RUSTWATCH

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RESPONSIBLE AUTHOR	Nerea Arias, INTIA

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LEAD CONTRACTOR	Aarhus University
AUTHOR(S)	Alberto Lafarga (INTIA) Cristina Virto (INTIA) Nerea Arias (INTIA)
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EXECUTIVE SUMMARY

The recent rust epidemics threat in Europe stresses the need to establish EU coordinated disease surveillance and pathogen monitoring as a part of a European wheat rust early warning system. Today, disease surveillance is carried out on regional or national scales, and observations are generally not available beyond the region or country, where they were collected. The RustWatch project, in its task 3.5 "Integration of disease surveillance in national extension service networks", proposes the development and monitoring of regional or national strategies for the best management of rust in wheat production, with surveillance and monitoring being one of the strategies shared in all case studies launched. It is in this context that the harmonization of working methods in this area becomes significant. Therefore, the objective of this deliverable is to gather information on how the surveillance systems is carried out in the different regions and European countries and recommend coordinated wheat rust surveillance activities in Europe based on input from stakeholders in five case study regions.

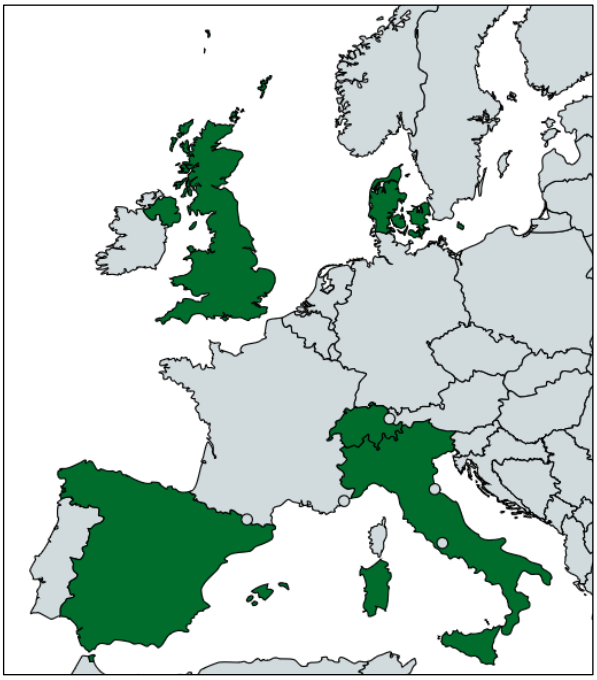
1. INTRODUCCTION

The re-emergence of wheat stem rust at epidemic levels in Europe in 2016, the experiences from the replacement of the pre-existing yellow rust population in Europe since 2011 and severe epidemics of yellow rust in several regions in Europe in 2019, stresses the need for a coordinated wheat rust surveillance and an early warning system in Europe (GRRC news, 7 February 2019; RustWatch news, 28 May, 2019; GRRC news 3 July, 2015). Today, disease surveillance in Europe (including rusts) is carried out on regional or national scales, and observations are generally not available beyond the region or country, where they were collected.

Among European countries, wheat rust surveillance is carried out in different ways. For example, in Spain, each of the Autonomous Communities (CCAA) has the power to carry out health surveillance tasks and every one of them has developed their own system to carry out this function. In other European countries something similar occurs. For example in Switzerland disease surveillance is performed at a cantonal level. However, there are also countries like Denmark that have centralized services for the entire country.

The objective of this deliverable is to gather information on how disease surveillance is carried out and organised in different European countries. To enable the development of a common European wheat rust disease surveillance and monitoring system, recommendation will be given on coordination and harmonization of wheat rust surveillance activities in Europe. The analysis and recommendation will be based on input from stakeholders in five case study regions (CSR) (Figure 1).

*__Surveillance__ is often defined as the process whereby information on particular diseases and/or pathogen populations, which are of concern for an area or region is gathered from many sources. This may comprise assessment of disease incidence and/or severity on crop plants at different sites. Surveillance data can be used to describe a disease risk for particular cultivars or the general disease pressure in a considered area at a given time point. Disease surveillance systems often play an important role for the development of on-farm recommendations for disease management strategies. In a broader context, 'surveillance' may also cover the assessment of race/genotype frequencies in pathogen popoulations, which is a main activity in WP1.



Contacts to CSRs:

Denmark: SEGES.
UK: NIAB.
Italy: AS.A.R.
Switzerland: Agroscope.
Spain: INTIA

Figure 1: Map of Europe. Green areas represent countries involved in the case study regions in RustWatch.

2. DISEASE SURVEILLANCE IN CONTEXT OF THE RUSTWATCH EARLY WARNING SYSTEM

The proposed European early warning system for wheat rust is based on shared facilities and engagement and contributions from a wide range of stakeholders in the agricultural sector as well as in academia. As such, wheat rust surveillance is one of the component that relates to operational decision making in the frame of Integrated Pest Management (IPM) and use of field specific and regional decision support systems. More strategic actions are needed in the breeding sector facing an arms-race the evolution of new pathogen races against the breeding of new varieties with effective resistance against present races.

In case of a new rust epidemic event e.g. on previous rust resistant crop varieties, the processes and information flow in the system as it is illustrated in Figure 2. On the left hand side of this figure, it is described what is needed, and on the right hand side how RustWatch will contribute. Basically, the end-user farmer has the option to adjust his IPM strategy, e.g., apply fungicides immediately and/or to choose a different crop variety with improved rust resistance in the following season. However, changes in susceptibility due to the emergence of new pathogen races must be taken into account. The system is going beyond the interest of the individual end-user farmer i. e. impact and risks are assessed in a broader perspective in a second phase of the RustWatch project (6-18 months).

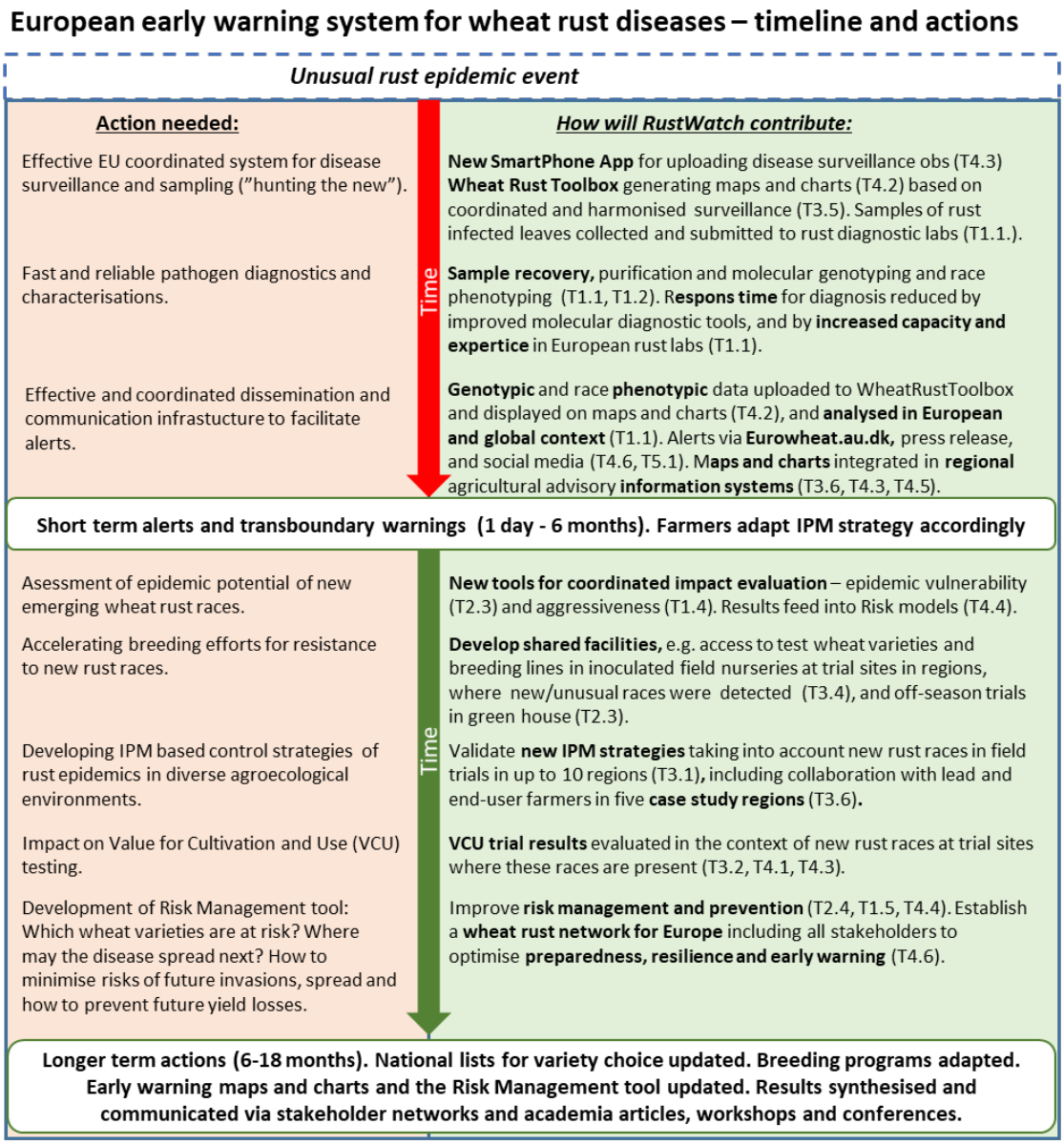


Figure 2: Illustration of actions needed and how RustWatch will contribute for the development of an European early warning system for wheat rusts.

In order to obtain a general overview of how surveillance is currently organized in the five case study regions, a questionnaire was designed by the Navarre Institute of Agricultural Technologies and Infrastructures (INTIA) and sent to the case study regions to obtain information and afterwards perform coordinated recommendations. Websites and platforms from different countries were revised and virtual meetings were used to complete the information.

First of all, an overview of the results from the questionnaires are displayed. Secondly, the main features of the disease surveillance methodology applied by the case study regions are presented. Following this, it is explained the way in which platforms can be

integrated in the framework of the existing tools and services used in the Rustwatch project. Finally, conclusions and reccomendations are listed.

3. INFORMATION COMPILATION OF DISEASE SURVILLANCE SYSTEMS AT EUROPEAN LEVEL

The way of carrying out the early warning system, presenting the results of the survey during and at the end of the season, and giving information and recommendations varies between countries although there are also some common methodologies. This is why in order to compile this information, a questionnaire was sent to people involved in case study regions in order to collect information, analyze the similarities and differences between European countries and propose recommendations to develop a common integrated system.

There were questionnaire responses from United Kingdom, Denmark, Switzerland, Italy and Spain. This report is based on these replies. In Annex 1 the responses of each country and a summary of them are displayed. Main points in the questionnaire were as follows:

3.1 Approach of the surveillance system

Objective of the surveillance system: in these countries (United Kingdom, Denmark, Switzerland, Italy and Spain), the main goal is to detect disease appearance but also to follow the expansion and level of the attacks, detect unusual behavior i.e severe infections on previously resistante cultivars and sample isolates to detect new pathogen races.

Target of the surveillance system: the main users in all countries are field technicians/advisors and farmers although in three and two countries are also scientists and Agrochemical industries respectively (Annex 1).

Data sharing: data of sampling are public in all countries, although not all information is shared freely to everybody.

Extension of the surveillance system/sampling: regarding the extension of the surveillance system/sampling, it can be at national (UK and Denmark) or regional level (Italy, Switzerland and Spain) including between 78,000 (Navarra) and 1.86 million hectares (UK), it depends on the country. Each country uses different wheat varieties, and the sowing density varies between 250 and 400 seeds per square meter (see Annex 1).

3.2 Data collection

The sampling thoroughness and spatiotemporal strategies are key features of the sampling design.

Area of field observed: two kinds of basic sampling are performed: walking through the field or in small plots (trial plots). In the field the sampled area is variable (see Annex 1) whereas small plots vary between 10 and 15 m^2.

Frequency of observations: principally, sampling is carried out once a week, starting in March-April and ending in June. Methodology followed is to use a stratified sampling taking into account wheat variety as subcategory. In most cases the frequency of observations varies according to some kind of criterion, such as the risk of rust appearance, rust phenology or others. Besides there may be more intense surveillance during critical periods.

3.3 Data management

Data Quantity: the information gathered by surveillance systems can be described in terms of quantity and quality. The most common information collected about the location of the sample is latitude, longitude, postcode and plot type. Regarding the information about disease, host and time of sampling. In every region/country rust type, crop species, crop variety, date and the observer is always collected, but in many cases wheat phenology stage, the presence of the disease, severity, sample ID and fungicide treatments are considered (see Annex 1).

Data quality: the reference system to define the coordinates is usually the cadastral information of the fields or decimal coordinates. In some cases only the presence of the disease is evaluated, although when severity and incidence is measured, a percentage scale estimating the percentage of the foliar area and the number of plants affected is used, respectively (Figure 3).

Protocol to measure severity
SEGES, Denmark
RustWatch

Yellow rust:

Cover, %	Plants attacked, %	Description
0	0	No attack
0,01	1-5	One or few lesions/stripes in the plot
0,1	6-25	Few lesions/stripes per plant, attack uneven in plot
0,5	26-50	Few lesions/stripes per tiller, attack uneven in plot
1	51-100	Some lesions/stripes pr. tiller on the lower leaves
5	-	Several leaves with coherent lesions in plot
10	-	Many leaves with 25 percent cover of rust or higher
25	-	Many leaves with 50 percent cover of rust or higher
50	-	25 percent of leaves are green, top leaves are wilting
75	-	Half of leaves are wilting: lower leaves 75-100 percent wilt, top leaves 25 percent wilt
100	-	No green leaves

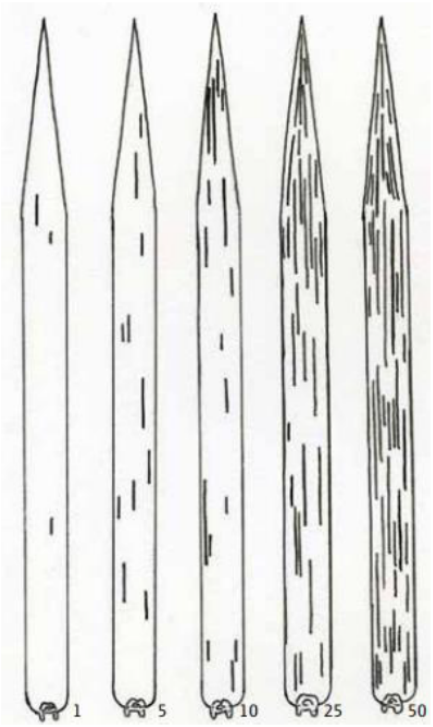


Figure 3: At the extension service in Denmark (SEGES), initially the disease is scored as incidence. After a certain crop growth stage, the severity as percentage coverage of the disease is scored on the flag leaf and leaf 2 respectively.

In some countries, United Kingdom and Spain, documentation about the sampling protocol is provided in the website. No country provides meta-data concerning definitions, vocabulary, measurement units in their website.

3.4 Data transfer

Data transfer refers to communication of the information from the organization responsible for the surveillance system to the end user. The information that is translated to the final users is: rust type, crop species, date and wheat phenology stage. In some countries also the incidence, severity and crop variety are communicated. The main means to communicate the information to the final users are the website, email, SMS, WhatsApp and personal communications. At the end of the campaign it is frequent to have meetings or conferences to transmit the information of the campaign and some recommendations for the future.

4. INTEGRATION OF DISEASE SURVILLANCE IN THE CASE STUDY REGIONS (CSR)

For every one of the five case studies, the companies involved in the surveillance, the development of the methodology for monitoring, the information that they obtain and share with external agents as well as their platforms/websites with the information that they shared are described below.

4.1 Navarra (Spain):

The Institute for Agri-food Technology and Infrastructures of Navarra (INTIA) https://www.intiasa.es/web/es is a public company attached to the Department of Rural Development, Environment and Local Administration of the Government of Navarra, Spain. Disease surveillance, pest monitoring and the estimation of the expansion of the diseases are some tasks that INTIA has commended.

To this end, specialized technicians conduct sampling throughout the region during all year in order to detect the first appearances and to track pest and diseases. Also, advisors, who belong to the company, report the appearance of pest and diseases. Advisors and technicians check tramps and walk throughout the field to detect pest flights or diseases. The information that is collected is: type of disease/pest, location (cadastral information), date, crop species and cultivar name and in the case of rust the rust type.

Immediately, when a pest/disease is detected the information is transmitted to the rest of technicians and advisors and uploaded to a platform https://estacionavisos.agrointegra.intiasa.es/ai/accesoVisor.do where a map of the region indicating the date and location of the observation is showed (Annex 2). This warning system is called “Station of warnings” and shows information about a wide

range of crops, pest and diseases. The user has the option of selecting one crop and disease to check if the disease has been detected or is spreading in a specific region. Every point of the region where the pest/disease was detected are provided including technical information about diseases and pests (biology, epidemiology, protection and prevention methods) and crops (diseases and pests that affect the crop and the phenological stage in which the crop can be affected for each pathogen). In the main screen of the platform is shown the main pests that you must consider depending on the time of year considered. This information is publicly available, although more details, like the variety affected, are only available after personal contact with some technician. Another mode of systems used for communicating are SMS, WhatsApp or directly from the advisors to cooperatives or farmers.

4.2 United Kingdom:

In the UK there is not one common national surveillance system. There are two companies involved in disease surveillance. NIAB is a semi-public company which has over 2,000 members, 200 of them participating actively in surveillance systems, half of which are farmers, the rest being independent advisers, agrochemical companies, seeds companies and distributors. Most of these have very close contacts with NIAB and both give and receive intelligence on disease incidence https://www.niab.com/. Surveys are also carried out at national level by another company: The CropMonitor™ http://www.cropmonitor.co.uk/ which was first launched by Fera in 2003, and extended and updated through investment from Innovate UK.

During the growing season, NIAB issues 'Agronomy Updates' weekly to all members, giving information on disease incidence and updates on new races whenever possible, along with advice on disease control. These members also send samples to the NIAB which are incorporated into the UKCPVS (The UK Cereal Pathogen Virulence Survey) monitoring system. NIAB performs the disease surveillance on at least 15 different varieties of winter wheat. The outputs from the UKCPVS project are reported to the industry at an annual event, usually held in March at NIAB Cambridge.

In recent years NIAB has carried out crowd-sourcing exercises for yellow rust reporting where members can record the incidence of yellow rust on wheat crops, also recording the variety affected. This data was reported back to users in real-time and was quite successful in allowing mapping of the incidence of yellow rust outbreaks. This was replaced in 2019 by the RustWatch app for disease monitoring. This was used too but to a lesser extent than the original crowd-sourcing app.

On the other hand, CropMonitor™ assesses approximately 50 crops reporting agronomic information for each crop at the end of the growing season. On the platform

http://www.cropmonitor.co.uk/wwheat/surveys/wwheat.cfm the map of the United Kingdom is displayed, which shows the points where diseases have been detected (Annex 2). After selecting one of these points it is possible to obtain more information: a description of the disease, the current risk of pests and diseases for this place (using a scale: red = high risk; amber = moderate risk; green = low risk), the risk for the current campaign and the estimated risk for each day. Users can register free to access regional risk forecasts for all pests and diseases currently available via the platform. With a subscription it is possible to have access to a risk forecasting and decision support at the local (field) scale (currently under development). The information is also transmitted via stakeholders meetings and an annual report.

Maps of disease incidence showing regional disease risk have been developed using monitoring data from the last years. Also, graphs displaying survey information from the last decade can be generated.

http://www.cropmonitor.co.uk/wwheat/surveys/surveygraphs/index.cfm.

To summarize, NIAB is very active regarding surveillance during the growing season in order to inform farmers on time about the level and expansion of the diseases. On the other hand, CropMonitor™ records the level of disease at the end of the season for monitoring purposes and long term strategic analysis.

4.3 Switzerland:

In Switzerland diseases surveillance is carried out mostly by cantonal phytosanitary or agricultural services (one per each canton, 27 cantons in Switzerland) by advisors and technicians. The idea of unifying the different systems of the cantons does not exist, today. Agroscope plans to develop a national website that could be connected to the European system in the future. For the moment, Agroscope carries out a limited number of surveys of the Swiss territory. The surveillance is focused on detecting disease appearance and estimating the expansion of the disease.

In Switzerland there is no standard disease surveillance method. Usually, regional services assess the presence of diseases/pests during visits on farmer's field. A regional observation network exists in the French speaking part of Switzerland. Here, the incidence of symptoms on 100 randomly selected plants is scored.

Farmers, agricultural advisors, agrochemical industries and mainly the regional phytosanitary services receive the information of the surveillance, this information being public and relayed through publications on websites or in specialized journals /reports (Agri, Schweitzer Bauer, Pflanzenbau aktuell, agrometeo.ch), newsletters, information sessions or directly to the producers. In the website

http://www.agrometeo.ch limited information of rust is available at regional level but for other diseases there are different places in the map of each region where it is possible to see a lot of information: Meteorological data, risk of infection on different dates, technical records, the cycle of the disease and a strategy to follow (Annex 2). For fusarium head blight there is a specific website run by Agroscope http://www.fusaprog.ch/.

Farmers, in order to reduce fungicide use, consult and produce according to recommended variety lists (www.swissgranum.ch) and cantonal recommendations. All information is available all the year around on the internet and local newsletters. A long term surveillance and alerting system would be very welcome according to Agroscope.

For the cantonal services, rusts are not the only phytosanitary problem on wheat. Similar surveillance systems are required for *Septoria* diseases and powdery mildew. More and up to date information about rusts biology and management, and resistance genes in varieties should be included.

Actually, Agroscope, in collaboration with the Federal Office of Agriculture is developing new modules on the http://www.agrometeo.ch/ platform, including information on rust.

4.4 Denmark:

SEGES https://www.seges.dk/en is part of the Danish Agriculture and Food Council and responsible for carried out the surveillance: managing the surveillance, finding finance to surveillance, contact to local advisors and commenting on findings every week.

Local advisors walk though targeted fields or observation plots Monday and Thursday every week and the recordings (the location, date, wheat phenology, rust type, incidence, severity, crop species and variety) is uploaded to the surveillance system platform https://registreringsnet.dlbr.dk/ (Annex 2). Thereafter, SEGES is commenting on the findings in the same week including recommendations for control actions if needed. Surveillance in winter wheat starts mid April and ends in the beginning of July. Yellow rust, brown rust, Septoria, powdery mildew and tan spot are monitored for both in treated and untreated plots of the commercially most important varieties.

The information and comments are uploaded to the information platform which is public. The comments are also uploaded to the information platform (www.landbrugsinfo.dk) where also local advisors and farmers can see the comments, including for example a list of recommended varieties.

Another part of the (same) surveillance system in Denmark is weekly observations in sentinel (fixed) plots, covering 7-8 cultivars at 30 locations widespread in Denmark.

4.5 Sicily (Italy):

In Italy surveillances are performed by CREA (Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria). Since 2015 AS.A.R. has hosted CREA epidemiological trials.

Disease surveillances are carried out in plot trials (about 60-80 trials) in both durum and soft wheat (mainly durum wheat) distributed through different Italy locations (6 to 8). Disease surveillance is not carried out in farmers' fields. The responsible of every CREA's single trial provides the epidemiological and disease evaluation information to the national CREA´s coordinator in August.

Data generated by CREA's epidemiological trials are published in September- October in a national magazine, and only people who subscribe to this magazine can see the results. Unfortunately, there is none website or platform which share data. However, with the help of researchers, academics, stakeholders and breeding companies, surveys are being done during growing season at national level in Sicily and in 4-5 regions in mainland Italy. This information is shared by GRRC (Global Rust Reference Center) and published on the Rustwatch website on-the-fly. No stakeholders so far have offered to host a web based national warning system for cereal diseases.

According to Biagio Randazzo, AS.A.R, Italy needs a system in order to share data of surveillance during the growing season as well as pathogen information. The information shared by CREA's network is late (September- October) and it is published in a magazine for a fee. For this reason, a new public website is being built where data generated by RustWatch disease surveillance will be shared.

5. INTEGRATION OF PLATFORMS IN THE FRAMEWORK OF RUSTWATCH

Nowadays information technology (IT) is the way to share information and connect agents from different regions and countries, including disease surveillance and alerts for immediate management recommendations. Therefore, one of the objectives of RustWatch is to identify instruments or utilities that make it possible to increase the connections between the different European systems.

The first instrument is to **identify existing expert knowledge** in each country in order to share it and foster the flow of information at European level. Expert knowledge is supported by various instruments, such as (i) documentary information and (ii) specialists. It is clear that to integrate documentary information from different countries the most useful way is via IT. Creating a shared space in the cloud where information of different countries is available and people have an easy access could be an option. An ambitious idea would be using an existing website or platform, for example the Wheat Rust Toolbox (WRT), creating a new space in this website to share documentary information. A more active plan, involving experts from different countries, is the possibility of sharing live information promoting international webinars. Webinars are useful to share information between experts but if the goal is to reach the maximum people possible including farmers, the language could be a problem.

The second instrument is the **available technologies**, especially through (iii) specialized platforms which should be in different languages if the objective is to reach a large number of people like farmers, (iv) IT tools such as app (FairShare H2020) and (v) models, etc. Free websites like https://rusttracker.cimmyt.org/?page_id=7274 shows information from around the world concerning yellow, brown and stem rust including European countries. The survey mapper and the wheat rust pathogen tool maps and charts are generated by the Wheat Rust Toolbox, a data management and display system, hosted by the Global Rust Reference Centre at Aarhus Univerity. This was initiated in 2010 in the frame of the BGRI community projects Co-funded by the Melinda and Bill Gates foundation and DFID in the UK. The WRT is now the database system used by GRRC and it is the data management system used in the RustWatch system. In this way, many tools and services are directly available for the RustWatch consortium and existing tools can relatively easily be adapted or expanded according to identified needs. Access to the toolbox require login, but all quality controlled data are available on several websites and also for using in the Rustwatch project. https://web05.agro.au.dk/WheatRustToolbox/Menu/01_Home/Home.faspx.

Currently, the WRT holds global data on wheat rust disease surveillance (36,618 observations from 53 countries), approximately 10,000 race and/or phenotype records on all three rusts, trap nursery information from approximately 100 VCU trials in Europe, 2018 and 2019 etc. The advantage of using a single international system – BGRI and RustWatch - is that the data can be analysed in a global context and duplication of work can be avoided. A challenge is that different communities on a global scale have to agree on terminologies, nomenclature, disease scoring, scales, etc. The existing maps e.g. the disease survey mapper and the maps and charts for races and genotypes recorded for Europe and beyond, is now translated into 5 different languages and special versions of the tools are made available for RustWatch partners enabling integration of these maps

into regional Agricultural Knowledge and Information Systems (AKIS). As described in section 4, most countries already operate one or more disease surveillance systems. Not to duplicate work, the RustWatch approach is to develop a metadata platform on top of those existing systems and then supplement with data from the RustWatch trap nursery data management system (Hansen et al., 2019a) and data from survey campaigns using the RustWatch Wheat Rust Surveillance App (Hansen et al., 2019b) (Figure 4). The challenge is to develop the Application Programming Interfaces (APIs) to integrate between the existing disease surveillance systems at regional AKIS´s and the Wheat Rust Toolbox, and to ensure that survey data based on different methods can be interpreted using a common standard (see Annex 1, the answers to the question: "What information is collected about the disease").

The third instrument in RustWatch is to coordinate disease surveillance strategies, and develop a common understanding of methodologies for disease assessment and sampling of isolates. Based on the results of the questionnaire, the RustWatch team in Work Package 4 (WP4) has proposed a solution for transfering functions and a common standard for disease scorings used on maps and charts (see section 6.3).

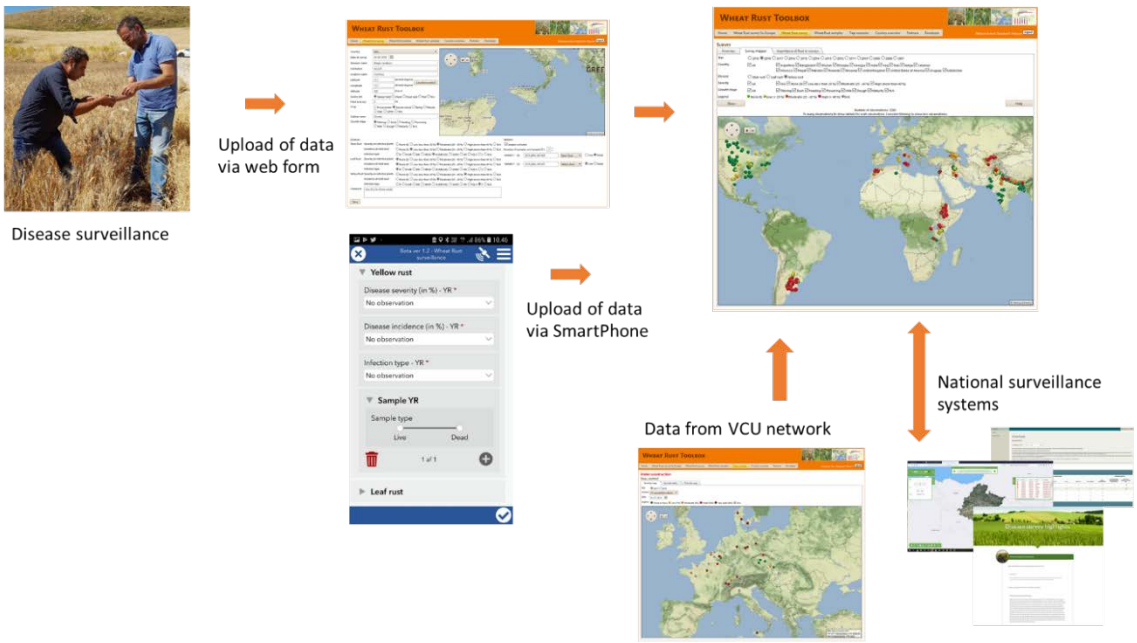


Figure 4: Sources and upload features for wheat rust disease data in the RustWatch project.

Some steps have been already taken in order to carry out disease surveillance such as the development of a SmartPhone App. The next information is required by the App: Location name, coordinates, survey site, crop, growth stage, field area, cultivar name, disease severity, disease incidence, and an optional picture of the field/plant. Data

collected by this system are transferred to the Wheat Rust Toolbox, but also data captured by other systems can be uploaded to the platform.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions of the questionnaire

After compiling information, analyzing the similarities and differences between regions and examining IT technologies is possible to draw some conclusions:

- **Lack of shared disease monitoring activities** There is a lack of shared disease monitoring activities among the different European countries or regions.
- **The scope of the surveillance systems may vary**, in some cases the system seeks to know the presence or the date of appearance of a disease or pest; in others it establishes a follow-up of disease expansion both spatially and temporally, through the use of more precise protocols of severity evaluated periodically in a network of observation or follow-up points, thus allowing the construction of incidence maps. Finally, there are also monitoring systems that incorporate the collection of samples of the pathogen for characterization in recognized reference laboratories, as is the case of the races of rust on wheat in the RustWatch project.
- Disease surveillance has a practical purpose, i.e., provide inputs to more or less complex **warning and alert systems**, in which the agricultural advisors plays an important role. There is also a wide variety of situations in this sense. There are monitoring systems that end up issuing explanatory warnings of the existing risks for crops in a given crop area or region; others also offer available technical solutions to the risks detected.
- On the other hand, **information transfer uses different channels** in different regions and countries. Digital communication systems are becoming increasingly important, using the available technologies, with the mobile phone being the most accepted and commonly used support by end users.

6.2 Similarities and opportunities for developing a common system for disease surveillance

The study of the five case studies has shown that there are some similarities between their systems.

- Sampling has a practical purpose: early warning and alert system, and in this sense there are some common proceedings at international level.
- In every country surveillance is carried out by technicians and advisors, in some countries these data are completed by information given by farmers or independent advisors.
- At critical time points in the growing season, the frequency of sampling is another point in common, at least weekly, although in some countries is more frequent (twice per week).
- Countries that have a platform upload the information weekly, given more or less information (disease, coordinates of the place and date of sampling is the basic information that they offer to the users). Information like variety, severity, incidence or the race of the pathogen are parameters that some countries collect more selectively as they give this information, for example just to partners or farmers involved in this job. The reason by which some countries do not collect severity and incidence information is due to lack of time or lack of funding for such activities
- At the end of the growing season partners in all case study regions do have meetings with farmers, partners or companies in order to share and inform about the development of the growing season and give recommendations and technical solutions for the following year.

RustWatch is an opportunity to increase fluency in the different AKIS at regional and member state level (EEMM), as well as at European level, thus contributing to one of the fundamental strategies of the new CAP 2021. This dynamic is intended to be based on the promotion of different resources among which are the following:

- Implementation of Expert Networks: Expert contacts from the five case study regions have been located: Spain: Carmen Goñi (cgoni@intiasa.es); United Kingdom: NIAB: Bill Clark (bill.clark@niab.com); CropMonitoring: Phil Jennings (philip.jennings@fera.co.uk) and Judith Turner (Judith.turner@fera.co.uk); Denmark: Ghita Cordsen Nielsen (gcn@seges.dk); Switzerland: Michel Gygax (Michel.Gygax@vol.be.ch); Italy: Biagio Randazzo (biaran@yahoo.it).
- Creation of interconnected thematic Databases: The Wheat Rust Toolbox is an example.
- Implementation of Operational Groups and multi-stakeholder projects within the framework of EIP Agri.
- Promotion of multi-stakeholder thematic workshops, conferences and congresses.
- Development of communication tools based on the new technologies available.

RustWatch is an opportunity to make European monitoring and warning systems a reality, fostering cooperation between actors and connectivity.

- It is necessary to establish the minimum data that a protocol has to gather in order to be able to share protocols.
- It is necessary to find models capable of functioning flexibly, so that the sovereignty of each organization, country or region is basically guaranteed and they also promote innovation and continuous progress.
- At the same time, it is necessary to identify the basic elements to be shared in a uniform and easily accessible European Platform, without multiplying the efforts of the different actors. The key is connectivity and basic protocols.
- Data quality is a fundamental criterion for ensuring value services for end users.

Summarizing, a European global surveillance and monitoring system should identify the moment in which the disease appears in a given region and location. For this, we have to share observations performed in all European regions and countries using platforms/websites or file transfers where we share a minimum data including: presence or absence of the disease, date, coordenates, species and variety affected. A European map will display the points where the disease has been detected on different dates.

6.3 Harmonising disease assessment scales for a European disease surveillance mapping system

For disease surveillance and integration of data at European level it is important to have a disease assessment scale common to all regions and/or countries. During the RustWatch project the question about the use of a scale for disease scoring was dicussed during the development of the Trap Nursery Data Management System and also during the development of the Wheat disease surveillence App. For both systems it has been decided to use a % scale with 9 steps where 5% disease severity is the mid-point. The critical issue is to have sufficient steps and resolution to categorize disease levels, which are of relevance for IPM thresholds for rust control in Europe. The suggested % scale is mirroring the international 1-9 scale approved by UPOV for describing phenotypic traits (including disease susceptibility) in variety testing and plant breeding, see: https://www.upov.int/edocs/tgdocs/en/tg003.pdf. The color code used on maps and charts is an attempt to simplify the % scale (5 steps only) in order to visualize disease scores on maps and charts, defined by interval mid-points on the % scale (Figure 5).

Use of this scale in all RustWatch tools and services was agreed upon on the RustWatch Excom meeting in Paris on the 8 October 2019.

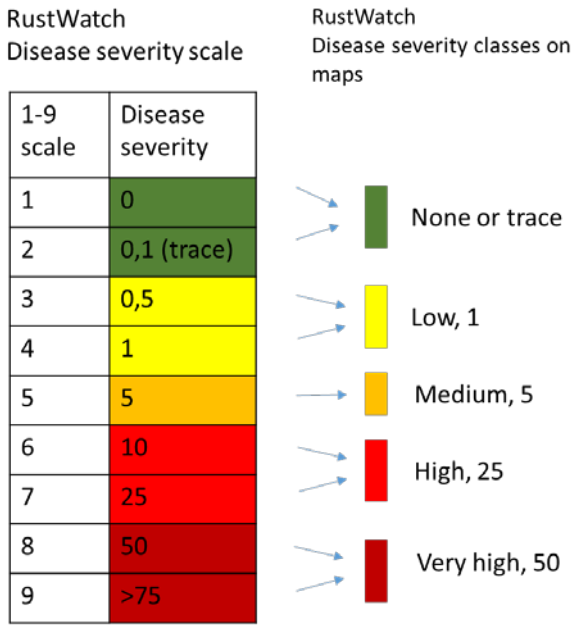


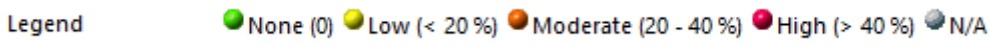
Figure 5: Equivalence of the disease severity scale used in all RustWatch tools and the scale observed in the WRT maps.

Why using 5 as the midpoint of the scale?

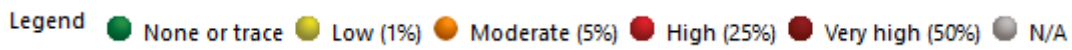
The midpoint of the scale reflects a general rule of thumb threshold in plant breeding, where breeding lines with values above the midpoint are often discarded, and at the same time there are sufficient steps below 5 to differentiate susceptibility levels of relevance for IPM decisions about potential fungicide application. See link to EuroWheat below:

http://agro.au.dk/forskning/internationale-platforme/eurowheat/wheat-ipm-tools-and-information/control-thresholds-for-diseases.

The Wheat Rust Toolbox serves both the BGRI community that use these classes: BGRI Disease legend (See the map on Figure 6).



And at the same time serves RustWatch using these classes: RustWatch Disease legend (See the map on figure 7).



From the information in the questionnaires it is clear that the different partners in the five case study regions use all different kind of systems for disease scoring. It was therefore decided to store the raw and original scoring and then transform data into either the BGRI disease classes or the Rustwatrch Classes depending on the target maps

to produce. The system will store raw data as incidence, severity on whole plants or severity on single leaf layers and then transform the results appropriately. Consequently the same data can be shown on both a map for Europe using the RustWatch legend or a global map using the BGRI legend. If data are store directly according to the RustWatch 1-9 scale these data can be transformed to the BGRI 1-4 scale.

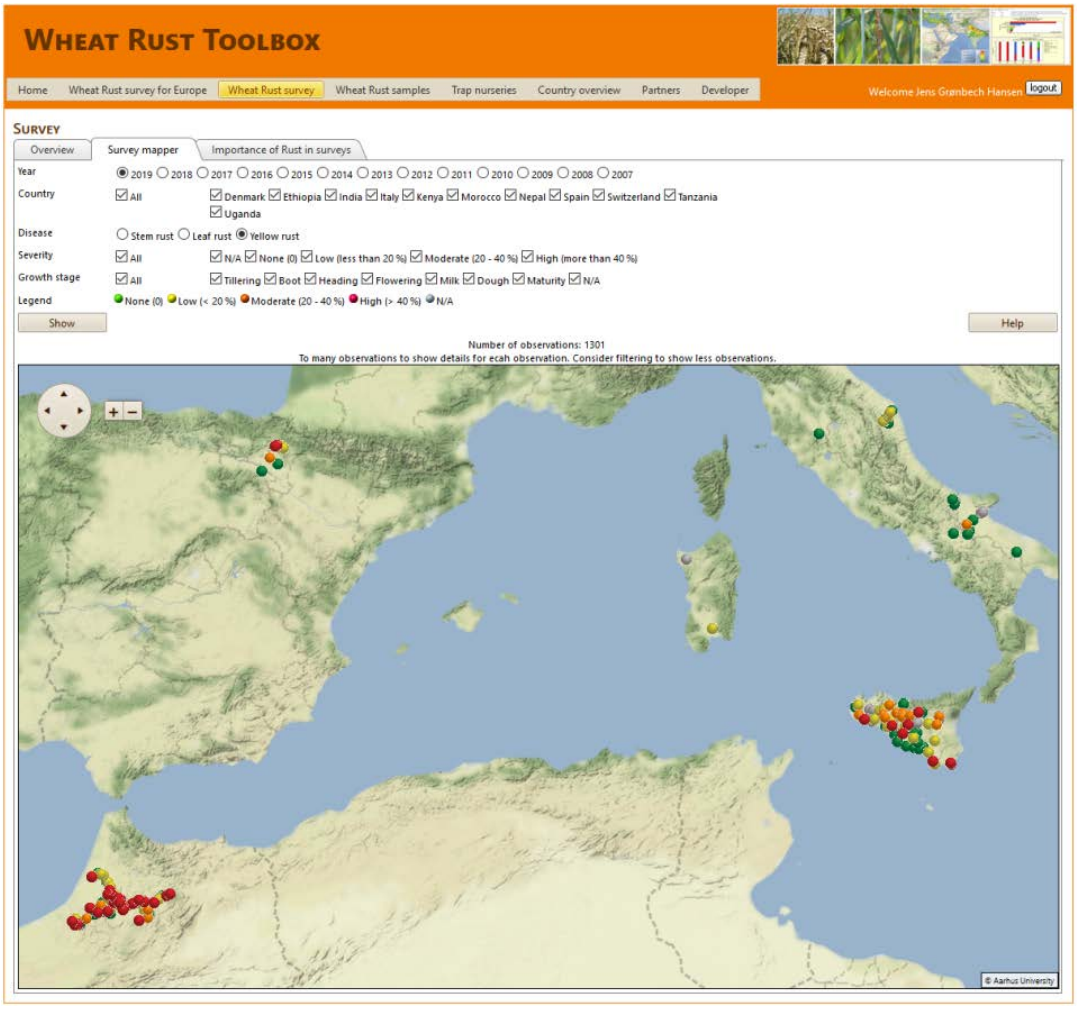


Figure 6: Yellow rust disease surveillance data from South Europe and Moracco 2019 using the BGRI legend for disease severity.

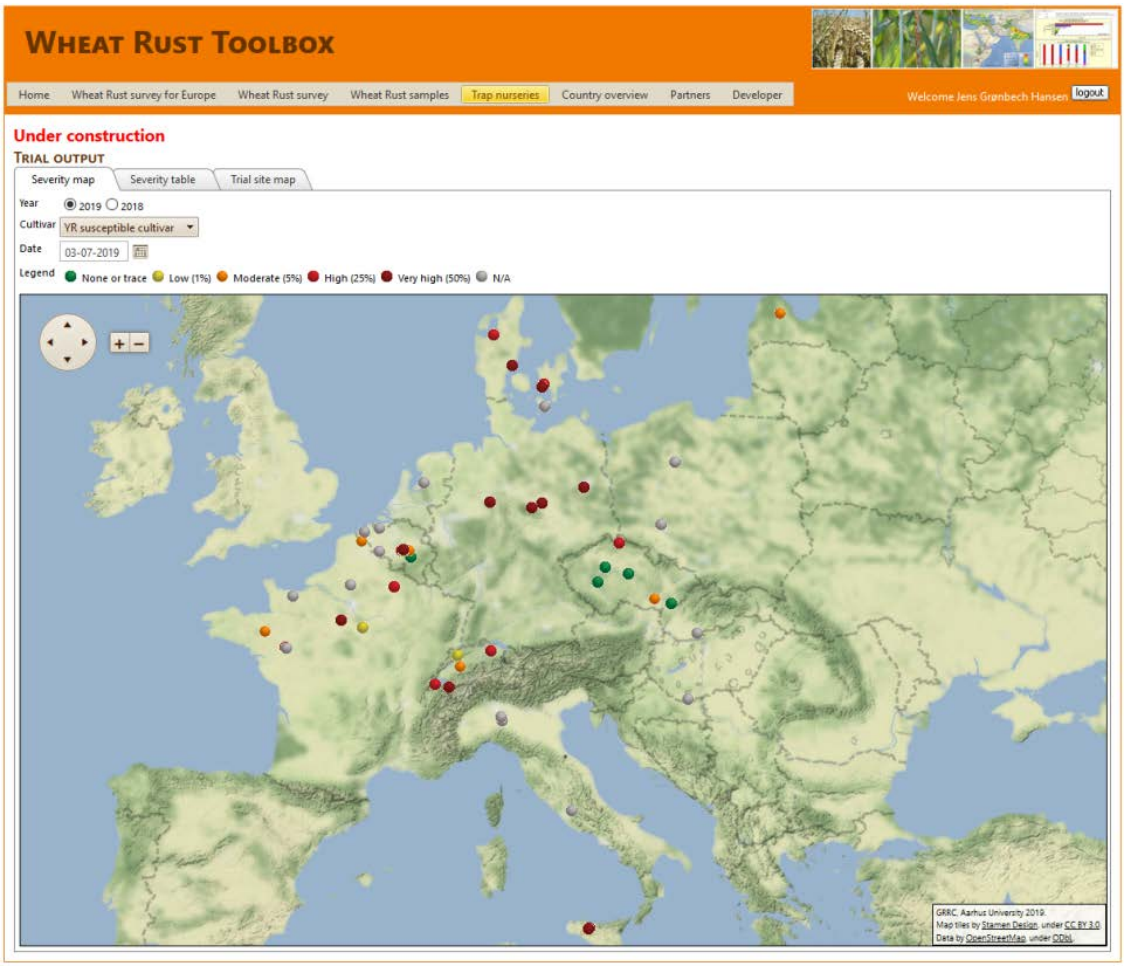


Figure 7: Yellow Rust disease scorings in local yellow rust susceptible cultivars in the Trap Nursery (VCU) System using the RustWatch legend for disease severity.

Literature:

RustWatch news story, 28 May, 2019. Wheat rust threaten European wheat production. http://agro.au.dk/forskning/projekter/rustwatch/news-and-events/show/artikel/wheat-rusts-threaten-european-wheat-production/

GRRC news story, 7 February, 2019. Reemergence of stem rust on wheat in Western Europe. http://agro.au.dk/forskning/internationale-platforme/wheatrust/news-and-events/news-item/artikel/re-emergence-of-stem-rust-on-wheat-in-western-europe-1/

GRRC news story, 3 July, 2015. Replacement of the European wheat yellow rust population by new races from the centre of diversity in the near-Himalayan region.

http://agro.au.dk/forskning/internationale-platforme/wheatrust/news-and-events/news-item/artikel/replacement-of-the-european-wheat-yellow-rust-population-by-new-races-from-the-centre-of-diversity/

Hansen JG, Lassen P and Cadot V (2019a). RustWatch Deleverable D4.4 report - Web based Trap Nursery Data Management, analysis and display system. Documentation and user guide, June 2019.

Hansen JG, Bach EO, Jørgensen MS and Lassen P (2019b) RustWatch Milestone report M4.6 - RustWatch cross platform APPs for reporting and dissemination of wheat rust diesease data and information, version 1.

Annex 1: Questionnaire

Overview	Summary	Navarra	Sicily	Switzerland	United Kingdom	Denmark
What is the main objective of the surveillance system in your region?						
Detect disease appearance	4	X	X	X		X
Estimate the expansion of the disease	3	X	X	X		
Detect unusual behavior and new races	4	X	X	X	X	
Who is the main user of the rust surveillance system?						
Farmers	5	X	X	X	X	X
Agricultural advisors	5	X	X	X	X	X
Agrochemical industries	3	X	X		X	
Scientists	3		X	X	X	
Is the data from the surveillance system public?						
Yes	5	X	X	X	X	X
No						
What territorial scope does your surveillance system has? If necessary, you can check the definitions of NUTS territorial units here and maps can found here.						
National	2			X	X	
Group of regions (NUTS – 1)						
Region (NUTS – 2)	3	X	X			X
District, county, department (NUTS – 3)						
How many hectares of wheat does your surveillance system approximately cover?						
		78000	250000	80000	1.86 million	

Overview	Summary	Navarra	Sicily		Switzerland	United Kingdom	Denmark
Could you please specify the most frequent wheat varieties grown in your area followed by their approximated cropland share? E.g. Avalon (37%)							
		Bread wheat:	**Durum wheat**	**Bread wheat**	Nara	Skyfall (10,3%)	Benchmark (33%)
		Camargo (44%)	Simeto (20%)	Palesio (30%)	Forel	Graham (9,2%)	Torp (18%)
		Marcopolo (34%)	Core (15%)	Anapo (20%)	Claro	Kws Kerrin (7,7%)	Sheriff (17%)
		Botticelli (8%)	Iride (10%)			Rgt Gravity (7,4%)	Kalmar (16%)
		Berdún (5%)	Duilio (10%)			Kws Zyatt (6,7%)	KWS Lili (5%)
			Marco Aurelio (10%)			Kws Siskin (6,7%)	Elixer (3%)
			Furio Camillo (8%)			Costello (5,9)	Pistoria (2%)
			Emilio Lepido (5%)			Gleam (5%)	Graham (2%)
			Monastir (5%)			Crusoe (4,4%)	Creator (1%)
							Viborg (1%)
What is the most frequent sowing density (seeds per square meter) in your area?							
		400	400		250	350	300

Data collection	Summary	Navarra	Sicily	Switzerland	United Kingdom	Denmark
In surveillance systems, information about the population is obtained by drawing samples. Samples include mere observations. The sampling thoroughness and spatiotemporal strategies are key features of the sampling design. Here we aim at depicting the sampling design of the surveillance system in your area.						
What is the basic sampling unit in your surveillance system?						
Plant	1				X	
Small plot (e.g. trial plots)	3		X	X		X
Field	3	X		X		X
Land or farm(group of fields)	1		X			
If your sampling unit is a plot, field or land area, What is the average area of the sampling unit?						
		3-5 Ha	plots 10m^2, farmer field 5000 hectares			Plots 15 m^{2,} Fields vary in size
How many sampling units are collected or observed every time sampling is done?						
		Walking throughout the field			1	One plot or one field per variety
On average, how often surveys are carried out?						
Once a week	3	X	X			X
Once every two weeks	2		X	X		
Once a month						
Other (specify)	1				daily	

Data collection	Summary	Navarra	Sicily	Switzerland	United Kingdom	Denmark
Which of the following spatial sampling strategies better describes your sampling design?						
Convenience sampling (samples are drawn based on some king of convenience, for instance fields located along a road)	1			X		
Systematic sampling (samples are drawn in regular space intervals)	2		X	X		
Random sampling (the entire area has the same probability to be sampled)	1	X				
Stratified sampling (samples are randomly drawn from subcategories)	3		X	X		X
None	1				X	
If stratified sampling was your choice, what is the main criterion defining the population subcategories?						
By wheat variety	4		X	X	X	X
By agroclimatic zones	1		X			
By traffic density derived from commerce						
By historical data on rust incidence	2		X	X		
Which of the following temporal sampling strategies better describes your sampling design?						
4□ Adaptive (the frequency of sampling varies according to some kind of criterion, such as the risk of rust appearance, rust phenology or others)	3	X	X		X	
Fixed	1					X
When does your sampling start?						
		Tillering BBCH30	Beginning of March	April	November	Mid April
When does your sampling ends?						
		Flowering BBCH69	Mid June	June	July	Mid June

Data management	Summary	Navarra	Sicily	Switzerland	United Kingdom	Denmark
The information gathered by surveillance systems can be described in terms of quantity and quality. The quantity refers to the diversity of information collected during the sampling process. The quality has to do with ability to find, access, interoperate and reuse the information surveyed. Therefore, our goal is to understand the quantity and quality of the information surveyed by the system in your area.						
Data quantity:						
What information is collected by the rust surveillance system about the location being sampled?						
Latitude	3		X		X	X
Longitude	3		X		X	X
Altitude	1		X			
Postcode	3			X	X	X
Nearest city	2		X		X	
Plot type	3		X		X	X
Cadastral information of the plot	1	X				
What information is collected about the time of sampling?						
Date	5	X	X	X	X	X
Time of the day						
Wheat phenology stage	3		X		X	X
What information is collected about the disease?						
Rust type	5	X	X	X	X	X
Absence of the disease	3	X	X	X		
Presence of the disease	3	X	X	X		
Incidence (percentage of plants damaged by the disease)	3		X		X	X
Severity (average damage of individual organs)	3		X	X		X
Live sample	1		X			
Dead sample	1		X			
Picture	1		X			

Data management	Summary	Navarra	Sicily	Switzerland	United Kingdom	Denmark
What information is collected about the host?						
Crop specie	5	X	X	X	X	X
Crop variety	5	X	X	X	X	X
Level of resistance	1		X			
What other information is collected?						
Sample ID	3		X	X		X
Observer ID	3		X	X		X
Absence/presence of alternative hosts in the surroundings						
Description of terrain orography						
Other (specify)	1				X	
Fungicide treatments	1		X			
Data quality:						
Which reference system do you use to define your coordinates?		Cadastral information	decimal coordinates		Postcode	
If applicable, What protocol do you use to measure severity? Please provide a reference or, if available, upload documentation			https://rusttracker.cimmyt.org/wp-content/uploads/2011/11/rustdiseases.pdf...	Protocole agreed with the other operators	% scale	
If applicable, What protocol do you use to measure rust incidence? Please provide a reference or, if available, upload documentation			**% plant attached**		% scale	
If applicable, What protocol do you use to measure host resistance? Please provide a reference or, if available, upload documentation			**https://rusttracker.cimmyt.org/wp-content/uploads/2011/11/rustdiseases.pdf**			

Data management	Summary	Navarra	Sicily	Switzerland	United Kingdom	Denmark
Do you provide documentation about the sampling protocol at your website?						
Yes	1	X				
No	4		X	X	X	X but we use www.landbrugsinfo.dk to this
Do you provide meta-data concerning definitions, vocabulary, measurement units at your website?						
Yes						
No	4	X	X	X		X
Data transfer						
Data transfer refers to communication of the information from the organization responsible for the surveillance system to the end user. The model of the communication process is formed by a sender, message, communication channel and receiver. Information about some of these elements has been requested before. Here we address the remaining aspects.						
What means do you use to communicate the information collected by the surveillance system to your final users?						
Website	4	X	X		X	X
Email	1		X			
SMS	1	X				
2□ WhatsApp	2	X	X			
1□ Other	3	X		X	Stakeholders meeting, annual report	
What information is being communicated to the users?						
Latitude						
Longitude						

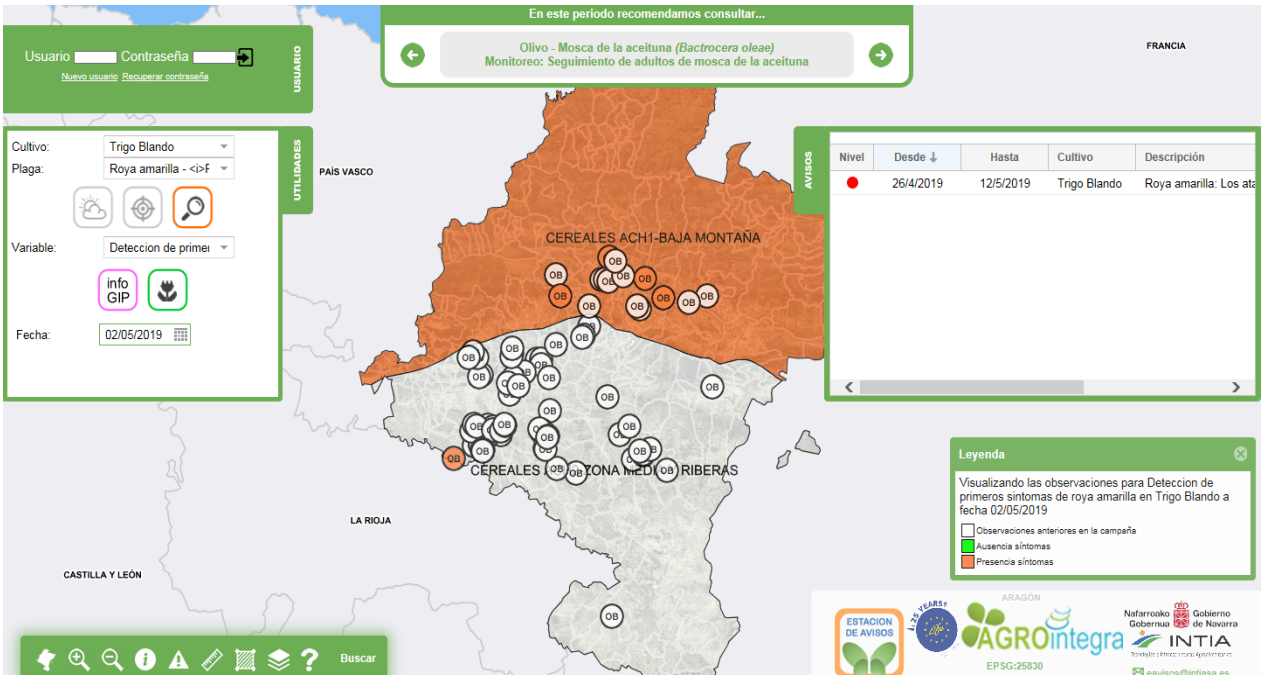
Altitude						
Postcode						
Nearest city	2		X			X
Plot type	1		X			
Data transfer	**Summary**	**Navarra**	**Sicily**	**Switzerland**	**United Kingdom**	**Denmark**
Date	3	X			X	X
Time of the day						
Plot type	1		X			
Rust type	4	X	X		X	X
Absence of the disease	1		X			
Presence of the disease	1		X			
Incidence	2		X			X
Severity	2		X			X
Live sample						
Dead sample						
Crop specie	4	X	X		X	X
Crop variety	3		X		X	X
Level of resistance	2		X		X	
Sample ID	2				X	X
Observer ID	1		X			
Absence/presence of alternative hosts in the surroundings						
Description of terrain orography						
Other (specify)						

Annex 2: Platforms from the different case study regions

Below we can see the link to the different platforms from the different case study regions. We can also visualize the image or appearance of the different websites. There is not information about Italy because does not have a platform.

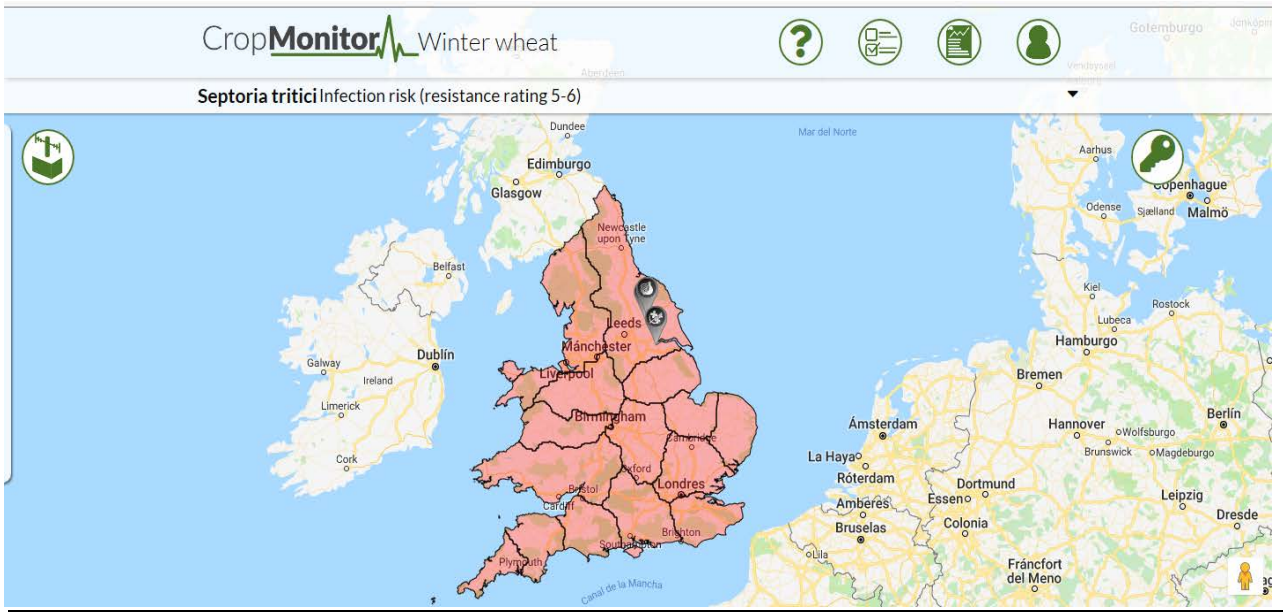
Navarra:

https://estacionavisos.agrointegra.intiasa.es/ai/accesoVisor.do



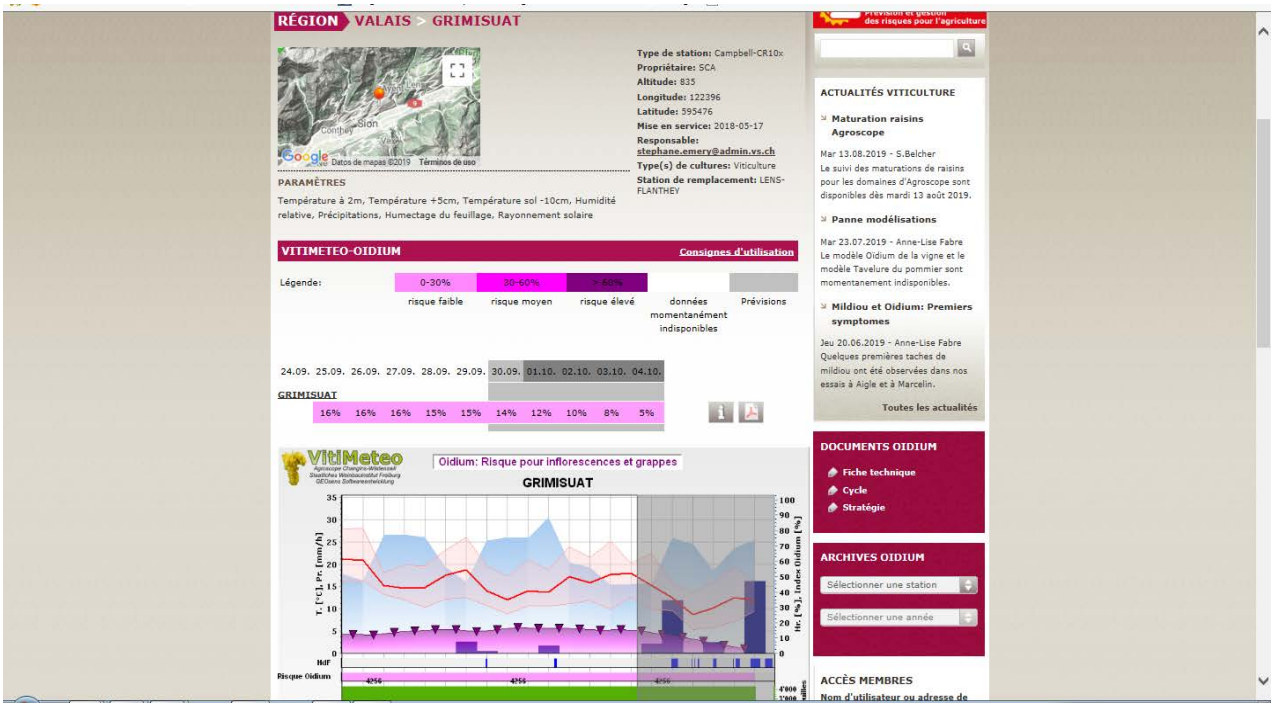
United Kingdom:

https://map.cropmonitor.co.uk/map?_ga=2.174906338.1590332942.1569843027-1938610005.1569843027



Switzerland:

http://www.agrometeo.ch/fr/viticulture/diseases/oidium/station/304



Denmark:

https://registreringsnet.dlbr.dk/#/results/presentation/17