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An Overview of Pest and Disease Occurrence in Organic Pome Fruit Orchards in Europe and on the Implementation of Practices for Their Control

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Abstract: There is limited data regarding the specific problems faced by organic fruit growers when dealing with plant protection, particularly at a European Union level, though some general knowledge about pest and disease incidence can be found. Such information is crucial to improve the efficacy of a targeted knowledge transfer to organic fruit growers and advisors aiming at an increased adoption of innovative practices. A survey was thus carried out in seventeen European countries (16 EU member states and Switzerland), within the framework of the EU-funded project BIOFRUITNET, aiming at filling this knowledge gap also in terms of research needs. A questionnaire including a section about general aspects of orchard management (functional biodiversity, fertilization management, varietal/rootstock selection) and a section specifically dedicated to pest and disease occurrence and management in organic orchards was utilized to interview about 250 professionals (farmers and advisors), 155 of which were involved in pome fruits (including apple and pear) production. The analysis of the answers related to plant protection pointed out a varied situation about pest and disease occurrence in apple and pear orchards across Europe, though related to the zonal location of the respondent. However, more than 50% of respondents generally considered just few among the most damaging ones, normally co-occurring in the orchards. Interestingly, regardless of the respondents' nationality or zonal location, more pests than diseases were indicated as relevant agents threatening organic pome fruits production. Nevertheless, only few measures promoting functional biodiversity in the orchards resulted in being broadly implemented in all regions. The analysis of the data underlines the strong demand for the development of a toolbox of measures that can be integrated successfully into the general orchard management strategy including the successful enhancement of functional or general biodiversity.

Keywords: functional biodiversity; organic orchard management; disease resistance; research need

1. Introduction

Organic plant production can be defined, in line with the definition established by the European Union (EU) Regulation 2018/848, as a system of farm management that combines best environmental and climate action practices, a high level of biodiversity and the preservation of natural resources. This production system shall meet the increased demand of consumers for organic products, which in Europe in 2019 recorded a growth rate of 8% for temperate fruits [1], and the EU policies promoting the expansion of organic production (Green Deal and Farm to Fork strategies) that support the targets set by the

Sustainable Development Scenario (SDS) goals [2]. The EU is the leading region for the production of organic fruits in the world, with the land dedicated to organic temperate fruit production covering about 121 thousand hectares, i.e., about 13% of total area used for organic production [1]. However, to achieve the targets set by the Green Deal, the number of organic producers in the EU needs to increase at a faster rate to increase the supply of organic products. This means that to support the transition for more organic fruit farmers it is necessary to foster knowledge sharing [3–5].

Plant protection measures were indicated among the agronomical practices of major concern by professionals (both advisors and farmers) working in organic fruit production [6]. According to the topics present in the last few ECOFRUIT conferences, a biannual international forum for professionals and researchers dedicated to organic fruit production https://www.ecofruit.net/proceedings/ (accessed on 1 December 2022), the major concern in this regard derived from the resistance of *Cydia pomonella* to the codling moth granulovirus (CpGV), the insurgence of *Marssonina coronaria* occurrence or the outbreak of *Halyomorpha halys*. However, as different pests and diseases could have a different level of impact on organic fruit grown across Europe, the knowledge about the possible measures or strategies to be adopted for their control could vary accordingly.

Even though a general knowledge about pest and disease incidence in crops can be found (e.g., [7–9]), there is limited data regarding the specific problems faced by organic fruit growers in this respect, particularly on a wider territorial level as it could be that of the European Union. This information, however, could be crucial in order to improve the efficacy of knowledge transfer to serve the organic fruit sector and increase adoption of innovative practices [10]. To this aim, a survey was carried out in the framework of an EU-funded project (BIOFRUITNET—https://biofruitnet.eu/ (accessed on 1 December 2022) and meant to support the identification of practical aspects related to the protection of organic fruit crops (pome, stone and citrus fruits), and the needs in terms of knowledge and research gaps. The paper presents the results of this survey in relation to the situation of organic pome fruits orchards, reporting also some data about the application in all three fruit crop groups of practices fostering functional biodiversity, highlighting the features and aspects that could be useful in developing activities to improve the technical level and state of knowledge of organic fruit farmers across Europe.

2. Materials and Methods

A survey to gain information about pest and disease management, the application of functional biodiversity practices, soil and fertilization management, and major varieties and rootstocks utilized in organic orchards, for pome, stone and citrus fruits, was carried out in seventeen countries from Europe (16 EU member states and Switzerland). The present work reports the analysis of pome fruits orchard data. The survey was conducted from November 2020 to March 2021. Qualitative and quantitative methods were employed for the study based on the Grounded Theory [11], applying a constructivist approach [12], which conceptualizes the actors' (farmers and agricultural advisors) knowledge as context specific [13]. In this respect, agricultural advisors were considered the professional directly involved in technical advice and support to farmers. Therefore, the criteria used to identify the farmers and advisors to be surveyed were (in order of importance): (1) coverage of the different climatic zones in Europe; (2) representing the different production areas in each country; (3) assuring the diversity of farms in terms of the level of inputs used for pest and disease management; (4) favour farmers and advisors who are likely to share their technical innovations, i.e., are part of a knowledge network. The order of importance of the criteria was established during the process of designing the survey considering the need to assure the assessment of the highest diversity of pests and diseases occurrence (criterium 1); to provide the broadest possible base of fruit production thus covering different landscapes and cropping systems (criterium 2); to obtain information that derive from the majority of the management systems applied in the organic orchards (criterium 3); to obtain reliable information that could be relevant not only for the respondent, but also for the other professionals with whom s/he is networking for knowledge exchange (criterium 4). The minimum number of questionnaires to be filled in each country was adjusted according to the land area of cultivation of each fruit species in the 17 countries resulting from the most recent statistical data [14].

Each respondent was requested to provide information following a questionnaire during semi-structured interviews carried out in local language or by filling out the questionnaire online. The questionnaire included a section about general aspects of orchard management (functional biodiversity, fertilization management, varietal/rootstock selection), and a section specifically dedicated to pest and disease occurrence and management per fruit crop (see "S1 Questionnaire" form in Supplementary Material). The majority of the questions proposed multiple choice answers, to favour a standardized approach by respondents, while few allowed open-ended answers.

The collected data were analysed statistically, calculating frequencies and also categorizing the answers whenever possible on the basis of the country or EU zonation defined for plant protection products registration [15], using the R software version 4.0.2 [16]. The results were visualized as barplots or heatmaps using: ggplot2 [17], gplots [18] and UpSetR [19] packages.

3. Results

A total of 155 questionnaires (63% from farmers and 47% from advisors) from 17 countries were collected for the pome fruits (including apple and pear) out of 247 respondents that provided information on all three groups of crops together (pome, stone and citrus fruits). The country distribution of this group of respondents matched with the production capacity of the major countries producing apples and pears (Figure 1). Interestingly, a common feature of the respondents from different countries was their specialization in one or the other crop, with a limited (only about 10%) share of the respondents providing information for both crops (marked in red on Figure 1).

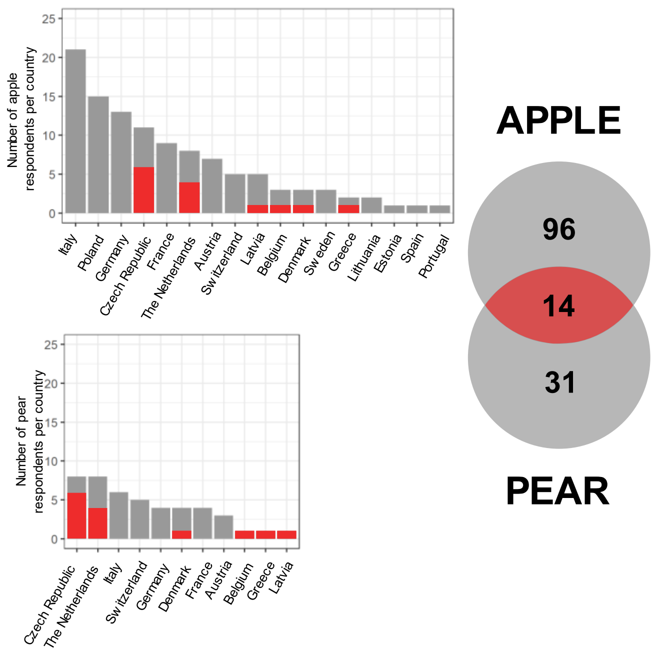

Figure 1. Country distribution of the survey respondents for apple (**upper** bar graph) and pear (**lower** bar graph), and the share of the respondents for both crops (Venn diagram). The common share for apple and pear is marked in red in all graphs.

3.1. Pests and Diseases Threatening European Organic Apple Orchards

All the surveyed farmers declared to have experience in producing organic fruits, but to a different extent (between 1 and 38 years of practice); about 20% of them also having practice in conventional production. The area of their orchards varied between 1 to 100 ha, and the farms generally specialised in fresh fruits and only two produced also for processing (cider, juices). The group of advisors also included people with a diverse level of work experience and, interestingly, about 50% of them were consulting only on organic farming.

Considering the answers related to the pests, the respondents had to choose the most relevant pests in their apple orchards from a list of eleven major apple pests. The selection was expected to include pests either occurring and managed with any practice or not managed but considered commercially threatening for the production. Most of the respondents (about 95%) selected between three to eight pests, while less than 5% of them indicated a higher incidence of pests and only one respondent (from Sweden) indicated a single pest (apple sawfly) as being relevant in his conditions.

Four pests were mentioned as relevant species by more than 50% of respondents (Figure 2A), with the codling moth (*Cydia pomonella*) resulting in the most widespread one (indicated by almost 90% of respondents). The rosy apple aphid (*Dysaphis plantaginea*) was the second most selected pest (76%) followed by the apple sawfly (*Hoplocampa testudinea*) and the woolly apple aphid (*Eriosoma lanigerum*) (about 60% of respondents for each of them). The detailed analysis of the co-selection within the group of four most relevant pests showed that the majority of respondents (66%) marked all four or at least three of them (Figure 2B). Considering the country as a factor, only respondents from Austria, Czech Republic and France mentioned the occurrence of all eleven species mentioned in the questionnaire, while both the codling moth and the rosy apple aphid were not considered as relevant pests only in Portugal and Estonia (Figure 3). The least problematic pest resulted to be the San Jose scale (*Quadraspidiotus perniciosus*), though it was marked as relevant by respondents representing nine different countries, while others (the apple sawfly and the apple blossom weevil) were not recognized as relevant in southern countries (Spain, Portugal or Greece).

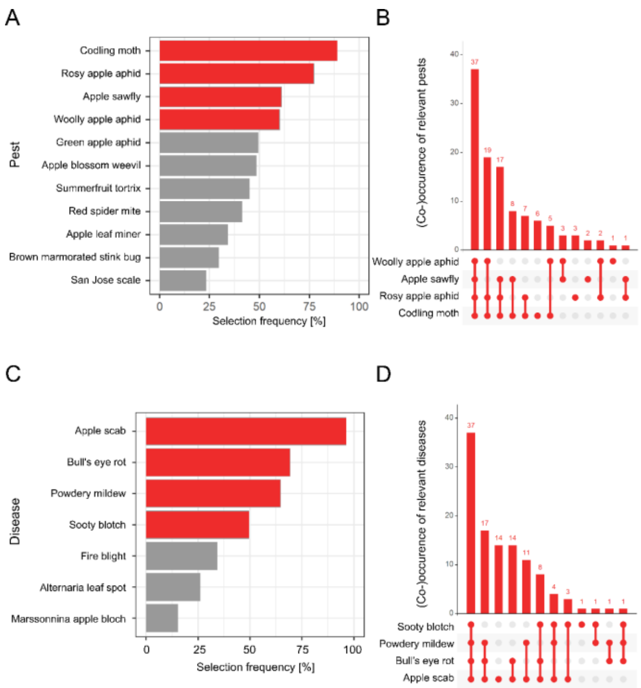

Figure 2. The ranking of pests occurring in organic apple orchards according to the respondents (**A**) and the frequency of co-occurrence of the four most selected ones (**B**), and diseases occurring in organic apple orchards according to the respondents (**C**) and the frequency of co-occurrence of the four most selected ones (**D**). The most relevant pests and diseases mentioned by more than half of the respondents are marked in red in graphs A and C.

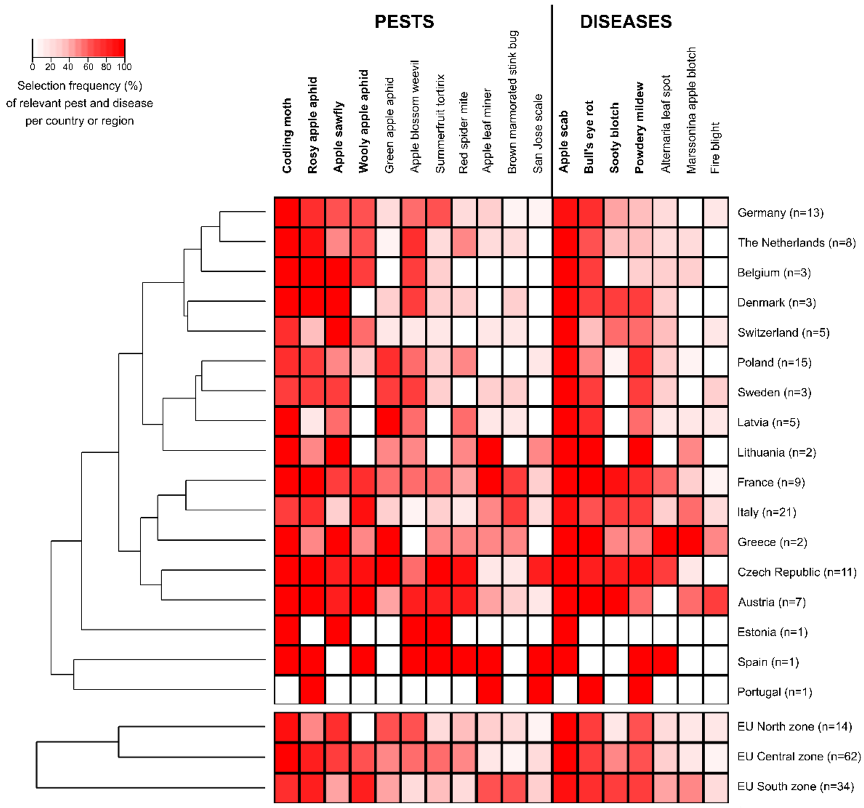

Figure 3. Heat map of the selected relevant apple pests and diseases represented in the questionnaire per country (**upper** map) and grouped according to EU zones (**lower** map). Numbers in brackets indicate the number of questionnaires per country or zone; the four most relevant pests and diseases are in bold. Pests and disease were ordered according to the overall selection frequency.

Thirty respondents (i.e., about 25%) mentioned also additional relevant pests, which were not included in the list of the questionnaire, among which the most cited were the oriental fruit moth (*Cydia molesta*) (7 respondents: 6 from F, and 1 from D) and the small fruit tortrix (*Cydia lobarzewskii*) (3: 2 from F, and 1 from CH), voles (10 respondents: 4 from I, 2 each from A and F, and 1 from D), the pear lace bug (*Stephanitis pyri*) (2, from F), the dock sawfly (*Ametastegia glabrata*) (2, from NL) and the apple fruit moth (*Argyresthia conjugella*) (2, from SE).

Considering the disease's occurrence, the respondents had to choose the most relevant in their apple orchards from a list of seven major apple diseases. The majority of orchards resulted in being damaged by several diseases, though there was no case where all seven diseases were considered as relevant by the respondent (data not presented). Four diseases were mentioned as relevant by at least 50% of respondents (Figure 2C), with apple scab (Venturia inaequalis) as the most important disease (96% of the respondents) in 16 out of the 17 countries (not relevant in Portugal). The following most relevant diseases affecting apple production were bull's eye rot (Neofabraea spp.) and powdery mildew (Podosphaera leucotricha) (mentioned by 77% and 72% respondents, respectively), together with sooty blotch (about 50% of respondents). The analysis of the co-occurrence within the group of the four most relevant diseases showed that the majority of respondents (60%) marked all four or at least three of them (Figure 2D). The least problematic disease resulted in being the Marssonina apple blotch (Diplocarpon coronariae), though indicated as relevant by about 20% of respondents (Figure 2C), representing eight different countries (Figure 3). Nine respondents mentioned additional diseases not listed in the questionnaire: apple canker (Neonectria ditissima) (7 respondents: 3 from NL, 2 each from D and F and 1 from B), black rot (Botryosphaeria obtusa) (1 each from NL and B) and anthracnose (Neofabraea malicorticis) (2 from F).

Zonal Relevance of Apple Pests and Diseases

The respondents, regardless of their nationality or zonal location, chose more pests than diseases as relevant agents threatening apple production in organic orchards (Figure 4A). The respondents from countries of the central and south EU zones resulted in having on average the highest occurrence of pests. However, irrespective of the zone, the respondents' answers resulted in more scattered, i.e., with different numbers of common pests and diseases present in their orchards. Analysing the distribution of answers at a country level, respondents from the Czech Republic resulted in always being among those declaring a high, more than the average, number of pests and diseases. Respondents from other countries in all three zones were spread without any specific pattern (Figure 4A).

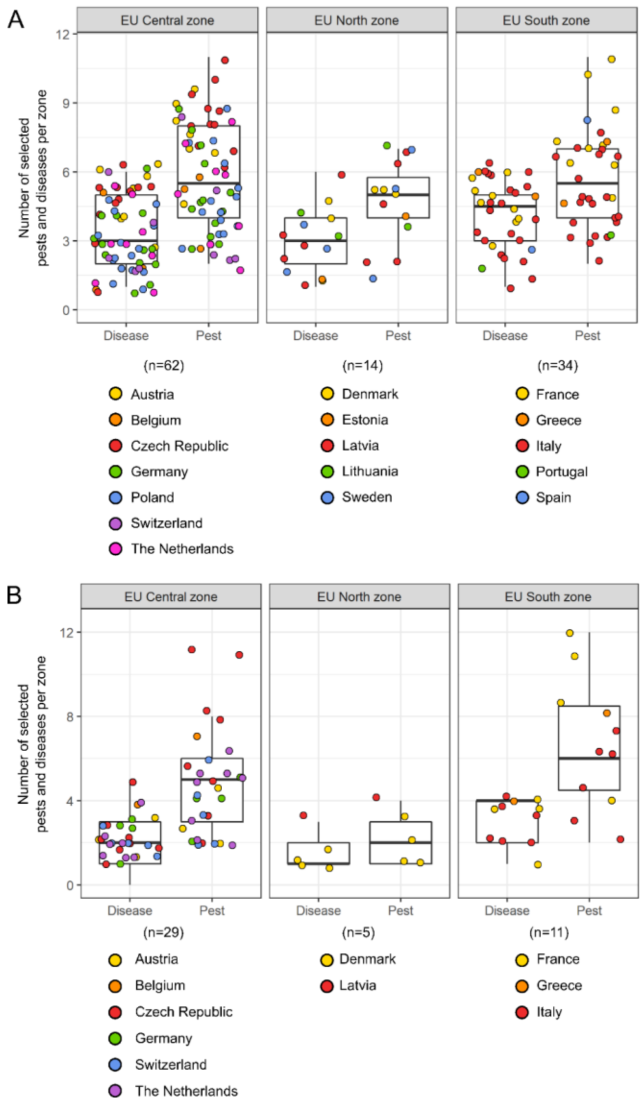

Figure 4. Distribution of the number of pome fruit pests and diseases selected by respondents in each country grouped according to the EU zones. Apple diseases and pests (**A**), and pear diseases and pests (**B**). Numbers in brackets indicate the total number of questionnaires per zone. Answers from different countries are marked with colours, according to the legend.

3.2. Pests and Diseases Threatening European Organic Pear Orchards

Forty-five professionals (64% farmers and 36% technical advisors experienced in organic pear production) filled the questionnaire on pears. The farmers declared that their orchards' area varied between 0.15 and 30 ha. About 40% of the advisors were consulting only organic farmers.

Even though the respondents could choose the most relevant or threatening pest from a list of 13 major pear pests, the majority (65%) selected only up to five pests and less than 10% of them indicated more than ten pests as relevant (data not presented). The four pests mentioned as relevant by more than 50% of respondents were the codling moth (*Cydia pomonella*) (75% of respondents), the pear psylla (*Cacopsylla pyri*) (64%), the pear leaf blister mite (*Eriophyes pyri*) and the pear gall midge (*Contarinia pyrivora*) (about 51% each) (Figure 5A). Half of the respondents co-selected at least three of these pests (Figure 5B). The codling moth and the pear psylla resulted in being relevant across the whole of Europe (except Denmark and Austria, respectively), while the San Jose scale and oriental fruit moth were of concern in only three countries (Figure 6). Seventeen respondents mentioned additional pests not listed in the questionnaire, among them the forest bug (*Pentatoma rufipes*) and other stink bugs (8 respondents: 6 from NL, and one each for DK and D), the sinuate pear tree borer (*Agrilus sinuatus*) (3, from F), pear lace bug (*Stephanitis pyri*) (2, from IT) and *Aphanostigma piri* (2, from F).

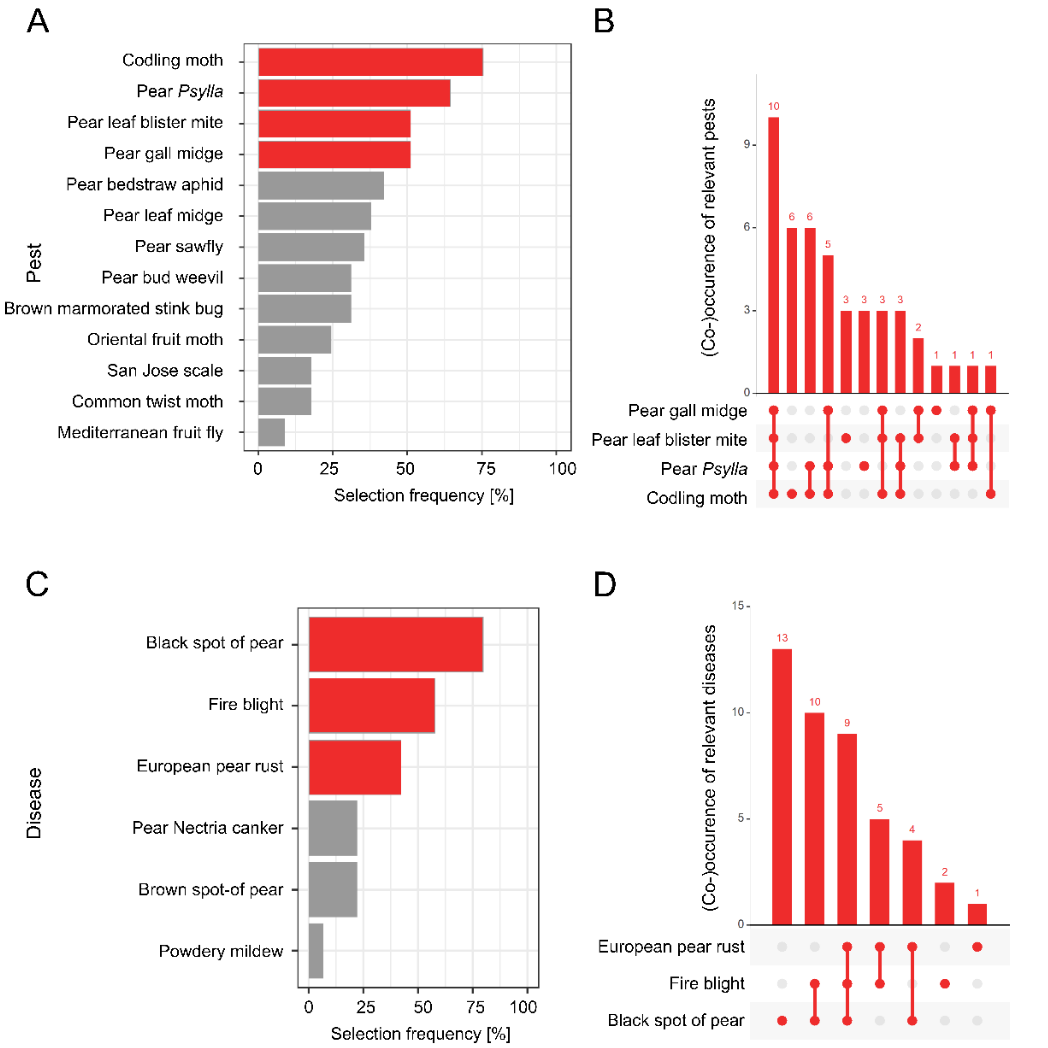

Figure 5. The ranking of pests occurring in organic pear orchards according to the respondents (**A**) and the frequency of co-occurrence of the four most selected ones (**B**), and diseases occurring in organic pear orchards according to the respondents (**C**) and the frequency of co-occurrence of the four most selected ones (**D**). The most relevant pests and diseases mentioned by more than half of the respondents are marked in red in graphs A and C.

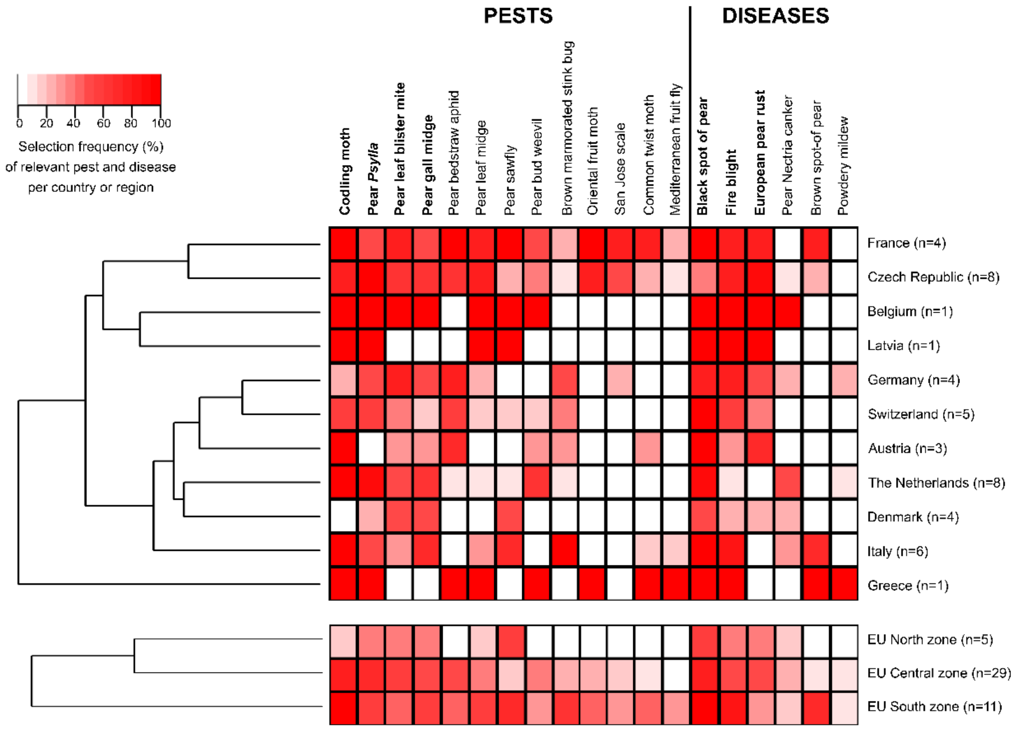

Figure 6. Heat map of the selected relevant pear pests and diseases represented in the questionnaire per country (**upper** map) and grouped according to EU zones (**lower** map). Numbers in brackets indicate the number of questionnaires per country or zone; the four most relevant pests and diseases are in bold. Pests and disease were ordered according to the overall selection frequency.

From the list of six diseases included in the questionnaire, about 55% of respondents selected two or three diseases as relevant, with the black spot of pear (*Venturia pirina*) being the most frequent (80% of respondents), followed by fire blight and European pear rust (*Gymnosporangium sabinae*) (57% and 42% of respondents, respectively) (Figure 5C). However, only nine respondents co-selected all three diseases together (Figure 5D). Considering the country distribution (Figure 6), black spot of pear and fire blight resulted to be relevant in all countries, while powdery mildew (*Podosphaera leucotricha*) (was reported only by professionals from three countries (Germany, The Netherlands, and Greece). Eight respondents mentioned additional diseases not listed in the questionnaire, including pear decline phytoplasmosis (5 respondents: 4 from IT, and 1 from A), pear fruit spot (*Septoria pyricola*) (2, from France), and storage diseases (1 from NL).

Zonal Relevance of Pear Pests and Diseases

Overall, more pests than diseases resulted in being of high concern in the organic pear orchards of the surveyed respondents (Figure 4B). The respondents of both South and Central zones considered the number of pests and diseases present in their orchard with a similar pattern, even though a higher variability was present in the answers from the South zone. Interestingly, respondents from The Netherlands always considered the number of pests and diseases lower or equal to the average, while those from Belgium almost always declared the number of pests/diseases above the average. For the other countries of all three zones, the answers were in general spread without any specific pattern.

3.3. Practices to Support Plant Protection Strategies in Organic Orchards

The questionnaire was also meant to highlight to which extent practices that can support the control of pests are really adopted by organic farmers. Here, we report the results from the total number of respondents (n = 247), as there was no specific difference between pome fruits and the other fruit crops (stone and citrus fruits) considered. Among the six practices that can affect orchard functional biodiversity proposed by the questionnaire, the establishment of hedgerows was the most adopted (more than 70% of respondents), while all others were more or less implemented at the same level (around 50–60% of respondents) (Figure 7A). Interestingly, even though with a limited number of responses, the bottleneck factors to the adoption of practices that promote functional diversity in organic orchards were quite differentiated: sometimes the technical difficulty of applying the practice, in other cases the time consumption (e.g., for cover crops and flower strips), the cost (e.g., hedgerow and bird or bat boxes), or their perceived ineffectiveness (e.g., for vertebrate shelters or insect boxes) (Figure 7B).

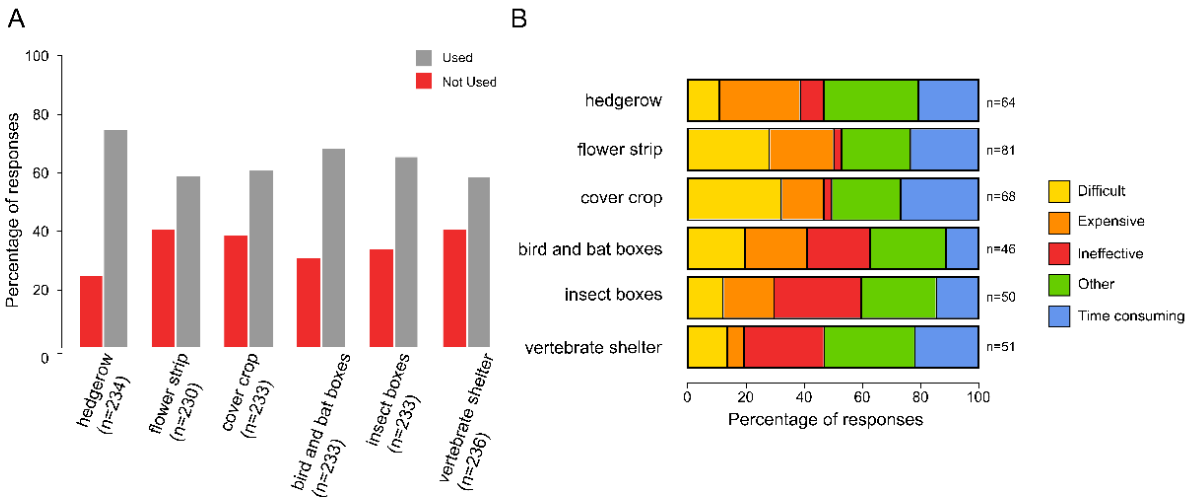

Figure 7. Frequency of adoption of practices aiming at increasing the functional biodiversity of organic fruit orchards in 26 European countries (**A**), the distribution of negative factors affecting the adoption of functional diversity practices in organic orchards (**B**).

4. Discussion

The criterium applied in selecting farmers or advisors was meant to favour the collection of first-hand information, useful also when analysing the questionnaires' data with regard to the country or climatic zone. Even though in some cases, particularly in small countries, the limited number of respondents could not fully reflect the situation of the country, the overall picture emerging from the survey can describe the status of organic pome fruit orchards in Europe with respect to crop protection measures and the issues to be considered for additional support and further research.

4.1. Pest Occurrence in Organic Apple Orchards

When analysing the pest incidence in organic orchards, it was not unexpected that the codling moth (*Cydia pomonella*) was among the most relevant pests in almost all surveyed countries for both organic apple and pear orchards, since it is regarded as the most damaging insect pest in most pome fruit growing regions [20]. However, even though the spraying of the codling moth granulovirus (CpGV) is a highly effective control method, a major concern for organic farmers could derive from the increased observation of resistance toward this active substance [21]. Furthermore, two aphid species (the rosy apple aphid and the woolly apple aphid) were commonly regarded as an important pest issue for organic apple orchards, while a third aphid species (the green apple aphid) was of less concern. All three were also less worrying in Baltic countries, even though in these northern countries the risk of pests spread deriving from climate change was appraised as a possible threat in another survey carried out in the frame of the BIOFRUITNET project (Malusà et al. unpublished). The rosy apple aphid (*Dysaphis plantaginea*) was confirmed to be the most detrimental aphid in organic apple orchards, even though several agronomical measures can be applied to reduce its incidence, including functional biodiversity practices fostering parasites and predators, which, however, do not sufficiently prevent damage to the apple trees [22]. Interestingly, the woolly apple aphid (*Eriosoma lanigerum*) was mostly critical in central European countries. This threat could derive from landscape characteristics or climatic conditions not favouring that generalist predators such as earwigs [23] or their possible synergies with the specific parasitoid *Aphelinus mali* occur early enough to control the outbreaks [24].

The apple sawfly appeared to be also quite widespread across Europe and was perceived as a particularly dangerous pest for organic apples. This can be explained by its high damage potential regarding fruit losses, the challenges of its control and the concerns for the future availability of the only effective products for its control (*Quassia amara*), which is a plant extract that is still undergoing the registration process. Alternative control measures, e.g., based on parasitic organisms such as entomopathogenic nematodes and fungi or based on sticky white belts are of high cost, difficult to apply and of rather limited and uncertain efficacy [25].

The concern for other pests varied across the countries, though with some interesting patterns. For example, leaf miners were considered more damaging in Mediterranean countries, while the apple blossom weevil (*Anthonomus pomorum*) and the summer fruit tortrix (*Adoxophyes orana* F. v. R.) were both quite diffuse across the EU zones. On the other hand, unlike in conventional production, mites were considered in general not of concern, likely as an effect of the higher activity of natural predators [26] or the impact of some sulphur fungicides on mites populations [27]. The case of the brown marmorated stink bug (*Halyomorpha halys*) exemplified the pattern of the recent insect invasion in Europe, with high concern expressed by professionals from Italy and France, where the insect has already provoked widespread damage [28,29] and minor or no concern in northern countries, which have not experienced its occurrence or damage yet [30,31]. It could be expected that the experiences of the physical control of this pest [32] or the successful introduction of the parasitoid *Trissolcus japonicus* [33,34] together with the activity of generalist parasitoids such as *Anastatus bifasciatus* [35] could in the future reduce its level of concern among organic professionals.

Interestingly, the relevance of pest control appeared to be higher than that of diseases for the respondents across Europe. This is in accordance with reports about the spread of pests and diseases and occurrence of new pests arriving from countries outside Europe as a result of climate change and trade globalization [36–38], which can affect organic orchards to a higher extent compared to conventional orchards due to the lower number of possible measures and products allowed for their control.

4.2. Disease Occurrence in Organic Apple Orchards

When considering the apple diseases, as expected, apple scab (*Venturia inaequalis*) and powdery mildew (*Podosphaera leucotricha*) were the two diseases concerning organic professionals the most, both individually and as co-occurrence. Beside their negative impact on apple production, the perception of their risk could also derive from the limited resources available to organic farmers for their control [39,40]. Moreover, for apple scab, the pressure of the major markets for varieties that are not expressing resistance or showing robustness against these pathogens (e.g., Golden Delicious or Pink Lady) as well as the diffuse breakdown of the major source of genetic resistance to apple scab (*Vf* gen—Rvi6) in orchards across Europe [41], is increasing the risk of damages. In addition, the concern could derive from the occurrence of another species of scab, *Venturia asperata*, which has been recently identified in apple orchards [42,43].

Bull's eye rot, a post-harvest disease caused by *Neofabraea* spp. and sooty blotch (caused by several fungal species, including *Gloeodes pomigena*) were two diseases that were identified as a major concern by the majority of the respondents, which corresponds to the claims raised in one of the major EU apple-producing regions, Alto Adige/South Tyrol, in Italy [44]. The availability of new kinds of biological products, e.g., essential oils, plant extracts [45], or microbial antagonists such as yeasts already available in other apple growing regions (e.g., Southern Hemisphere) [46] could represent new possibilities to reduce the damage and concern for these diseases.

The limited concern of other diseases, can be associated with a limited damage to the apple trees due to indirect control along with measures against other diseases or pests as in case of Alternaria leaf spot due to the control paralleled by that of scab and mites [47], or the improved methods for early detection [48] and control [49] in the case of the Marssonina apple blotch, or the effective implementation of control and surveillance activities during the certification process of planting materials as required by the EU legal provisions in relation to quarantine species such as *E. amylovora.*

4.3. Pest Occurrence in Organic Pear Orchards

The codling moth (*Cydia pomonella*) was perceived as the most relevant pest also in organic pear orchards. Nevertheless, the analysis of the results of the questionnaire showed that there were also many concerns about the damage caused by psyllids. Multiple psyllid species feeding on pears have been recorded worldwide [50]. They could cause multi-level destruction, firstly by directly damaging the plants, and indirectly by production of honeydew, which provides substrate for black sooty mould development [51]. Finally, some species such as *Cacopsylla pyri*, *C. pyricola* and *C. pyrisuga* are well-known vectors of pear decline phytoplasma, which is one of the most devastating pear diseases [52–54]. Most common pear cultivars are susceptible to *C. pyri* [55,56], and the approved control methods (e.g., foliar sprays with kaolin or potassium bicarbonate) are short-lived, time- and labour-intensive and, above all, weather-dependent [57]. However, as shown in Denmark, the use of an eco-friendly no-spray strategy that leads to the conservation of natural enemies in orchards and their surroundings, or the release of beneficial insects, such as *Anthocoris nemoralis* or *A. nemorum* into the environment, could visibly reduce psyllid problems in the long term perspective [58].

The pear leaf blister mite (*Eriophyes pyri*) and pear gall midge (*Contarinia pyrivora*) were considered as important pests by approximately 50% of the respondents representing all three EU zones. These species have also been recognized in the scientific literature as significant economic pests [59,60]. Pear leaf blister mites are tiny insects with a strongly "hidden" life-cycle, which efficiently protects them from the impact of any plant protection products [59]. Moreover, their size makes a timely detection difficult. Nevertheless, a new method for an effective biological control has recently been demonstrated using the entomopathogenic fungus *Metarhizium brunneum* [60].

The pear sawfly (*Caliroa cerasi*), that was mentioned by approximately one third of the respondents, could also be controlled by an entomopathogenic organism, the nematode *Steinernema feltia.* However, the difficulties normally encountered in applying living organisms for pest control (e.g., needs for specific technical know-how and application methods, optimal growth conditions for an effective control, etc.) in this case are matched with high costs of the products containing the nematodes, making it unlikely to be used. It is noteworthy that even though the natural range of the pear sawfly is Asiatic regions and warmer European countries [61], an increase in average summer temperatures along with climatic changes has widened the area of occurrence to northern countries [62]. Such an effect was reflected in the survey results, where respondents from all three EU zones showed concerns about this species. The pear leaf midge (*Dasineura pyri*), which causes severe damage especially to young newly planted trees and nurseries [63], appeared to be also quite widespread across the EU and was particularly perceived as a dangerous pest for organic pears.

Other pests were only a problem in central and southern European countries, and not in northern countries. Among these pests, the pear bedstraw aphid (*Dysaphis pyri*) was recognized as relevant by more than 40% of respondents. There is no effective control of this pest, although selection of resistant varieties using molecular techniques based on presence of microsatellite markers associated with resistance to this species may result in faster screening of targeted varietal development [64]. A similar number of respondents perceived the pear bud weevil (*Anthonomus pyri*) as a relevant pest, indicating that it could be considered a minor pest of organic pear, which is in line with scientific reports [62,65]. Pheromone communication seemed to be conserved within *Anthonomus* genus, although specific compounds for *A. pyri* have not yet been identified, which may be a major advantage when developing an eco-friendly control strategy [62]. The brown marmorated stink bug (*Halyomorpha halys*) was of concern in organic pear orchards and particularly in southern countries, and it was recognized as a relevant pest only by less than third of the respondents. The greatest concern has been noted in Italy, where it caused massive damage and yield losses in pear, peach and nectarine orchards [66]. The other pest of concern, but to a limited extent and local level, included the common twist moth (*Pandemis cerasana*), the Mediterranean fruit fly (*Ceratitis capitata*), oriental fruit fly (*Bactrocera dorsalis*) and the San Jose scale (*Quadraspidiotus perniciosus*). Their harmfulness may be a result of the range expansion of their natural habitats and presence of certain plant host species in European countries [67], which is evolving following climate change-induced patterns [68,69].

4.4. Disease Occurrence in Organic Pear Orchards

As expected, black spot of pear (*Venturia pyrina*) was the most important disease in all three EU zones as it is causing significant yield losses in many pear-growing areas, especially in the organic farming system [70–73]. However, the disease incidence over the years could show an irregular pattern of occurrence [74]. Many efforts to develop disease-resistant pear cultivars are in progress [70,71,75], although they are less advanced than similar studies on apple scab. Over 50% of the respondents from all over EU, especially central and southern zones, recognized fire blight (*Erwinia amylovora*) as a dangerous disease. The trend towards reducing the use of copper has prompted a search for biological control strategies against this bacterium and antagonistic bacteria could be an interesting alternative [76]. European pear rust (*Gymnosporangium sabinae*) gathered many concerns in central EU, but was also recognized as important in the northern and southern regions, which is in line with scientific reports about *G. sabinae* occurrence for many years in several countries such as Austria or Latvia [77,78]. Pear nectria canker (*Neonectria ditissima*) and brown spot of pear (*Stemphylium vesicarium*) were recognized as relevant diseases by a similar number of respondents (approx. 25%), although their distribution across Europe was quite different. The brown spot of pear has caused more damage in the southern parts of the continent, where it was identified long time ago [79], while pear nectria canker was more detrimental in Central European countries such as Belgium, Denmark, Germany, Czech Republic and the Netherlands, as well as in Italy, a country of the south zone, where it caused severe outbreaks [80]. Powdery mildew (*Podosphaera leucotricha*) constitutes a minor problem for organic pear orchards, more likely to occur when pear orchards are surrounded by apple orchards. Therefore, controlling powdery mildew in apple orchards is an important step to reduce the potential damage to pears, where various copper and sulphur were sufficiently effective in controlling the disease [81,82]. In addition, the seasonal disease development can be significantly reduced by removing the infected shoots not only during the dormant bud stage but also during the season when the primary infestation is manifested [83].

4.5. Constraints in Implementing Supporting Methods of Pest Control in Organic Orchards

The adoption of practices aiming at increasing the functional biodiversity was associated with their difficulties in their implementation (e.g., for flower strips and cover crops) or the cost (e.g., hedgerows) or perceived ineffectiveness (insect boxes and vertebrate shelters). However, the cost resulted in not being the most critical issue considered, as hedgerows, considered by about 30% of respondents as a critical factor, did not prevent the highest percentage share of implementation (probably as they can also be planted for wind breaking purposes). Consistently, the practices requiring specific knowledge and skills for their management (e.g., flower strips or cover crops) were those implemented the least. Our results are consistent with those from a different set of interviews of organic European apple producers showing that disadvantages related to the promotion of functional biodiversity are mainly caused by the difficulties to apply or combine these practices with those commonly applied and by the perceived reduction of production [84]. It has been demonstrated that ecosystem services in orchards are correlated with the presence of diverse natural enemies, both predators and parasitoids, as well as pollinators (both honey bees and wild species) that can be promoted introducing plants that provide both food or shelter and overwintering sites at different landscape levels [85–89]. Furthermore, it has been demonstrated that flower strips can also be established as living mulches in the orchard, and, using multifunctional species, several ecosystem services as well as additional income could be provided [90,91], making them more attractive for adoption by farmers. Moreover, some negative effects on yield, due to competition by the cover crop or living mulch, observed in organic apple orchards, were found to be partly offset by indirect positive effects deriving from both higher abundance of natural enemies, which lead to less fruit damage, and higher flower visitation rates, leading to better fruit setting [92]. This aspect should be promoted and disseminated to organic professionals, as it has been proved that the use of functional biodiversity supported beneficials quantitatively and qualitatively to a much higher extent in organic than conventional orchards [93]. It is believed that only a holistic and complex approach also in the management of biodiversity could provide better benefits. Indeed, deploying a set of habitat diversification tools together with other sustainable measures resulted in increased population levels of natural enemies and lower levels of pest insects in organic apple orchards [94]. Nevertheless, the benefits of functional biodiversity shall not be expected on a short-term period: in Canada, for example, a significant damage reduction (from 95.2 to 9.2% damage) was achieved after five years from the introduction of flower strips in orchards [95].

4.6. Research Needs to Support the Control of Pests and Diseases in Organic Pome Fruit Orchards

It clearly appears that key trends for research in control of pests and diseases in organic pome fruits production to address the concerns of professionals should include:

- Breeding of varieties resistant to or highly tolerant of pathogens applying the concept of high genetic diversity, thus based on a broad germplasm;
- Improvement of the knowledge about the mechanisms that could lead to the effective exploitation of biodiversity in the orchard and to define practical guidelines for general protection and for the reduction of the occurrence of specific pests;
- Development of new products and continuous availability of the traditional products suitable for the use in organic orchards, including a support for the registration of the substance, which will increase the impact of research on agricultural practice.

Related to the first point, it should be mentioned that since the 1990s many new varieties were advertised to be tolerant of or to carry resistance to one or more diseases. However, it has become evident that expectations were not fully met in the long term. For example, in case of the apple scab the single gene resistance (*Rvi6, Vf*) has been broken down frequently in European orchards and from the 18 resistance genes currently known, 11 are already no more providing genetic protection from the disease [96,97]. To overcome such bottleneck, pyramiding several scab resistance genes or breeding for low susceptibility to several diseases based on gene-based quantitative tolerance are two approaches that have benefited from the evaluation of traditional varieties and thus could be used for breeding of new varieties suitable for organic farming [74,98] It is noteworthy that specific rules for organic breeding have been developed [99] and the first steps for new breeding programs to produce varieties dedicated to organic apple production started in countries such as Germany and Switzerland [100,101], and were later also fostered by EU programs (e.g., Liveseed—[102]). It is noteworthy that the varieties derived from these programs are generally not protected [96,103] or have been also developed applying the commons-based approach [104] and in few cases are tested in collaboration with organic farmers under organic conditions [105]. A wider implementation of such a participatory approach of breeding and variety testing in organic orchards is highly advised. This should be paralleled with new concepts developed to introduce the new varieties into the market involving the whole production chain.

Biodiversity plays a central role in pest control according to organic farming principles [106]. However, it is fundamental to understand which measures can be included in an overall strategy that can build or support the conservation of functional biodiversity in the orchard up to a level that could effectively improve pest control. Addressing this issue also in relation to or in conjunction with other orchard management practices (e.g., soil management, fertilization, irrigation, etc.) [90,107] would foster the still limited adoption of functional biodiversity practices. A holistic approach in this respect has been recently proposed [94,108]. However, studies to fill the knowledge gap about the complex interactions among many natural or artificially introduced predators or parasites and the pests, as well as assessing the effects of climatic changes on the orchard "web of life", are also needed to better exploit functional biodiversity in practice.

The improvement of products and strategies including direct control measures (i.e., application of plant protection products based on natural substances) is still required, even though a high efficiency of the products is not imperative being more important to enhance the efficiency of the whole control strategy. The strategy applied by organic farmers especially in Central Europe for disease control of apple orchards within the scenario of copper minimization could be an example of such an approach [39]. The strategy includes the choice of less susceptible varieties and the increase of the varieties' genetic diversity as much as practicable, the improvement of the measures to reduce the pathogen infestation potential, the use of forecasting models for precise timing of product applications and the development of new products and/or the improvement of application methods for known products [109,110].

The plant protection products allowed in organic farming are predominantly based on substances of mineral origin (i.e., copper, sulphur, lime sulphur, various carbonates, etc.), botanical substances (i.e., azadirachtin, pyrethrum, plant oils, etc.), pheromons and microorganisms. The increased availability of "active substances" based on microorganisms (e.g., viruses, bacteria and fungi) is opening up new opportunities to exploit them synergically with functional biodiversity or other measures [111,112]. Nevertheless, to expect a broad use of new microbial-based products in organic orchards, as well as in other crops, several practical aspects are still in need to be addressed by research work, particularly concerning the mode of application, the relation between microbial inocula and rootstocks or the methods to track and assess the persistence of the inoculum in the soil [113]. Research on microbial-based products or the authorization of new substances (e.g., organic compounds) should be fostered also in the frame of the copper minimization programmes [114,115]. Nevertheless, regulatory issues are considerably limiting the use of many substances traditionally applied in organic farming and the development of new substances based on natural substances or of new products that express multi-functional properties (i.e., showing direct or indirect pathogen/pest control together with biostimulant and/or fertilization features) [116,117]. The existing process of authorization of an active substance for plant protection use is still not really adapted to natural substances which is a considerable obstacle for the improvement of plant protection strategies in organic fruit growing. The engagement of researchers also to support the development of legal provisions could thus be important to research impacting on the whole production chain and the stakeholders.

5. Conclusions

The outcome of the survey pointed out a varied situation about the risks derived from pest and disease occurrence in both apple and pear orchards across Europe. In organic pome fruit orchards, between three to eight pests or diseases were generally indicated to require control measures, whereby four pests or diseases were selected by more than 50% of respondents as those highly affecting orchards, normally co-occurring in the orchards. However, the level of damage risk for each of them resulted to be affected by the zonal location of the respondent. The respondents, regardless of their nationality or zonal location, chose more pests than diseases as relevant agents threatening organic apple production. Only few measures promoting functional biodiversity in the orchards were broadly implemented. The analysis of these data underlines the strong demand for the development of a toolbox of measures, as it is currently under development in Germany through a national participatory project, that can be integrated successfully in the general orchard management strategy including the successful enhancement of functional or general biodiversity. The development of new plant protection products and the availability of traditional products based on natural substances or microorganisms could be compromised by registration issues, requiring an urgent adaptation of the process for these substances. Promoting the transfer of the available knowledge about innovative methods of plant protection in this respect could help in fostering its implementation in practice and be crucial for the extension of the pome fruit area under organic cultivation in Europe.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/agriculture12122136/s1, File S1: "Questionnaire".

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