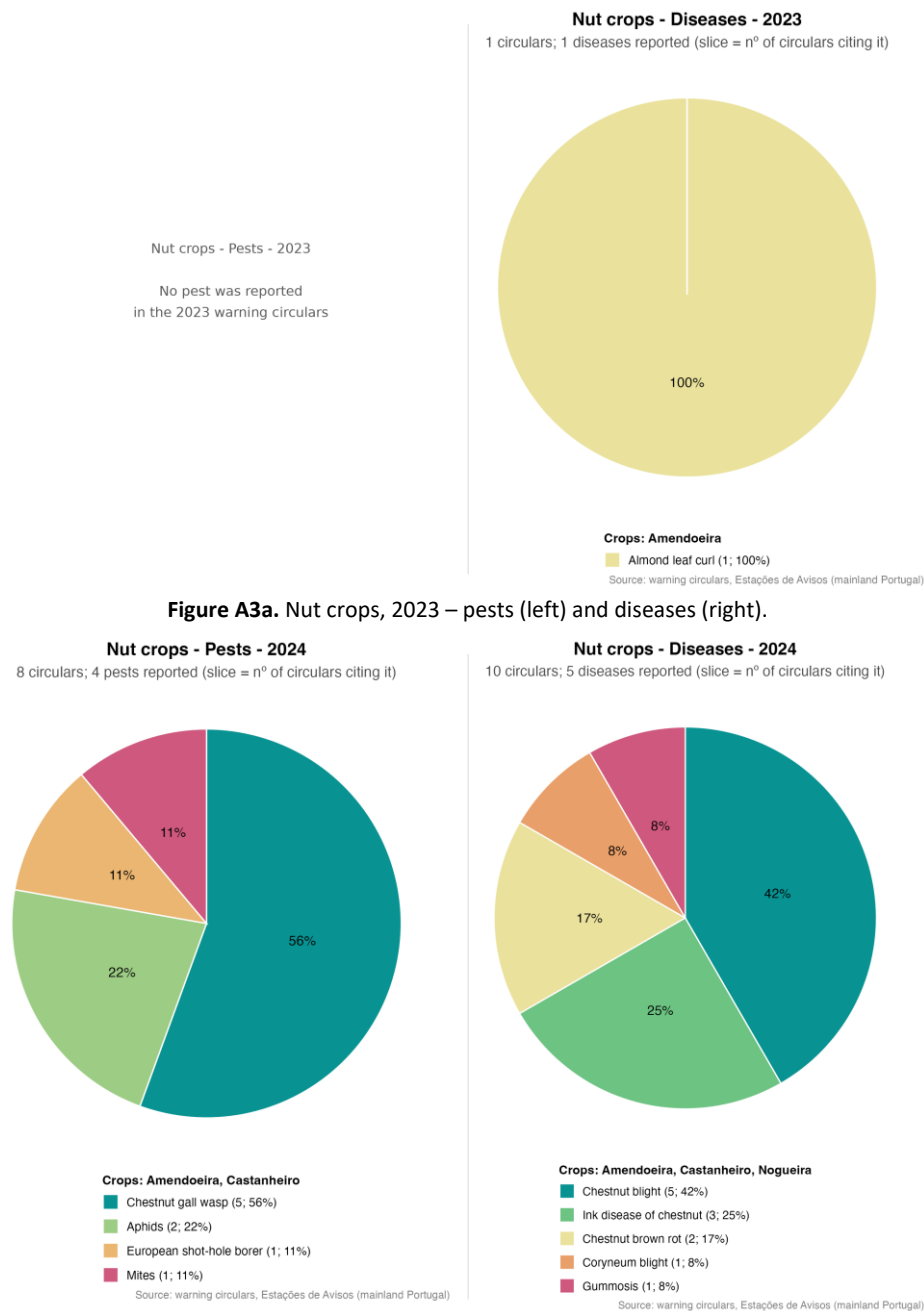


Figure A3b. Nut crops, 2024 – pests (left) and diseases (right).

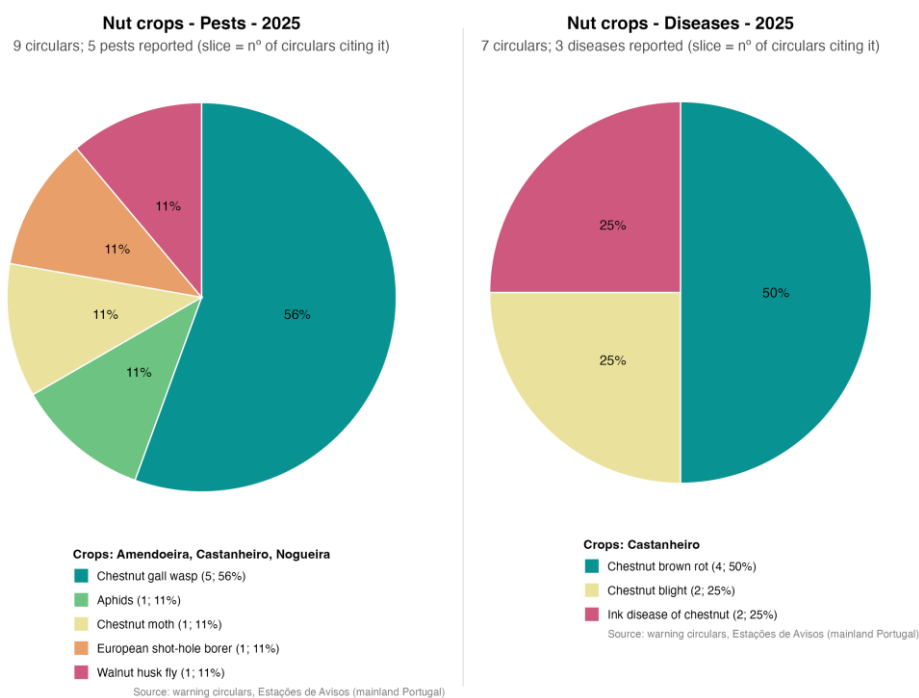


Figure A3c. Nut crops, 2025 – pests (left) and diseases (right).

Figure A4. Citrus

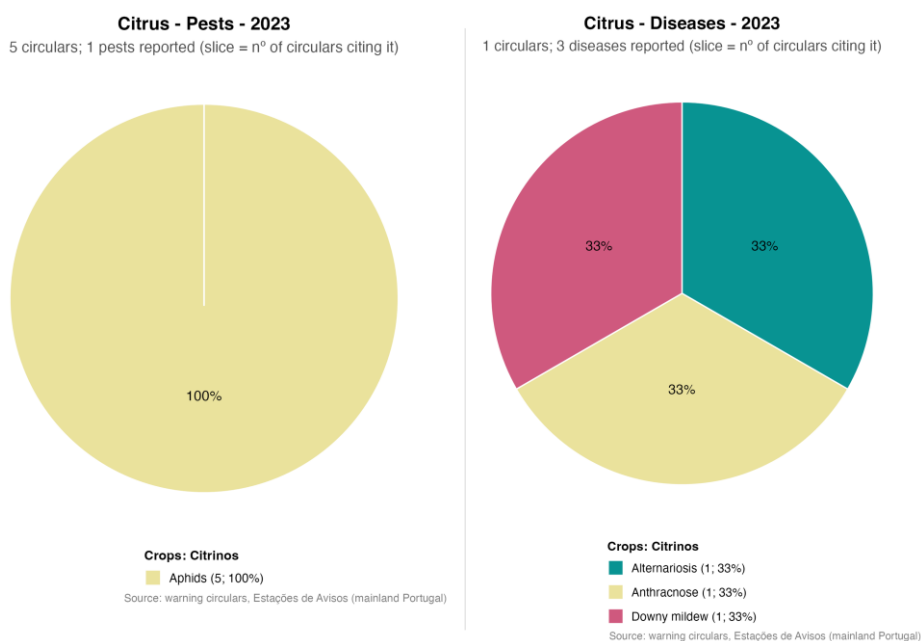
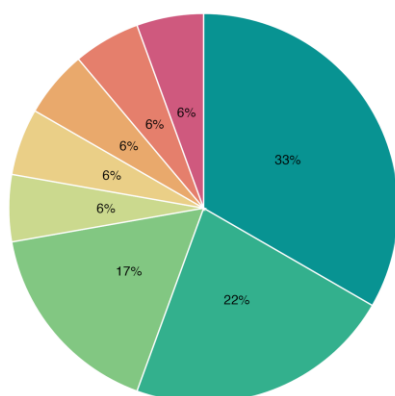


Figure A4a. Citrus, 2023 – pests (left) and diseases (right).

Citrus - Pests - 2024
15 circulars; 8 pests reported (slice = n° of circulars citing it)

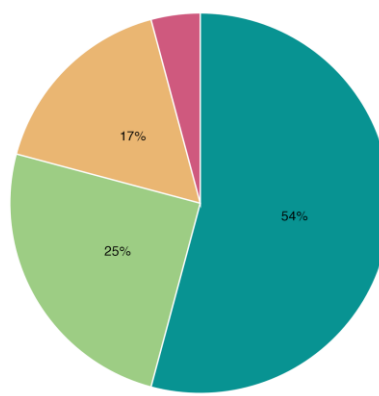


Crops: Citrinos

- Mediterranean fruit fly (6; 33%)
- African citrus psyllid (4; 22%)
- Aphids (3; 17%)
- California red scale (1; 6%)
- Citrus flatid planthopper (1; 6%)
- Mealybug (1; 6%)
- South African citrus thrips (1; 6%)
- Thrips (1; 6%)

Source: warning circulars, Estações de Avisos (mainland Portugal)

Citrus - Diseases - 2024
14 circulars; 4 diseases reported (slice = n° of circulars citing it)



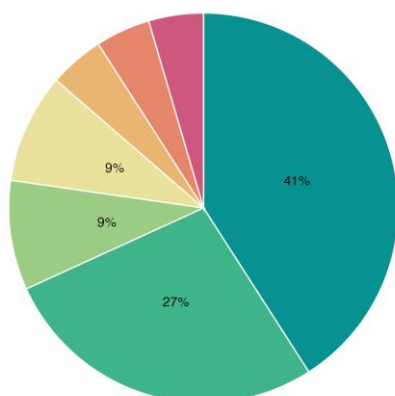
Crops: Citrinos

- Downy mildew (13; 54%)
- Anthracnose (6; 25%)
- Alternariosis (4; 17%)
- Gummosis (1; 4%)

Source: warning circulars, Estações de Avisos (mainland Portugal)

Figure A4b. Citrus, 2024 – pests (left) and diseases (right).

Citrus - Pests - 2025
18 circulars; 7 pests reported (slice = n° of circulars citing it)

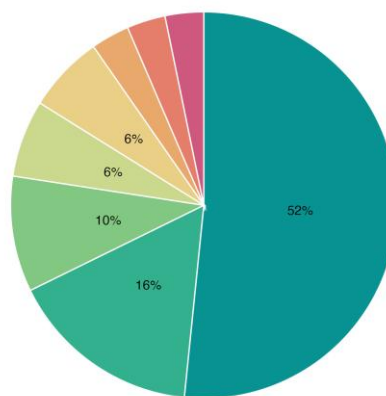


Crops: Citrinos

- Mediterranean fruit fly (9; 41%)
- Aphids (6; 27%)
- California red scale (2; 9%)
- Mealybug (2; 9%)
- Citrus flatid planthopper (1; 5%)
- Citrus leafminer (1; 5%)
- South African citrus thrips (1; 5%)

Source: warning circulars, Estações de Avisos (mainland Portugal)

Citrus - Diseases - 2025
21 circulars; 8 diseases reported (slice = n° of circulars citing it)



Crops: Citrinos

- Downy mildew (16; 52%)
- Anthracnose (5; 16%)
- Alternariosis (3; 10%)
- Gummosis (2; 6%)
- Powdery mildew (2; 6%)
- Aphids (1; 3%)
- Grey mould (1; 3%)
- Xylella fastidiosa (1; 3%)

Source: warning circulars, Estações de Avisos (mainland Portugal)

Figure A4c. Citrus, 2025 – pests (left) and diseases (right).

Figure A5. Pome fruit

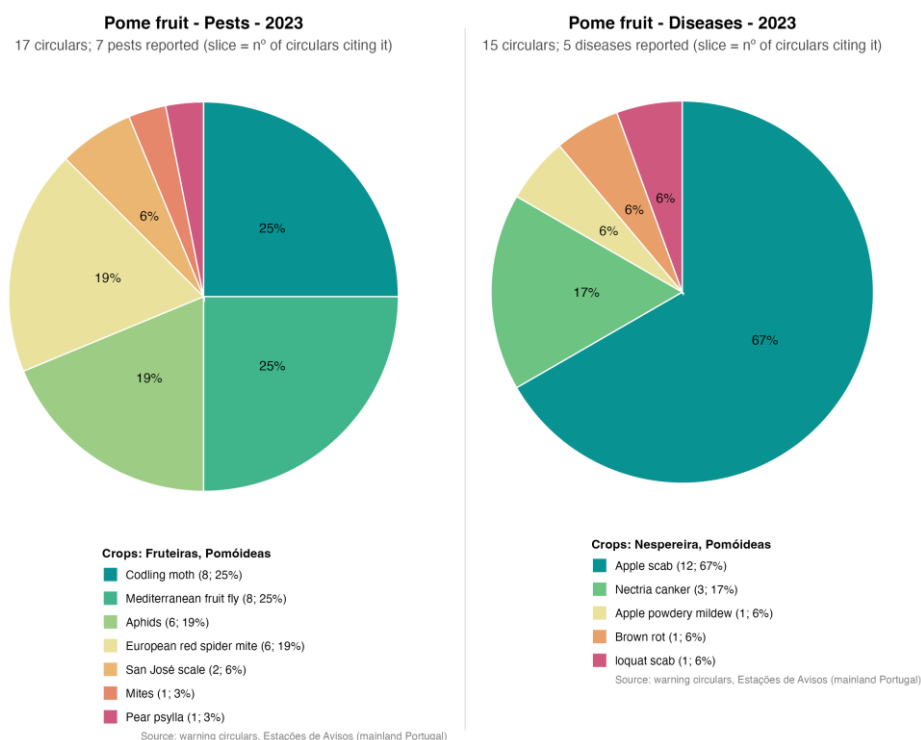


Figure A5a. Pome fruit, 2023 – pests (left) and diseases (right).

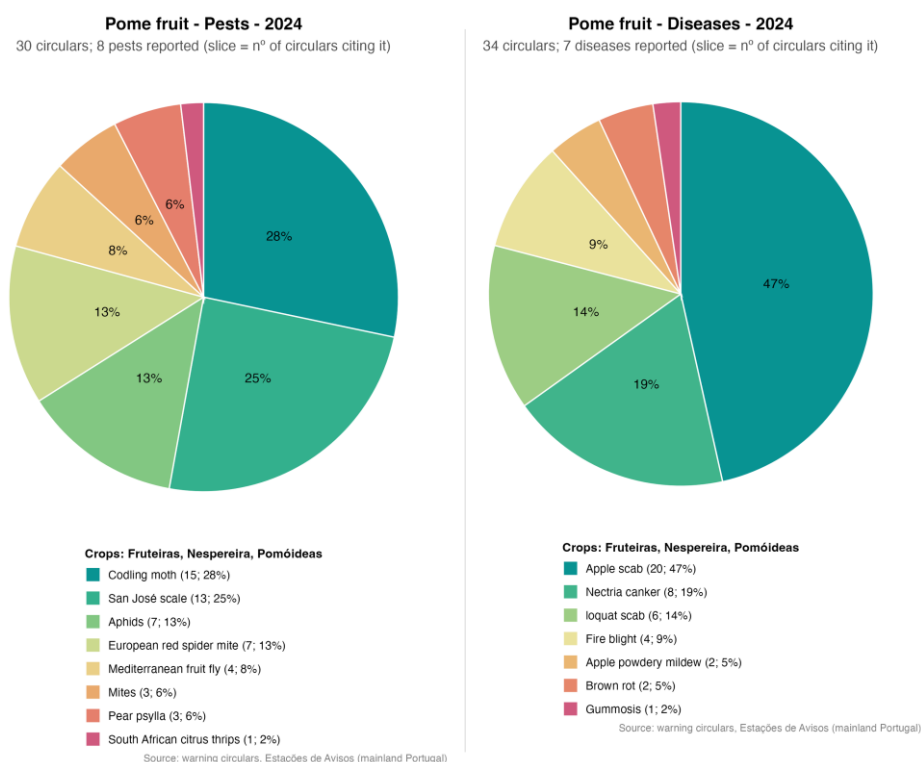


Figure A5b. Pome fruit, 2024 – pests (left) and diseases (right).

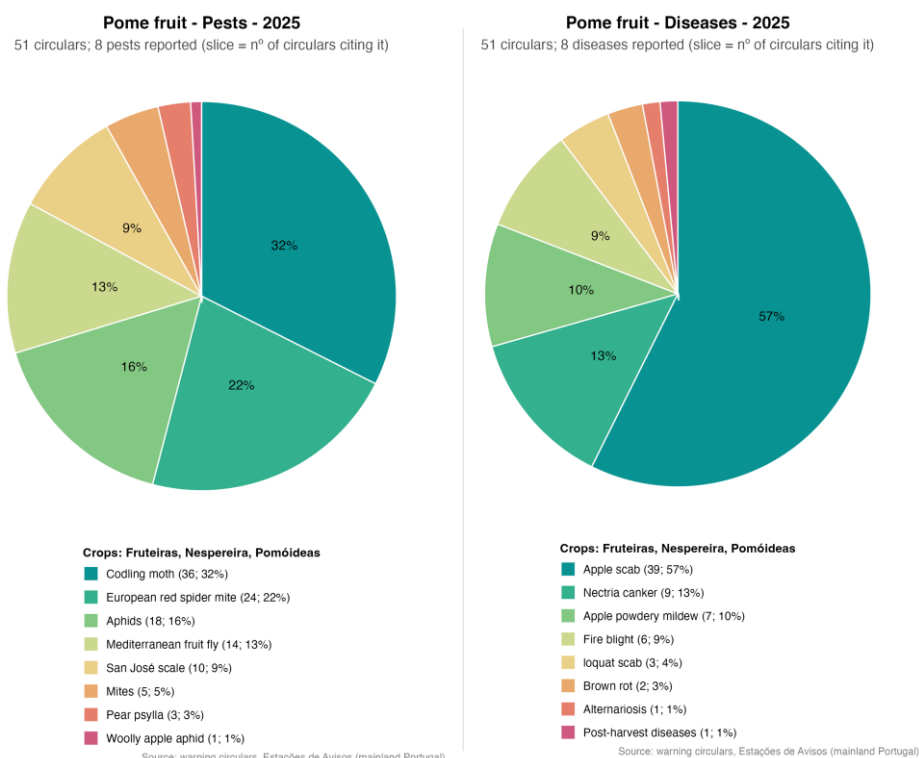


Figure A5c. Pome fruit, 2025 – pests (left) and diseases (right).

Figure A6. Stone fruit

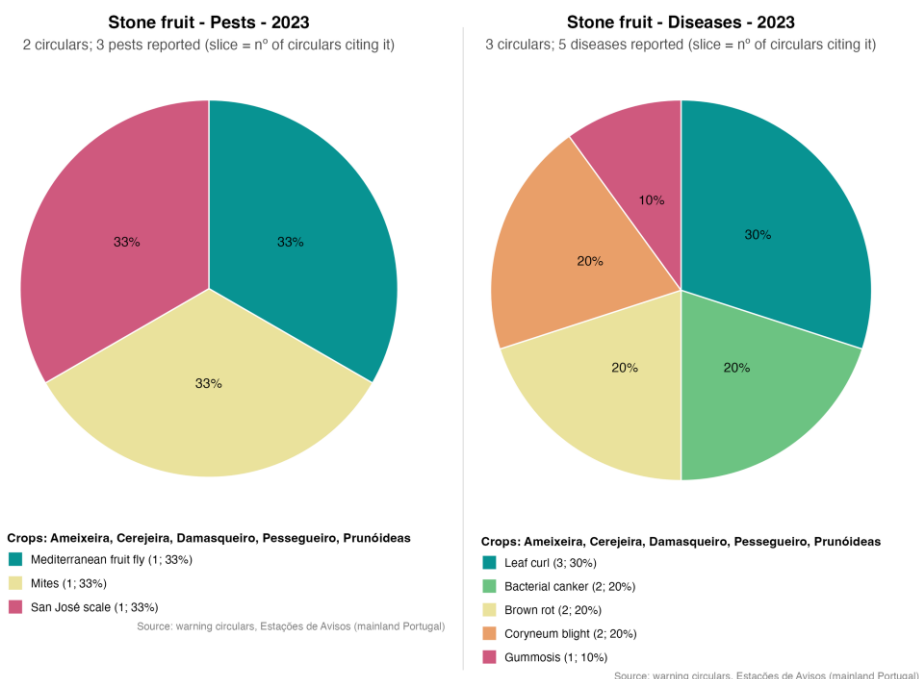
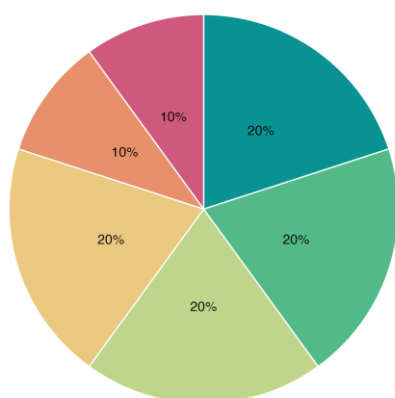


Figure A6a. Stone fruit, 2023 – pests (left) and diseases (right).

Stone fruit - Pests - 2024
8 circulars; 6 pests reported (slice = nº of circulars citing it)

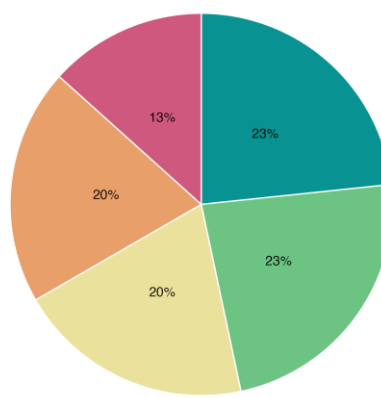


Crops: Cerejeira, Pessegueiro, Prunóideas

Aphids (2; 20%)
Mealybug (2; 20%)
Mediterranean fruit fly (2; 20%)
Mites (2; 20%)
San José scale (1; 10%)
Thrips (1; 10%)

Source: warning circulars, Estações de Avisos (mainland Portugal)

Stone fruit - Diseases - 2024
14 circulars; 5 diseases reported (slice = nº of circulars citing it)



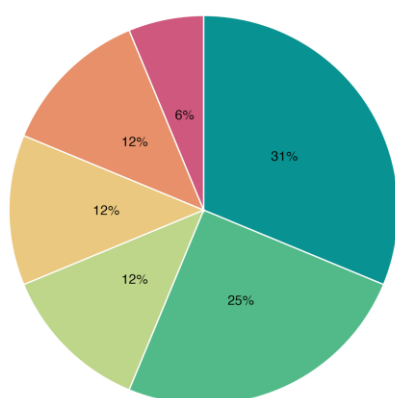
Crops: Cerejeira, Pessegueiro, Prunóideas

Brown rot (7; 23%)
Leaf curl (7; 23%)
Coryneum blight (6; 20%)
Peach leaf curl (6; 20%)
Bacterial canker (4; 13%)

Source: warning circulars, Estações de Avisos (mainland Portugal)

Figure A6b. Stone fruit, 2024 – pests (left) and diseases (right).

Stone fruit - Pests - 2025
11 circulars; 6 pests reported (slice = nº of circulars citing it)

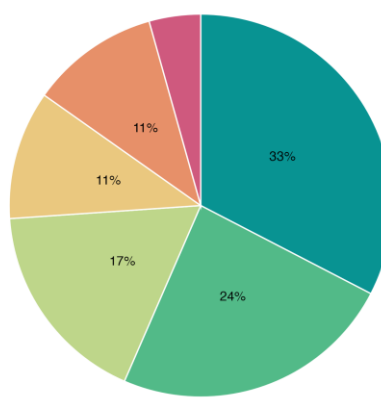


Crops: Cerejeira, Pessegueiro, Prunóideas

Mediterranean fruit fly (5; 31%)
Spotted-wing drosophila (4; 25%)
Aphids (2; 12%)
Mealybug (2; 12%)
Mites (2; 12%)
Peach twig borer (1; 6%)

Source: warning circulars, Estações de Avisos (mainland Portugal)

Stone fruit - Diseases - 2025
24 circulars; 6 diseases reported (slice = nº of circulars citing it)



Crops: Cerejeira, Pessegueiro, Prunóideas

Peach leaf curl (15; 33%)
Brown rot (11; 24%)
Coryneum blight (8; 17%)
Leaf curl (5; 11%)
Rose powdery mildew (5; 11%)
Bacterial canker (2; 4%)

Source: warning circulars, Estações de Avisos (mainland Portugal)

Figure A6c. Stone fruit, 2025 – pests (left) and diseases (right).

Annex II – Treatment advice in the warning circulars: pesticides and alternatives per crop group (2023–2025)

Treatment advice given in each warning of the SNAA circulars for the six crop groups of Annex I. One warning = one circular × crop × pest or disease (1465 warnings). A warning was classed as **pesticide advice** when it named a conventional plant protection product (copper and sulphur included) or gave a spray instruction without naming a product, and as **alternative advice** when it named biological control (microbial agents, parasitoid releases, conservation of beneficials), biotechnical means (mating disruption, pheromone or mass trapping, attractant baits), cultural or mechanical measures, or organic-farming products other than copper and sulphur. A warning can carry both. Monitoring and risk estimation are counted separately and are not treated as alternatives.

Table A1a. Warnings per year and crop group, by type of treatment advice (n).

Year	Crop group	Circulars	Warnings	Warnings with text	Pesticide	Alternative (any)	Biological	Bio-technical	Cultural / mechanical	MPB products
2023	Vines (grapevine)	26	88	77	60	23	2	0	22	2
2023	Olive	17	34	30	17	8	0	0	6	2
2023	Nut crops	2	2	1	1	0	0	0	0	0
2023	Citrus	8	19	12	7	2	0	0	2	0
2023	Pome fruit	19	54	52	43	10	1	1	5	4
2023	Stone fruit	4	24	24	23	5	0	0	4	1
2024	Vines (grapevine)	59	198	173	120	47	9	2	31	16
2024	Olive	30	57	52	34	26	3	0	22	3
2024	Nut crops	15	30	16	6	7	1	0	7	0
2024	Citrus	26	58	47	40	28	8	3	19	4
2024	Pome fruit	45	108	94	64	27	2	4	18	5
2024	Stone fruit	19	48	42	28	12	2	0	5	7
2025	Vines (grapevine)	83	315	289	182	109	27	0	65	47
2025	Olive	43	89	80	65	26	0	0	23	3
2025	Nut crops	16	23	14	6	8	4	0	8	2
2025	Citrus	35	62	56	41	30	3	1	22	8
2025	Pome fruit	63	186	174	139	40	6	5	21	14
2025	Stone fruit	31	70	63	54	22	0	0	17	6
Total	2023–2025	541	1465	1296	930	430	68	16	297	124

Circulars: a circular covering several crop groups is counted once in each group, so the total exceeds the number of circulars. Warnings with text: 169 warnings have no treatment text in the database. Alternative subtypes can overlap.

Table A1b. Combinations of advice within the same warning, and circulars recommending each type (n).

Year	Crop group	Pesticide only	Alternatives only	Both	Monitoring only	Monitoring (any)	No treatment advised	Circulars with pesticide advice	Circulars with alternative advice
2023	Vines (grapevine)	45	8	15	2	18	2	24	17
2023	Olive	12	3	5	0	7	0	12	6
2023	Nut crops	1	0	0	0	0	0	1	0
2023	Citrus	5	0	2	1	3	0	5	2
2023	Pome fruit	36	3	7	4	24	0	19	7
2023	Stone fruit	19	1	4	0	7	0	4	1
2024	Vines (grapevine)	89	16	31	10	49	5	54	32
2024	Olive	18	10	16	3	18	0	23	16
2024	Nut crops	0	1	6	0	1	1	5	6
2024	Citrus	16	4	24	0	13	1	23	17
2024	Pome fruit	53	16	11	5	27	1	37	19
2024	Stone fruit	22	6	6	0	10	0	13	4
2025	Vines (grapevine)	113	40	69	12	82	5	74	49
2025	Olive	43	4	22	2	26	1	38	18
2025	Nut crops	1	3	5	0	2	1	6	7
2025	Citrus	15	4	26	2	21	1	27	24
2025	Pome fruit	113	14	26	7	76	4	59	27
2025	Stone fruit	38	6	16	3	20	0	26	8
Total	2023–2025	639	139	291	51	404	22	450	260

Monitoring only = risk estimation or observation without a pesticide or alternative measure. Circulars with pesticide / alternative advice = circulars with at least one such warning for the crop group.

Table A1c. Share of warnings and circulars with pesticide and with alternative advice (%).

Year	Crop group	Pesticide, % of all warnings	Alternative, % of all warnings	Pesticide, % of warnings with text	Alternative, % of warnings with text	Circulars with pesticide advice (%)	Circulars with alternative advice (%)	Alternative : pesticide ratio
2023	Vines (grapevine)	68.2	26.1	77.9	29.9	92.3	65.4	0.38
2023	Olive	50.0	23.5	56.7	26.7	70.6	35.3	0.47
2023	Nut crops	50.0	0.0	100.0	0.0	50.0	0.0	0.00
2023	Citrus	36.8	10.5	58.3	16.7	62.5	25.0	0.29
2023	Pome fruit	79.6	18.5	82.7	19.2	100.0	36.8	0.23
2023	Stone fruit	95.8	20.8	95.8	20.8	100.0	25.0	0.22
2024	Vines (grapevine)	60.6	23.7	69.4	27.2	91.5	54.2	0.39
2024	Olive	59.6	45.6	65.4	50.0	76.7	53.3	0.76
2024	Nut crops	20.0	23.3	37.5	43.8	33.3	40.0	1.17
2024	Citrus	69.0	48.3	85.1	59.6	88.5	65.4	0.70
2024	Pome fruit	59.3	25.0	68.1	28.7	82.2	42.2	0.42
2024	Stone fruit	58.3	25.0	66.7	28.6	68.4	21.1	0.43
2025	Vines (grapevine)	57.8	34.6	63.0	37.7	89.2	59.0	0.60
2025	Olive	73.0	29.2	81.2	32.5	88.4	41.9	0.40
2025	Nut crops	26.1	34.8	42.9	57.1	37.5	43.8	1.33
2025	Citrus	66.1	48.4	73.2	53.6	77.1	68.6	0.73
2025	Pome fruit	74.7	21.5	79.9	23.0	93.7	42.9	0.29
2025	Stone fruit	77.1	31.4	85.7	34.9	83.9	25.8	0.41
Total	2023–2025	63.5	29.4	71.8	33.2	83.2	48.1	0.46

Alternative : pesticide ratio = warnings with alternative advice ÷ warnings with pesticide advice.

Table A2. Warnings with advice in each pesticide group (n), by the major groups used in the pesticide sales statistics.

Year	Crop group	Fungicides and bactericides	Herbicides, haulm destructors and moss killers	Insecticides and acaricides	Molluscicides	Plant growth regulators	Other plant protection products	Warnings with pesticide advice
2023	Vines (grapevine)	44	1	14	0	0	1	60
2023	Olive	9	0	8	0	0	0	17
2023	Nut crops	1	0	0	0	0	0	1
2023	Citrus	3	0	2	0	0	2	7
2023	Pome fruit	17	0	26	0	0	0	43
2023	Stone fruit	13	1	9	0	0	0	23
2024	Vines (grapevine)	93	3	22	0	0	3	120
2024	Olive	25	1	9	0	0	0	34
2024	Nut crops	6	0	2	0	0	0	6
2024	Citrus	23	1	14	0	0	2	40
2024	Pome fruit	33	0	30	0	0	1	64
2024	Stone fruit	23	1	4	0	0	0	28
2025	Vines (grapevine)	136	3	43	0	0	5	182
2025	Olive	41	0	22	0	0	3	65
2025	Nut crops	4	0	2	0	0	0	6
2025	Citrus	24	0	16	0	0	1	41
2025	Pome fruit	59	0	80	0	0	0	139
2025	Stone fruit	45	1	8	0	0	0	54
Total	2023–2025	599	12	311	0	0	18	930

Named products are grouped by their main use (copper and sulphur = fungicides and bactericides). When no product is named, the group follows the target: diseases → fungicides and bactericides; pests and mites → insecticides and acaricides; weeds → herbicides; frost, hail, sunscald and general notes → other plant protection products. A warning can fall in more than one group, so the group columns can add up to more than the last column. No molluscicide or plant growth regulator advice was found for these crop groups.

Source: SNA warning circulars 2023–2025 (Database_COSTFB match.xlsx); tables from Treatments_pesticide_vs_alternatives_2023-2025.xlsx (sheets Summary_Year_Crop and Pesticide_groups_Year_Crop).

Annex III – Groups Extended responses to pesticides alternatives use and barriers to adoption

Results listed by participants for the main barriers to pesticides alternatives transition in agriculture.

Table A3. Results as reported. Crops, pests and diseases, alternative techniques and constraints of the six working groups (G = group).

G	Crop	Pest / disease	Alternative technique	Reported constraints
1	Oat	Septoria leaf blotch	Crop rotation	Yield reduction in the other crops
	Oat	Septoria leaf blotch	Intercropping to reduce oat density	Yield reduction; technical difficulties
	Oat	Weeds	False seedbed	Yield reduction; technical difficulties
	Vine	Downy mildew	Tolerant/resistant varieties	Market difficulties; lack of consumer acceptance
	Vine	Downy mildew	Citrus essential oils	Not presented – lack of time
	Vine	Downy mildew	Wider spacing between plants for canopy aeration	Lower yield per unit area
2	Maize	Soil insects	Resistant plants	No effective resistance to soil insects
	Maize	Soil insects	Use of natural enemies against soil insects	Lack of natural enemies able to regulate the soil insect population
	Maize	Soil insects	Crop rotation with legumes	Machinery, irrigation system and cultivation methods must be adapted; risk of change; yield reduction
3	Cucumber	Aphids	Parasitoids	Cost of implementation; lack of training (variety choice); need for closer technical follow-up to optimise the intervention; valorisation of the final product; transition and maintenance costs; lack of support under the Common Agricultural Policy; availability on the market; efficacy of the alternatives; cost-benefit and risk; difficulty of obtaining technical decision support
	Pome fruit	Codling moth	Mating disruption	
	Lettuce	<i>Fusarium</i>	Tolerant/resistant varieties	
	Lettuce	Downy mildew	Tolerant/resistant varieties	
4	Cereals	Weeds	Robotics	Needs complementary methods, such as herbicides
	Apple	Aphids	Release of natural enemies; conservation biological control; ground cover as ecological infrastructure	Slow response and fear of putting income at risk; lack of knowledge to plan the releases (timing and location)
5	Winter cereals	Aphids	Ecological infrastructures	Lack of knowledge
	Pear	Pear psylla	Release of natural enemies	Fear of economic loss; slow response
	Tomato (greenhouse)	Whitefly	Release of natural enemies + ecological infrastructures	Lack of technical knowledge and of decision support
6	Sweet pepper	Aphids (<i>Aphidius</i> spp. as natural enemy)	Biological control and conservation of natural enemies	Lack of technical knowledge and of decision support
	Tomato	<i>Tetranychus urticae</i>	Biopesticides and natural products (nettle extract)	Economic cost and risk for the farmer; closer follow-up with less predictable results than chemical treatment
	Vine	<i>Lobesia botrana</i>	Mating disruption with pheromones	Availability, regulation and suitability of the pheromones; very specific conditions required; rules vary between countries; slow authorisation procedures

Source: consolidated group tables of the national meeting (22 records).

Annex IV – Online voting results of barriers to adoption of pesticides alternatives from the working group (2023–2025)

Summarised results of online voting by the participants using Mentimeter for the main barriers to pesticides alternatives transition in agriculture.

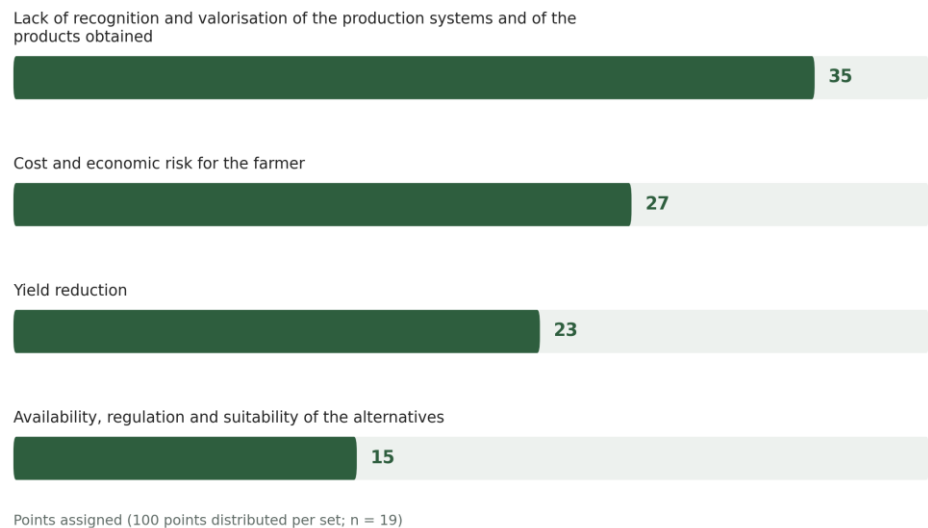


Figure A7. Barriers to the adoption of alternatives, first set (100 points distributed; n = 19).

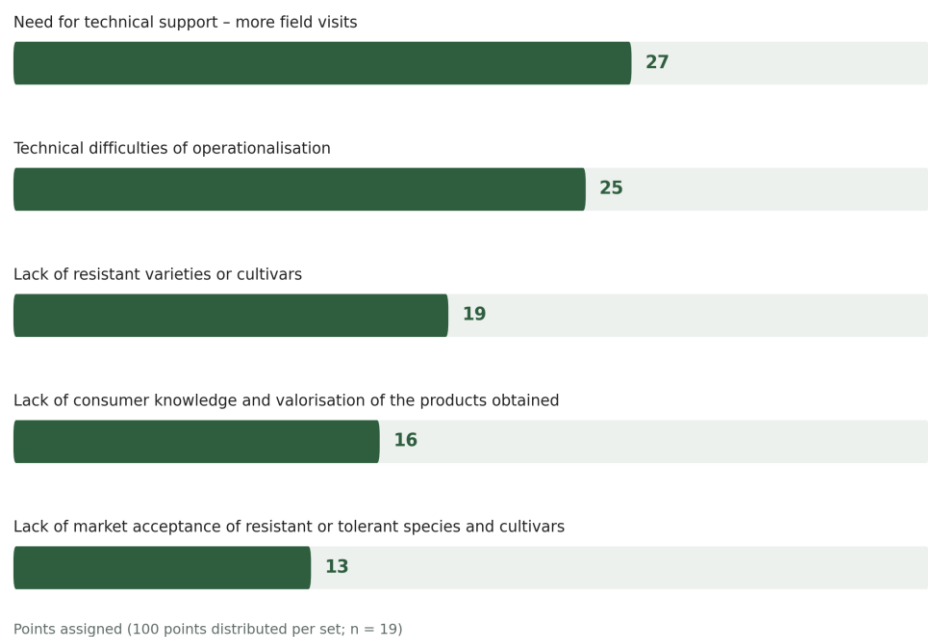


Figure A8. Barriers to the adoption of alternatives, second set (100 points distributed; n = 19).

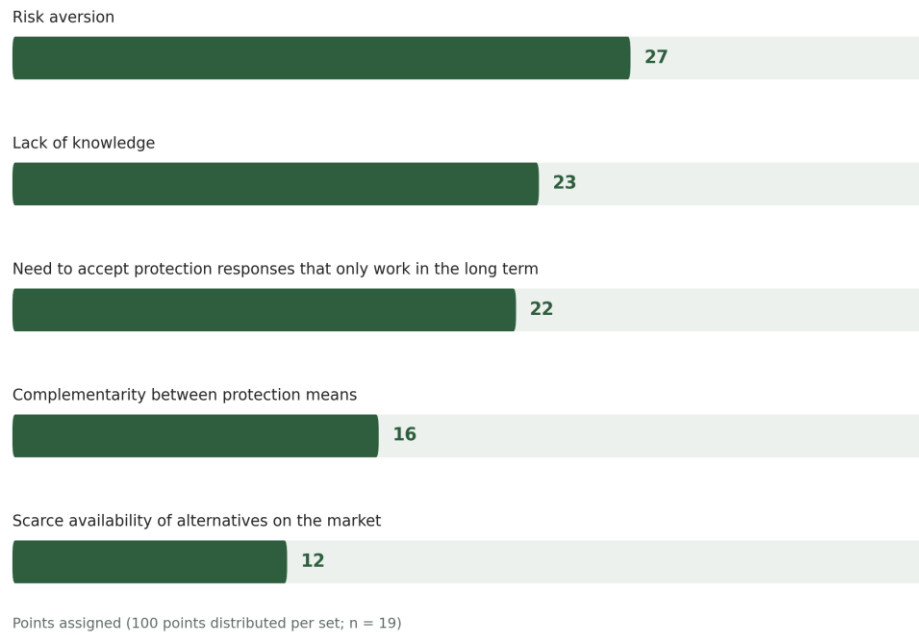


Figure A9. Barriers to the adoption of alternatives, third set (100 points distributed; n = 19).