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French agency for food, environmental and occupational health & safety

Investigate, evaluate, protect

Express pest risk analysis of tomato brown rugose fruit virus for France

Anses Opinion
Collective Expert Appraisal Report

January 2020 - Scientific Edition

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ANSES Opinion
Request No 2019-SA-0080

The Director General

Maisons-Alfort, 14 January 2020

OPINION
of the French Agency for Food, Environmental and Occupational Health & Safety

on the "Express pest risk analysis of tomato brown rugose fruit virus for France"

ANSES undertakes independent and pluralistic scientific expert assessments.
ANSES primarily ensures environmental, occupational and food safety as well as assessing the potential health risks they may entail.
It also contributes to the protection of the health and welfare of animals, the protection of plant health and the evaluation of the nutritional characteristics of food.

It provides the competent authorities with all necessary information concerning these risks as well as the requisite expertise and scientific and technical support for drafting legislative and statutory provisions and implementing risk management strategies (Article L.1313-1 of the French Public Health Code).

Its opinions are published on its website. This opinion is a translation of the original French version. In the event of any discrepancy or ambiguity the French language text dated 14 January 2020 shall prevail.

On 25 April 2019, ANSES issued an internal request to conduct the following expert appraisal: "Express pest risk analysis of tomato brown rugose fruit virus for France".

1. BACKGROUND AND PURPOSE OF THE REQUEST[1]

As a result of the health monitoring carried out separately by the members of ANSES's Expert Committee (CES) on "Biological Risks for Plant Health" (RBSV) and the staff of ANSES's Plant Health Laboratory (LSV), we became aware of an alert concerning an emerging tomato virus: tomato brown rugose fruit virus (ToBRFV).

ToBRFV is an emerging tobamovirus first reported in 2014 in Israel and 2015 in Jordan, in both cases on greenhouse tomatoes. In 2018, it was also reported in Mexico (where its eradication is under way), and in the USA where it was eradicated in the same year. Within the European Union

[1] The background and purpose of the request described in this section are those put forward during preparation of the internal request in March 2019. Since then, there have been developments in several areas, such as the distribution of the virus, its host plants and the regulatory status of the organism. These developments are discussed in detail in the risk analysis itself in the expert appraisal report.

(EU), it was reported in Germany in 2018 (North Rhine-Westphalia where its eradication is under way) and in Italy (Sicily) in early 2019. This virus was also the subject of an alert in the *Bulletin de Santé du Végétal* (BSV) for the Provence-Alpes-Côte d'Azur (PACA) region in December 2018. It was added to the alert list of the European and Mediterranean Plant Protection Organization (EPPO) in January 2019 and was the subject of an alert sheet issued by ANSES's LSV (LSV_2019_03_0027).

The main host plants of ToBRFV are tomatoes (*Solanum lycopersicum*) and peppers (*Capsicum annuum*) – it is important to state at this stage that in this opinion the name "pepper" covers both chilli peppers and sweet peppers as used in everyday language. The damage observed on greenhouse tomato plants includes chlorosis, mosaic and mottling on the leaves and necrotic spots on peduncles, calyces and flower stalks. Fruits show yellow or brown spots with characteristic rugose symptoms, and may be deformed and ripen irregularly, making them non-marketable. The incidence of the disease varies between 10 and 100% of fruit depending on the site. Similar symptoms have also been observed on *Capsicum annuum* fruits in Mexico.

Viruses belonging to the genus *Tobamovirus* have a particularly effective means of spread. Transmission is mechanical, through simple direct contact between plants or via hands, work tools, clothing, pollinating insects, birds or irrigation water. Seeds can also transmit tobamoviruses. Lastly, these viruses are highly stable and can survive for several months on inert media without any loss of infectivity. These epidemiological characteristics make tobamoviruses a formidable threat to high-density crops such as those grown in greenhouses.

The long-lasting resistance carried by the *Tm-2* and *Tm-2*^{2} genes deployed in tomato varieties in production since the 1970s has led to a considerable reduction in the negative impacts associated with other tobamoviruses (tomato mosaic virus and tobacco mosaic virus). However, these genes are ineffective against ToBRFV. The lack of resistance in tomatoes therefore particularly jeopardises this production sector, which has so far been spared.

In view of:
- the importance of the greenhouse tomato production sector in France,
- the high infectivity of this virus and the susceptibility of the tomato,
- the succession of reports at production sites on several continents and especially within the EU,
- and the lack of regulatory measures against this virus (in March 2019), which could lead to certain high risk pathways,

this internal request requires an express risk assessment of ToBRFV to be carried out in order to:

- assess the probability of introduction and spread of ToBRFV and the scale of the potential economic impacts in metropolitan France (PRA area),
- propose possible management measures in the event of an unacceptable risk to the production sector.

With regard to major developments in the background, without waiting for the details of the report or opinion, it is important to point out that between the date of the internal request and publication of this opinion, emergency measures were taken at European level to prevent the introduction and spread of ToBRFV in the form of Implementing Decision (EU) 2019/1615, applicable from 1 November 2019.

2. ORGANISATION OF THE EXPERT APPRAISAL

The expert appraisal was carried out in accordance with French standard NF X 50-110 "Quality in Expert Appraisals – General requirements of Competence for Expert Appraisals (May 2003)".

ANSES entrusted examination of this formal request to the "ToBRFV" Working Group, reporting to the CES RBSV.

The methodological and scientific aspects of this group's work were regularly submitted to the CES RBSV (on 13/05/2019, 09/07/2019, 02/09/2019 and 26/11/2019) and the work was adopted by the CES RBSV at its meeting on 26/11/2019. The report produced by the Working Group takes account of the observations and additional information provided by the CES members.

ANSES analyses interests declared by experts before they are appointed and throughout their work in order to prevent risks of conflicts of interest in relation to the points addressed in expert appraisals.

The experts' declarations of interests are made public via the ANSES website (www.anses.fr).

The outline of the collective expert appraisal report follows the Decision-support scheme for an Express Pest Risk Analysis issued by the European and Mediterranean Plant Protection Organization (EPPO) (PM 5/5(1)) in 2012. Implementation of the expert appraisal followed the guidelines of this scheme, namely an initiation step, a pest risk assessment step (assessment of the probability of entry, establishment and spread, assessment of potential economic consequences) and a pest risk management step.

3. ANALYSIS AND CONCLUSIONS OF THE ToBRFV WG AND THE CES

3.1. Pest risk assessment

3.1.1.Pest overview

Regarding the information presented in the "Background" section, there have been several developments, including two major ones:

- The virus was reported once on aubergine in Mexico; however, no symptoms were described on this host plant in experimental inoculation tests. The WG has considered aubergine in this risk assessment but currently has reservations about its host status due to the high uncertainties associated with these observations;
- The distribution of ToBRFV has evolved with new reports (official and confirmed by local authorities or unofficial in the literature or the press) on the European (United Kingdom, Netherlands, Greece, Spain), Asian (Turkey, Palestine, China), American (Canada, Chile) and African (Ethiopia, Sudan) continents.

3.1.2. Entry

The main relevant pathways identified by the WG were:

- seeds
- plants for planting
- fruits
- other possible pathways: any inert medium in contact with the crop, and pollinating hives with the bee colonies they contain
- passengers carrying plant material, including through the shoes/clothing they are wearing.

In the absence of regulations, the entry of ToBRFV into the PRA area via seeds is very likely given (i) the imports of tomato, pepper and aubergine seeds from contaminated countries, (ii) the location

of tobamoviruses in the outer coat of the seed, (iii) the virus's survival during transport, and (iv) transmission of the virus from seeds to plants (although there is uncertainty about the rate of this transmission).

Again, in the absence of regulations, the entry of ToBRFV into the PRA area via plants for planting is very likely due to (i) the presence of the virus in plants when imported from contaminated countries, (ii) the virus's survival during transport, (iii) transfer of the virus given that plants for planting will be planted in production units in contact with other plants.

Implementing Decision (EU) 2019/1615 applicable from 1 November 2019 establishes emergency measures to prevent the introduction and spread of ToBRFV in the European Union and specifically targets plants for planting and seeds of tomato and pepper. This therefore reduces the risk posed by these pathways.

As far as fruits are concerned, it is moderately likely that ToBRFV will enter the PRA area via this pathway. Fruit imports may come from contaminated countries, and contaminated fruits that are asymptomatic or show very few symptoms may enter commercial trade. It is very likely that the virus's infectivity on fruits will be maintained during transport. Nevertheless, the probability of ToBRFV being transferred from fruit intended for consumption to greenhouse plants in production is quite low. This transfer could take place if the same company packages imported tomatoes and locally-produced tomatoes, or via people present on a farm (farm workers, technicians, etc.) if they consume fresh fruit imported from at-risk areas.

3.1.3. Establishment

The likelihood of ToBRFV becoming established in the PRA area is rated as high, both in protected conditions and outdoors, based on the following factors:

- host plants:
  - tomatoes, peppers and aubergines are grown in the PRA area. Open-field tomatoes are mainly intended for industrial processing and greenhouse tomatoes are for fresh or direct consumption. Tomatoes and peppers are also grown in private gardens;
  - open-field tomato varieties/hybrids for industrial processing lack tobamovirus resistance and are susceptible to ToBRFV;
  - all tomato varieties/hybrids tested experimentally were found to be susceptible to ToBRFV, including F1 hybrids carrying tobamovirus resistance genes (*Tm-1, Tm-2, Tm-2*^{2} genes). These hybrids are mainly used in the PRA area in tomato crops for fresh or direct consumption that have been produced in greenhouses for more than 30 years;
- climate: this is not a limiting factor for ToBRFV insofar as the host plant finds favourable climatic conditions for its establishment;
- cultivation practices:
  - for open-field crops, cultivation practices favour the burial of plant debris in the soil at the end of the growing period, thus maintaining the virus in contaminated areas (very long survival of the virus with persistence of infectivity);
  - for greenhouse crops, the intensive handling, the high density of plants and the highly efficient mode of virus transmission favour the establishment of ToBRFV;
- the occurrence of the virus in its current area of distribution: establishment of ToBRFV has been observed both on open-field crops in Mexico and on greenhouse crops in Germany, Mexico, Israel and Italy, for example.

Uncertainty is low for greenhouse crops and moderate for open-field crops. In the latter case, herbaceous ToBRFV host plants such as *Chenopodium murale* or *C. quinoa or Solanum nigrum*

for example, or certain ornamental species such as *Petunia hybrida*, are found outdoors in the PRA area. Nevertheless, these species have experimental host status and have so far never been described as infected under natural exposure.

The area of potential establishment where an impact can be expected therefore includes both commercial production areas and private gardens where host plants are grown. However, the endangered area may be restricted to areas of large-scale production or marketing of tomatoes (in protected conditions and open-field), as well as areas of pepper production. These are mainly the regions of western France (Bretagne, Pays de la Loire), Provence-Alpes-Côte d'Azur and Nouvelle Aquitaine.

3.1.4.Spread

ToBRFV is mainly spread by mechanical transmission by contact between plants. In general for tobamoviruses, the high density of plants in crops, the frequency of passage, the stability of the virus and the efficiency of contact transmission facilitate the rapid development of outbreaks. Transmission involving phloem-feeding vectors has not been described in tobamoviruses. On the other hand, mechanical transmission via bumblebees has been demonstrated, in particular in the case of ToBRFV.
Spread via human activities can occur (i) over long distances through the movement of seeds, plants for planting and fruits; (ii) within production sites through plant handling operations such as grafting, trellising and harvesting; (iii) between farms through shared inert material such as plastic crates and pallets; (iv) through contaminated soil mainly via footwear and means of transport.
The magnitude of the spread in the PRA area is estimated to be high with low uncertainty.

3.1.5. Impact in the current area of distribution

The impacts related to the introduction and spread of ToBRFV in production sites are mainly economic.
No data on the quantification of damage in terms of yield losses are mentioned, but incidence measurements are available. The term incidence can be interpreted as the rate of diseased plants in a production area, a contamination rate that is likely to have a negative impact on the yield or market value of the fruit. It is important to remember that for plants grown under protected conditions, such as tomatoes, annual yield fluctuations are normally very small and a yield loss of more than 10% can be regarded as having a massive impact (according to the EPPO Decision-support scheme for quarantine pests 11-17053 PM5/3 (5)).
In its current area of distribution, the incidence rate of ToBRFV varies between 8% of fruits showing symptoms in the Netherlands, 10-15% of the fruits of a symptomatic plant for the first detections in Israel, 50% in tomato greenhouses in China, 55% of plants infected in Mexico, 80% of plants infected in Greece and up to 100% of plants infected in Palestine.

The magnitude of the impact in the current area of distribution is high with low uncertainty.

3.1.6.Potential impact in the PRA area

In the event of entry and establishment in the PRA area, the magnitude of the economic impact in the area of potential establishment is estimated to be high with low uncertainty, especially in the endangered area, in view of (i) the lack of chemical, genetic or biocontrol solutions, (ii) the extent of the damage observed in the virus's current area of distribution, especially in Israel and Mexico, (iii) the importance of the tomato on the French market.

3.1.7.Overall assessment of risk

In the absence of phytosanitary measures, the overall risk of ToBRFV for the PRA area is estimated to be high with moderate uncertainty.

Indeed, in the absence of regulations, there is a high likelihood of ToBRFV entering the PRA area via imports of seeds and plants for planting. Nevertheless, the regulation introduced on 1 November 2019 provides for a mandatory check for ToBRFV on plants for planting and seeds from third countries or circulating within the EU. There is no obligation to check for ToBRFV on susceptible plant material other than tomato and pepper, or on tomato and pepper fruits intended for consumption. Although implementation of this legislation will help reduce this risk from plants for planting and seeds, the risk of entry is still moderate in view of the risk posed by fruits intended for consumption, because (i) they are not covered by the current legislation and (ii) contaminated fruits may enter commercial channels as they may be asymptomatic or show very few symptoms. The risk of entry associated with the market for seeds purchased on the Internet by private individuals must also be considered but is not quantifiable.

The likelihood of establishment of ToBRFV is rated as high, both in protected conditions and outdoors in regions where tomato and pepper are grown, with low to moderate uncertainty. The magnitude of the spread in the PRA area is estimated to be high with low uncertainty. This spread will take place:

- naturally, through contact between plants;
- via human activities: by movements of seeds, plants for planting and fruits; and through contact by the handling of material, for example with cultivation tools (stakes, pruning shears, grafting knives, pollinating hives, etc.) and marketing equipment (pallets, cardboard boxes, packaging, etc.).

The economic impact caused by ToBRFV in its current area of distribution is estimated to be high, given the incidence rates reported at the different sites in the virus's current area of distribution. It is likely that these high levels of contamination will affect yields and marketability of fruits, even though no data on yield losses are currently available. In the event of entry and establishment in the PRA area, the magnitude of the impact in the area of potential establishment is also estimated to be high with low uncertainty, especially in the endangered area.

3.2. Pest risk management

The first recommendation concerns the establishment of a surveillance plan to determine the pest status of the PRA area with respect to ToBRFV.

Phytosanitary measures are recommended:

- Prevention of new introductions:
  - imports of plants for planting should comply with the specifications of Good Seed and Plant Practices (GSPP) for tomato seeds and seedlings with respect to *Clavibacter michiganensis*, a bacterium transmissible through seed and during cultivation, as these specifications can be suitably adapted to ToBRFV;
  - specific requirements are recommended for fruit imports, which should come from production sites declared free of ToBRFV.
- If infected plants are reported in a production unit, eradication is recommended by taking immediate action to destroy all the plants in the production unit, coupled with strict hygiene measures including a cleanout period. If such measures are not applied, risk management switches to a containment scenario, with the aim of limiting the virus's spread by applying hygiene measures and restricting the movement of contaminated plant material. In view of

the situation in Israel and Mexico, the Working Group has doubts about the success of the containment strategy.

- Risk communication: communication efforts targeting producers are also recommended. Awareness of prophylactic measures is essential and seems to have been applied in this sector, which has already been affected by other high-impact health crises in the past (PepMV, TYLCV, *Tuta absoluta, Clavibacter michiganensis*, etc.).

3.3. Uncertainty

Several sources of uncertainty were identified during this express risk analysis:

- the rate of transmission of ToBRFV from seeds to seedlings
- the location of ToBRFV on the surface of seeds
- the status of aubergine as a ToBRFV host plant
- quantification of flows of tomato and pepper plants for planting
- the lack of any guarantee as to current management conditions at the origin, in particular consideration and application of GSPP standards and the use of prophylactic measures suited to ToBRFV
- the transfer of ToBRFV from fruits to crops
- the effectiveness of seed treatments against ToBRFV
- the infection status of potential reservoir plants in its current area of distribution and their role in maintaining the virus from year to year
- the diversity of varieties/hybrids affected and their level of susceptibility to ToBRFV
- the range of incidences, which vary between different sites and the reporting or detection times during the growing cycle.

New information or data from scientific reports or studies that may appear in the coming months will no doubt help reduce the overall uncertainty of this risk assessment, which reflects the knowledge of this new virus at the time of finalisation of the report (November 2019).

4. AGENCY CONCLUSIONS AND RECOMMENDATIONS

Following the health monitoring carried out by its Plant Health Laboratory on the one hand and its CES on "Biological Risks for Plant Health" on the other, ANSES issued an internal request regarding tomato brown rugose fruit virus (ToBRFV), an emerging virus affecting various crops, mainly tomatoes and peppers (in the plant sense of the term, therefore including both sweet peppers and chilli peppers), throughout the world since 2014 (Middle East and Mexico) and more recently in Europe since 2018 (Germany and Italy, for example). For a producing country like France, this has economic consequences for the production sector, which is considerably regionalised, and may also affect household production, in which the area under cultivation is estimated to be of the same order of magnitude as open-field production for industrial processing. The importance of this subject has moreover been confirmed by the very recent adoption at European level of Implementing Decision (EU) 2019/1615, applicable from 1 November 2019, which prescribes emergency measures at least until 2022.

The French Agency for Food, Environmental and Occupational Health & Safety endorses the experts' conclusions, determining the overall risk level (entry, establishment, spread and impact) for this virus to be high with a moderate level of uncertainty. The uncertainties raised by the experts at various stages of the expert appraisal are largely due to the fact that it is a new and emerging pest.

The Agency stresses certain characteristics of this virus that need to be taken into account by all stakeholders to prevent, or if necessary manage, its introduction: lack of chemical, genetic or bio-control solutions, distribution throughout the whole plant (including seeds), and very high persistence with strong viral potential including outside its host plants.

ANSES also endorses the experts' recommendations. It calls for the development of research on ToBRFV in order to acquire scientific knowledge on this virus, which is needed for consolidating the risk assessment and proposing or refining the corresponding management measures.

ANSES reiterates that compliance with the regulations on seeds and plants for planting is of great importance in order to protect the Member States of the European Union from the introduction and spread of ToBRFV. Imports of fruits from contaminated host plants, which are not covered by the current regulations, are an entry pathway for ToBRFV. ANSES supports the proposed specific requirements for these fruits in view of the risk they pose, i.e. imports should come from production sites declared free of ToBRFV. In addition, the likelihood of virus transfer from imported fruits to growing plants could be higher for household or domestic production (than on professional holdings) as there is greater proximity between culinary and production activities. The question of suitable information for household production should also be considered.

Lastly, ANSES recommends implementing a surveillance plan in order to determine the occurrence of ToBRFV in France, and insists on the critical importance of rapidly reporting its presence in production areas. Indeed, the situations identified abroad have highlighted the importance of rapid dissemination of information related to detections, followed by swift and determined elimination action to achieve rapid eradication. If this fails, a containment strategy would take a long time to bear fruit and, according to the experts, would have little chance of success. Adequate information for professionals is therefore essential to make them aware of the stakes involved in a rapid detection/response cycle.

Dr Roger Genet

KEYWORDS

tomato brown rugose fruit virus, tobamovirus, tomate, piment, résistance, dissémination, semences, plant, évaluation du risque

tomato brown rugose fruit virus, tobamovirus, tomato, pepper, resistance, spread, seeds, plants, risk assessment, risk analysis

Express pest risk analysis of tomato brown rugose fruit virus for France

Request No 2019-SA-0080 ToBRFV

Collective Expert Appraisal
REPORT

Expert Committee on "Biological risks for plant health"

ToBRFV Working Group

November 2019

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Presentation of the participants

PREAMBLE: The expert members of the Expert Committees and Working Groups or designated rapporteurs are all appointed in a personal capacity, *intuitu personae*, and do not represent their parent organisation.

WORKING GROUP

Chair

Mr Eric VERDIN – Research Engineer, INRA, expertise in virology, emerging diseases, diagnosis, epidemiology, specialist in viruses of vegetable and ornamental species

Members

Mr Pascal GENTIT – Deputy Head of Unit, ANSES, Plant Health Laboratory, expertise in virology, detection, diagnostics

Mr Stéphan STEYER – Senior Research Fellow, Walloon Agricultural Research Centre (Belgium), expertise in virology, prophylaxis, diagnosis

Mr Thierry WETZEL – Research Director, DLR Rheinpfalz (Germany), Institute of Plant Protection, expertise in virology, molecular biology, emerging diseases

EXPERT COMMITTEE

The work covered in this report was monitored and adopted by the following Expert Committee (CES):

- CES on "Biological risks for plant health"

Chair

Mr Thomas LE BOURGEOIS – Research Director, CIRAD, Weed science

Members

Ms Marie-Hélène BALESDENT – Research Director, INRA, Mycology

Ms Françoise BINET – Research Director, CNRS, Functional ecology

Mr Antonio BIONDI – Researcher, University of Catania (Italy), Entomologist

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Mr Thierry WETZEL – DLR Rheinpfalz (Germany), Institute of Plant Protection, Virology

ANSES PARTICIPATION

Scientific coordination

Ms Christine TAYEH – Scientific Coordinator – ANSES

HEARINGS WITH EXTERNAL EXPERTS

Ms Claire GOILLON – Responsible for experimentation in market gardening, APREL (Provençal Association for Research and Experimentation on Vegetables)

CONTRIBUTIONS FROM OUTSIDE THE GROUP(S)

Provision of data on tomato, pepper and aubergine seed imports and statistics on tomato, pepper and aubergine seed and seedling production in France. Ms Marie-Pierre DEBRABANT – GNIS (French Interprofessional Organisation for Seeds and Plants) Organisation and Information Systems Directorate, Data, Studies and Statistics Department.

Data on epidemiology and the prevention and control measures put in place during occurrences and outbreak management were provided through a questionnaire sent to authors of scientific publications.

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Acronyms and abbreviations

APHIS: Animal and Plant Health Inspection Service
EPPO: European and Mediterranean Plant Protection Organization
FERA: Food and Environment Research Agency
NPPO: National Plant Protection Organization
PepMV: Pepino mosaic virus
TMV: Tobacco mosaic virus
ToBRFV: Tomato brown rugose fruit virus
ToMV: Tomato mosaic virus
SADER-SENASICA: Mexican National Service of Agrifood Health, Safety and Quality
USDA: United States Department of Agriculture
WG: Working Group

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1 Background, purpose and procedure for carrying out the expert appraisal

The background and purpose of the request described in this document are those put forward during preparation of the internal request in March 2019. Since then, there have been developments in several areas, such as the global distribution of the virus, its host plants and the regulatory status of the organism. These developments are discussed in detail in the risk analysis itself.

1.1 Background as of March 2019

As a result of the health monitoring carried out by the members of ANSES's Expert Committee and our ANSES employees, we became aware of an alert concerning an emerging tomato virus: tomato brown rugose fruit virus (ToBRFV).

Tomato brown rugose fruit virus is an emerging tobamovirus first reported in 2014 in Israel and 2015 in Jordan on greenhouse tomatoes. In 2018, it was also reported in Mexico (where its eradication is under way), and in the United States where it was eradicated in the same year. Within the European Union (EU), it was reported in Germany in 2018 (North Rhine-Westphalia where its eradication is under way) and in Italy (Sicily) in early 2019. This virus was also the subject of an alert in the *Bulletin de Santé du Végétal* (BSV) for the Provence-Alpes-Côte d'Azur (PACA) region in December 2018. It was added to the alert list of the European and Mediterranean Plant Protection Organization (EPPO) in January 2019 and was the subject of an alert sheet issued by ANSES's Laboratory for Plant Health (LSV_2019_03_0027).

The main host plants of ToBRFV are tomato (*Solanum lycopersicum*) and pepper (*Capsicum annuum*). The damage observed on greenhouse tomato plants includes chlorosis, mosaic and mottling on the leaves and necrotic spots on peduncles, calyces and flower stalks. Fruits show yellow or brown spots with characteristic rugose symptoms, and may be deformed and ripen irregularly, making them non-marketable. The incidence of the disease varies between 10 and 100% of fruit depending on the site. Similar symptoms have also been observed on *Capsicum annuum* fruits in Mexico.

Viruses belonging to the genus *Tobamovirus* have a particularly effective means of spread. Transmission is mechanical, through simple direct contact between plants or via hands, work tools, clothing, pollinating insects, birds or irrigation water. Seeds can also transmit tobamoviruses. Lastly, these viruses are highly stable and can survive for several months on inert media without any loss of infectivity. These epidemiological characteristics make tobamoviruses a formidable threat to high-density crops such as those grown in greenhouses.

The long-lasting resistance carried by the *Tm-2* and *Tm-2*^{2} genes deployed in tomato varieties in production since the 1970s has led to a considerable reduction in the negative impacts associated with other tobamoviruses (tomato mosaic virus and tobacco mosaic virus). However, these genes are ineffective against ToBRFV. The lack of resistance in tomatoes therefore particularly jeopardises this production sector, which has so far been spared.

1.2 Purpose of the request

In view of the importance of the greenhouse tomato production sector in France, the high infectivity of this virus and the susceptibility of the tomato, the succession of reports at production sites on several continents and especially within the EU, and the lack of regulatory measures against this virus, which could lead to certain high risk pathways, you are asked to carry out an express risk assessment of ToBRFV in order to:

(i) assess the probability of introduction and spread of ToBRFV and the scale of the potential economic impacts in metropolitan France,

(ii) propose possible management measures in the event of an unacceptable risk to the production sector.

1.3 Procedure: means implemented and organisation

ANSES entrusted examination of this request to the ToBRFV Working Group reporting to the CES on "Biological risks for plant health" (CES RBSV).

The methodological and scientific aspects of this group's work were regularly submitted to the CES RBSV (on 13/05/2019, 09/07/2019, 02/09/2019 and 26/11/2019). The report produced by the Working Group takes account of the observations and additional information provided by the CES members.

The outline of the collective expert appraisal report follows the Decision-support scheme for an Express Pest Risk Analysis issued by the European and Mediterranean Plant Protection Organization (EPPO) (PM 5/5(1)) in 2012. Implementation of the expert appraisal followed the guidelines of this scheme, namely an initiation step, a pest risk assessment step (assessment of the probability of entry, establishment and spread, assessment of potential economic consequences) and a pest risk management step.

The expert appraisal was carried out in accordance with French Standard NF X 50-110 "Quality in Expert Appraisals – General Requirements of Competence for Expert Appraisals (May 2003)".

1.4 Prevention of risks of conflicts of interest

ANSES analyses interests declared by experts before they are appointed and throughout their work in order to prevent risks of conflicts of interest in relation to the points addressed in expert appraisals.

The experts' declarations of interests are made public via the ANSES website (www.anses.fr).

2 Express pest risk assessment

2.1 Step 1. Initiation

2.1.1 Reason for performing the PRA

The reason for performing the PRA described here reflects the status of the virus in March 2019. Since then, its occurrence in different countries has changed and this aspect has been updated in Section 2.2.6.

Tomato brown rugose fruit virus (ToBRFV) is an emerging tobamovirus first reported in 2014 in Israel and 2015 in Jordan on greenhouse tomatoes. In 2018, it was also reported in Mexico (where its eradication is under way), and in the United States where it was eradicated in the same year. Within the European Union (EU), it was reported in Germany in 2018 (North Rhine-Westphalia where its eradication is under way) and in Italy (Sicily) in early 2019. This virus was also the subject of an alert in the *Bulletin de Santé du Végétal* (BSV) for the Provence-Alpes-Côte d'Azur (PACA) region in December 2018, with regular reminders in this PACA BSV. It was added to the alert list of the European and Mediterranean Plant Protection Organization (EPPO) in January 2019 and was the subject of an alert sheet issued by ANSES's Laboratory for Plant Health (LSV_2019_03_0027), and an alert issued in February 2019 by the members of ANSES's Expert Committee on "Biological risks for plant health".

2.1.2 PRA area

The PRA area is metropolitan France.

2.2 Step 2. Pest risk assessment

2.2.1 Taxonomy

Kingdom: Viruses and viroids
Order: Viruses
Family: *Virgaviridae*
Genus: *Tobamovirus*
Species: *Tomato brown rugose fruit virus* (ToBRFV)
Common name: Tomato brown rugose fruit virus
No synonyms

The virus was first described in 2016 in Jordan (Salem *et al.*, 2016). As a result, apart from the complete sequences of nine isolates (Israel, Jordan, Palestine, Germany, Mexico, United Kingdom and Italy, search conducted on 15.11.2019), five of which came from high-throughput sequencing, little information is currently available on its biological characteristics.
All nine isolates have very similar sequences (between 99.51% and 99.90% identity) (Cambrón-Crisantos *et al.*, 2018). The virus described in the different countries is therefore presumably the same (same origin) or has low variability.

Since this virus is a new emerging species, it has rarely been described. A few scientific publications, including a recent review (Oladokun *et al.*, 2019), present the main characteristics of this virus, which have been included in this report. Knowledge will be extrapolated from the other tobamoviruses and mentioned in the event of missing data, in order to reduce uncertainty. In addition, the literature resources are largely non-scientific in nature, since the descriptions of this virus (epidemiology, impacts and control measures) are found mainly in reports by public authorities, interviews with researchers and communication documents for the general public.

2.2.2 Pest overview

2.2.2.1 Life cycle

Tobamoviruses multiply exclusively in their host plants. Climate is not a limiting factor for virus establishment insofar as the host plant finds favourable climatic conditions for its establishment. Because of their high stability, tobamoviruses can survive without multiplying outside their host plant on any biological or inert media for several months or even years without loss of virulence (Roberts, 2014) and can even persist in processed food products (Colson *et al.*, 2010). They are spread via two modes of transmission: mechanical means and infected seeds.

- Mechanical means

Tobamoviruses can enter a plant through microdamage caused by physical contact with any virus-carrying media: biological media (human hands, plant debris, pollinating insects, etc.), inert media (soil, cardboard packaging/pallets, tools, clothing, vehicles, etc.) or irrigation water. Once inside, tobamoviruses multiply in infected cells at the contact site, spread from cell to cell and reach the vascular tissues before invading the entire plant. All organs of the host plant are therefore infectious.

- Infected seeds

Tobamoviruses can be present in the external tissues of infected seeds: outer coat and more rarely in the albumen. These viruses can penetrate through microdamage when the seedling, produced from the embryo, passes through the external tissues during germination. They will then develop in all the organs of the growing plant. The percentage of infected seedlings from a contaminated seed lot varies depending on the virus species belonging to the genus *Tobamovirus*, the host plants and the different studies on their transmission (Table 1). For TMV, this percentage varies from 0 to 21.8% for *Solanaceae* species (Table 1). The only data on the transmission rate of ToBRFV are those obtained by Davino[1] i.e. a 0.29% transmission rate from seeds to plantlets (data currently being published).

Table 1. Rates of contamination and transmission in seed-borne tobamoviruses

Species	Host plants	Seed contamination rate in %		Transmission rate from seeds to seedlings in %		Reference
Cucumber green mottle mosaic virus (CGMMV)	Cucurbitaceae	+ + + + +	84% NT NT 95% 100%	+ + + + +	2% NT 8% <1% 0.9%	Shargil *et al*., 2017 Clark and Adams, 1977 Kim *et al*., 2003 Reingold *et al*., 2015 Cordoba-Selle *et al*., 2007
Tobacco mosaic virus (TMV)	Solanaceae	+ + + + +	NT NT 100% NT 50%	- + - - NT	0% 21.8% 0% 0% NT	Broadbent, 1965 Genda *et al*., 2005 Pagán *et al*., 2014 Van Regenmortel *et al*., 2013 Clark, 1981
Tomato mosaic virus (ToMV)	Solanaceae	+ + + + +	NT NT NT NT 38%	+ - - + NT	NT 0% 0% NT NT	Taylor *et al*., 1961 Broadbent, 1965 Herrera-Vásquez *et al*., 2009 Clark and Adams, 1977 Clark, 1981

NT = Not Tested
Source: Adapted from Dombrovsky and Smith, 2017

[1] https://www.hortidaily.com/article/9079340/prevention-is-the-best-defence-for-tobrfv/

2.2.2.2 Host plants

Natural hosts: tomato (*Solanum lycopersicum* L.), pepper (*Capsicum annuum* L.), aubergine (*Solanum melongena* L.) (*Solanaceae*). In this document, the term "pepper" covers all fruits known by the common names "chilli peppers" and "sweet peppers". The term "variety" used in this document includes both (i) old varieties and (ii) hybrids resulting from crosses between plants bred for disease resistance, productivity, yield and taste.

Tomato

In the study conducted by Luria *et al.* (2017), all tomato varieties tested experimentally were found to be susceptible to ToBRFV, including F1 hybrids carrying tobamovirus resistance genes (*Tm-1, Tm-2, Tm-2*^{2} genes). Several recent studies of comparative genomics, transient expression of viral proteins and fusion/disruption of interspecies genes have enabled the identification of regions of the ToBRFV viral genome directly associated with resistance breaking in the tomato, in particular the gene coding for the movement protein, the main target recognised by *Tm-2* and *Tm-2*^{2} resistance in tomato infection by TMV and ToMV (Maayan *et al.*, 2018; Hak *et al.*, 2019).

It should be noted that the so-called "industrial" tomato varieties grown in the open field (intended for the production of tomato juice, sauce, concentrates, etc.) mostly lack tobamovirus resistance genes (R. Giovinazzo, SONITO, personal communication) and are also susceptible to ToBRFV.

Breeding programmes have been initiated by seed companies such as Syngenta and Limagrain to create tomato varieties resistant or tolerant to ToBRFV (E. Verdin, personal communication).

Pepper

In peppers, resistance to tobamoviruses is carried by the L locus (L1, L2, L3, L4). Varieties with these resistances appear to be less susceptible to ToBRFV than varieties without them (ASTA and HM Clause, 2019 and other sources[2,3]; Luria *et al.,* 2017).

Aubergine

ToBRFV was detected on aubergine in Mexico (Elota municipality, Sinaloa State) in December 2018. This is the first case reported on *S. melongena* (EPPO Reporting Service, 2019a). However, the host status of aubergine remains to be confirmed, in the light of observations reported in the scientific and non-scientific literature. According to Luria *et al.* (2017), no early (4 to 7 days post inoculation) or late (7 to 14 days post inoculation) symptoms were described on aubergine plants experimentally inoculated with ToBRFV and the diagnostic ELISA on inoculated plants was negative. In view of this information, the WG decided to consider aubergine in this risk assessment, while at the same time mentioning the current major uncertainties about its host status.

Experimental hosts (Luria *et al.* 2017):

- *Solanaceae*: tobacco (*Nicotiana benthamiana, N. clevelandii, N. tabacum cv. Samsun, N. glutinosa*), petunia (*Petunia x hybrida*), black nightshade (*Solanum nigrum*)
- *Amaranthaceae*: *Chenopodium murale, C. quinoa, C. amaranticolor (= C. giganteum; C. amaranticolor* is the Latin name given in the publication*)*

2 https://seedworld.com/tomato-brown-rugose-fruit-virus-tobrfv-threatens-the-tomato-and-pepper-industry/

3 https://www.nieuweoogst.nl/nieuws/2019/10/10/tomatenbedrijf-verdacht-van-besmetting-met-tobrfv,

Doubtful hosts

- *Impatiens* and *Cyclamen* are mentioned as host plants of tobamoviruses and are therefore included in the ToBRFV hygiene protocol of the Glastuinbouw Nederland, GroentenFruit Huis en Plantum (2019) without any further details.
- Cauliflower (*Brassicaceae*) is mentioned as a host plant of ToBRFV in Mexico without further details (SENASICA News, 2019).

Note:

Experimental transmission trials did not succeed in infecting potato (*Solanum tuberosum cv. Nicola*) (Luria *et al.*, 2017).

2.2.2.3 Symptoms

Tomato: chlorosis, mosaic and leaf mottling to a greater or lesser degree depending on the variety, sometimes with leaf narrowing. Browning and then drying of the calyx during the early stage of fruit development. Yellow or brown discoloration of the fruits with possible presence of rough areas on the surface making the fruits non-marketable. There may also be a decrease in the number and size of fruits (Luria *et al.*, 2017; Cambrón-Crisantos *et al.*, 2018; Menzel *et al.*, 2019, Salem *et al.*, 2016; Fidan *et al*., 2019).

However, these symptoms are not specific to ToBRFV. They can be confused with symptoms encountered in tomatoes infected by other viruses and in particular pepino mosaic virus (*Potexvirus*), potato virus Y (*Potyvirus*), tomato spotted wilt virus (*Tospovirus*) or physostegia chlorotic mottle virus (*Nucleorhabdovirus*) (Hanssen and Lapidot 2010; Gaafar *et al.* 2017).

Pepper: yellowing, mosaic and leaf blisters. Fruit ripening is irregular and necrosis of the peduncle may occur. Yellow or brown spots and stripes as well as necrosis, sometimes rough, may appear on fruits (Cambrón-Crisantos *et al.*, 2018). During experiments in some pepper varieties (cultivars Maor, Fiona, Romans and Lyri), ToBRFV caused a local hypersensitivity response (HR), multiplied in the whole plant, but was not associated with any systemic symptoms (Luria *et al.*, 2017).

Aubergine: Mexico[4] is the only country to have reported ToBRFV on aubergine and no symptoms have been described or shown in photos. There is therefore uncertainty about the expression of symptoms in this species when infected with the virus.

Experimentally, ToBRFV multiplies in the following host plants, without always being associated with symptoms: *Nicotiana benthamiana* (leaf lesions, plant death), *N. clevelandii* (leaf yellowing), *N. tabacum cv. Samsun* (leaf mottling), *N. glutinosa* (slight leaf mottling), *Petunia x hybrida* (asymptomatic), *Solanum nigrum* (light leaf mottling/asymptomatic), *Chenopodium murale* (slight leaf mottling and leaf necrotic lesions), *C. quinoa* (asymptomatic), *C. amaranticolor* (asymptomatic).

2.2.2.4 Detection and identification

Generic (biological, microscopic and serological indexing) and specific (molecular) techniques are available for the detection and identification of ToBRFV in plants (preferably leaves).

[4] https://www.hortidaily.com/article/9149139/mexico-positive-sample-for-tobrfv-in-aubergine/

Biological indexing of susceptible hosts can be used to detect tobamoviruses infecting tomatoes and peppers. Characteristic symptoms may be observed after inoculation of infected samples on susceptible tobacco, in particular *Nicotiana tabacum* cv. Xanthi and *N. glutinosa* (ISHI-Veg 2019).

Transmission electron microscopy observations reveal rigid particles of about 300 nm in length, typical of tobamoviruses.

This virus can also be detected by ELISA using commercially available serological reagents directed against other tobamoviruses similar to ToBRFV, such as tobacco mosaic virus (TMV) and/or tomato mosaic virus (ToMV). A serological reagent was developed by Luria *et al.* (2017) to specifically detect ToBRFV. However, it shows a slight cross-reaction with another tobamovirus, tobacco mild green mosaic virus (TMGMV). This reagent is not commercially available. Other serological reagents targeting tobamoviruses already exist, such as Agdia against TMV or Prime Diagnostics against ToMV (cited in Australian Government Emergency Measures, 2019). It should be noted that lateral flow assays or serological strips, marketed for the detection of tobamoviruses, are not very effective at detecting ToBRFV (Agdia, personal communication). These generic techniques, suited for pre-screening, cannot specifically identify ToBRFV. Only one serum has been recently developed by Loewe against ToBRFV, but its specificity has not been qualified[5].

Lastly, several molecular assays (RT-PCR) have been described for detecting ToBRFV from leaves using specific primers (Luria *et al.*, 2017; Alkowni *et al.*, 2019; ISHI-Veg, 2019) or generic primers (Li *et al.*, 2018). The amplified products, in particular those obtained with the generic primers, are then sequenced for accurate identification of the species and/or viral isolate. Some of these primers have also been validated for the detection of ToBRFV from seeds (Alkowni *et al.*, 2019; ISHI-Veg, 2019).

2.2.3 Is the pest a vector?

Yes ☐ **No** ☒

Not relevant

2.2.4 Is a vector needed for pest entry or spread?

Yes ☐ **No** ☒

Mechanical transmission by contact with living organisms (bumblebees, plants, seeds, humans) or inert media (cardboard/pallets, tools, clothing, vehicles, etc.) is possible for tobamoviruses. Transmission by arthropods, in particular pollinating insects, is therefore a secondary means of spread for these viruses and should be taken into account in this risk analysis. In particular, mechanical transmission via bumblebees has been demonstrated for ToBRFV (Levitzky *et al.*, 2019).

2.2.5 Regulatory status of the pest

Until 1 November 2019, ToBRFV was not considered a quarantine pest under Council Directive 2000/29/EC of 8 May 2000 on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community (as at 28 May 2019). In addition, it was added to the EPPO Alert List in January 2019.

From 1 November 2019, Implementing Decision (EU) 2019/1615 established emergency measures to prevent the introduction and spread of ToBRFV in the European Union (Annex 3). It covers (i) the prohibition of introduction and movement of ToBRFV into and within the European Union, (ii) the conditions for detection or suspected presence of ToBRFV, (iii) the monitoring of ToBRFV and its identification in Member States, (iv) the conditions for movement of plants for planting (including seeds), (v) the special requirements for the introduction into the EU of plants for planting (including

[5] https://www.loewe-info.com/tl_files/loewebiochemica-shop/pdf/flyer-ToBRFV%20180619.pdf

seeds). However, each Member State can determine whether measures should be taken when the virus is found in production areas.

Elsewhere in the world, emergency measures are being implemented by several countries.

Since March 2019, Australia has been applying detection tests using different techniques on imports of tomato and pepper seeds and requires a phytosanitary certificate from the country of origin[6].

In New Zealand, in view of the high risk represented by this virus and its probable transmission via seeds, the Ministry for Primary Industries (MPI) has included ToBRFV in the list of quarantine pests for which additional declarations are required on phytosanitary certificates accompanying pepper and tomato seeds from all origins (MPI, New Zealand Government, Import Health Standards: Seeds for Sowing, 19 March 2019).

In Mexico, the government has imposed regulatory controls on tomato and pepper seed imports[7]. These measures are detailed in Section 2.2.12.

In Turkey, with effect from 15 March 2019, imports of tomato and pepper seeds from contaminated countries (Jordan, Germany, Israel, Italy, Mexico) must be accompanied by a phytosanitary certificate with an additional declaration regarding the absence of ToBRFV. This additional declaration stipulates that the consignments have been analysed using the RT-PCR method and certifies that the goods are free from the virus (World Trade Organization, February 2019).

In the United States, from November 2019, the USDA (APHIS) required all lots of tomato and pepper seeds and plants for planting imported from countries where the virus is present to be officially tested and certified free from the disease. For fresh tomato and pepper fruits, pending the results of the in-depth risk analysis on the "fruit" pathway, APHIS requires fresh tomato and pepper fruits imported from Mexico, Israel and the Netherlands (countries authorised to export these fruits to the United States and known to harbour ToBRFV) to be inspected at the point of origin to ensure that they are free from disease symptoms[8].

2.2.6 Distribution

ToBRFV is an emerging tobamovirus first reported in 2014 in Israel and 2015 in Jordan on greenhouse tomatoes. In 2018, it was reported in Mexico and then in the United States, where it was declared eradicated in the same year. Within the European Union (EU), in 2018 it was reported in Germany (North Rhine-Westphalia, where it has been declared eradicated) and Italy (Sicily, where it is still present), then in 2019 in Italy again (Piedmont, NPPO of Italy, in EPPO Reporting Service (2019b), where it was declared eradicated in November 2019), in the United Kingdom (Skelton *et al.*, 2019; NPPO of the United Kingdom, 2019), in Greece[9] (NPPO of Greece, September 2019) and in the Netherlands[10]. There have also been reports from Turkey (Fidan *et al.*, 2019), Palestine (Alkowni *et al*., 2019), China (Yan *et al.*, 2019) and Spain (Figure 1).

Other unofficial reports/unconfirmed by local authorities were noted in Chile, Ethiopia, Sudan (ASTA and HM Clause, 2019) and Canada (Table 2).

A 2019 communication from SADER-SENASICA (the Mexican National Service of Agrifood Health, Safety and Quality)[11] states the origin of several infected seed lots and describes a potential invasion route with Israel as the origin and the Netherlands as a platform for long-distance virus spread. This

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[6] http://www.agriculture.gov.au/import/goods/plant-products/seeds-for-sowing/emergency-measures-tobrfv#how-were-emergency-measures-implemented

[7] https://seedworld.com/tomato-brown-rugose-fruit-virus-tobrfv-threatens-the-tomato-and-pepper-industry/

[8] https://www.aphis.usda.gov/import_export/plants/plant_imports/federal_order/downloads/2019/DA-2019-28.pdf

[9] http://www.minagric.gr/images/stories/docs/agrotis/Georgika_Farmaka/Fytoeigionomikos_Elegxos/ToRFV_nppo_tomato_bpi.pdf)

[10] https://www.nvwa.nl/nieuws-en-media/nieuws/2019/10/10/meldplicht-tobrfv-virus

[11] https://issuu.com/cesavesonora/docs/1_antecedentes_e_identificacion_tom

implies that the virus circulates through international trade and that its true global distribution is probably underestimated. Without more accurate data on the traceability of the seed lots examined, the WG is not in a position to refute or confirm this hypothesis.

The global distribution of ToBRFV in November 2019 is given in Table 2, which presents all reports (by local authorities or in the literature or press), while Figure 1 presents confirmed occurrences from official sources, validated by EPPO.

Table 2. Global distribution of ToBRFV in November 2019

Continent	***Distribution*** *(list countries, or provide a general indication, e.g. "present in West Africa")*	***Provide comments on the pest status in the different countries where it occurs*** *(e.g. widespread, native, introduced, etc.)*	***Reference***
America	Canada – Ontario*	Present	http://sinavef.senasica.gob.mx/ALERTAS/inicio/pages/single.php?noticia=3886 http://thegrower.org/news/tomato-brown-rugose-fruit-virus-identified-ontario https://www.greenhousecanada.com/news/growers-urged-to-take-precautions-against-new-tomato-virus-32925
America	Chile*	Unconfirmed	ASTA and HM Clause, 2019
America	United States – California	Absent, pest eradicated	Ling *et al*., 2019
America	Mexico	Present, restricted distribution**	NAPPO, 2018; Cambrón-Crisantos *et al*., 2018; Camacho-Beltrán *et al*., 2019; SADER-SENASICA, March 2019 and June 2019
Africa	Ethiopia*	Unconfirmed	ASTA and HM Clause, 2019
Africa	Sudan*	Unconfirmed	ASTA and HM Clause, 2019
Asia	China – Shandong	Present, few occurrences	Yan *et al*., 2019
Asia	Israel	Present, no details**	Luria *et al*., 2017
Asia	Jordan	Present, no details	Salem *et al*., 2016
Asia	Palestine	Present, no details	Alkowni *et al*., 2019
Asia	Turkey	Present, few occurrences	Fidan *et al*., 2019; NPPO of Turkey (2019)
Europe	Belgium	Absent, invalid record	http://www.promedmail.org/direct.php?id=20190607.6508658
Europe	Germany – North Rhine-Westphalia	Absent, pest eradicated	Menzel *et al*., 2019
Europe	Greece – Crete (south of Chania) and Triphylia	Present, few occurrences	http://www.minagric.gr/images/stories/docs/agrotis/Georgika_Farmaka/Fytoeigionomikos_Elegxos/ToRFV_nppo_tomato_bpi.pdf; http://www.haniotika-nea.gr/imerida-me-thema-ios-tis-kastanis-

Continent	***Distribution*** *(list countries, or provide a general indication, e.g. "present in West Africa")*	***Provide comments on the pest status in the different countries where it occurs*** *(e.g. widespread, native, introduced, etc.)*	***Reference***
			rytidosis-ton-karpon-tomatas/; NPPO of Greece (2019)
Europe	Italy – Sicily	Present, restricted distribution	NPPO of Italy, 2019; Panno *et al.*, 2019
Europe	Netherlands	Transient, under eradication	ASTA and HM Clause, 2019; https://www.gfactueel.nl/Glas/Nieuws/2019/3/Uitbraak-ToBRFV-in-Nederland-404408E/ https://www.dutchnews.nl/news/2019/10/blow-for-tomato-industry-as-highly-infectious-virus-arrives-in-nl/ https://english.nvwa.nl/topics/pest-reporting/contents/pest-reports https://www.dutchnews.nl/news/2019/10/five-more-cases-of-infectious-tomato-disease-found-in-westland-region/
Europe	Spain	Transient, under eradication	https://www.freshplaza.es/article/9168176/detectado-el-virus-rugoso-del-tomate-en-espana/; NPPO of Spain (2019)
Europe	United Kingdom – Kent	Transient, under eradication	Skelton *et al.*, 2019; NPPO of the United Kingdom (2019)

The WG has mentioned all countries for which information on the presence/absence of ToBRFV is available in the scientific literature or not and in the EPPO Global Database (GD).
The pest status of countries is according to the EPPO GD website when it is stated there (accessed 13 November 2019; https://gd.eppo.int/taxon/TOBRFV/distribution)
The pest status "Transient, under eradication" corresponds to countries where eradication measures have been taken by the NPPO, i.e. the pest is present but eradication is in progress (if successful, the status becomes "Absent, pest eradicated").

* = countries not mentioned in the EPPO GD
** = pest status probably underestimated. In view of the data available for these countries and published by the national authorities or in the scientific literature, the distribution of ToBRFV is widespread throughout the country

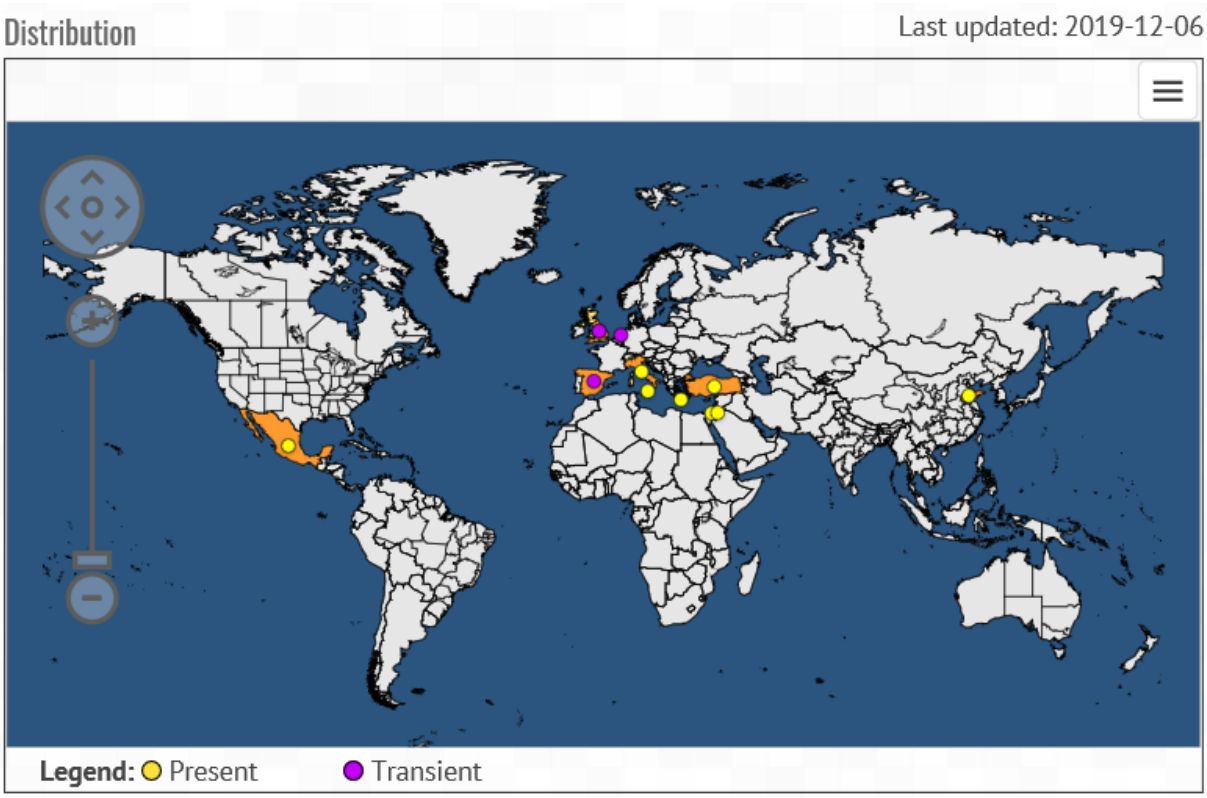

Figure 1. Global distribution of ToBRFV in December 2019[12]

(Source: EPPO GD, https://gd.eppo.int/taxon/TOBRFV/distribution, accessed on 06/12/2019)

2.2.7 Host plants and their distribution in the PRA area

Table 3 lists the host plants and their characteristics (surface areas, distribution) in the PRA area. Each of these host plants will then be discussed.

Table 3. Host plants and cultivated areas in the PRA area

Host scientific name (common name) / *habitats**	**Presence in PRA area (Yes/No)**	**Comments (e.g. total area, major/minor crop in PRA area, *major/minor habitats**)**	***Reference***
Solanum lycopersicum (Tomato)	Yes	Total tomatoes 4638 ha in 2018 of which: - Greenhouse tomatoes: 2020 ha - Open-field tomatoes for fresh (or direct) consumption: 295 ha - Open-field tomatoes for industrial processing 2323 ha	Agreste Chiffres & Données Agriculture, 2019
Capsicum annuum (Sweet peppers, chilli peppers)	Yes	807 ha in 2018	Agreste Chiffres & Données Agriculture, 2019
Solanum melongena (Aubergine)	Yes	536 ha in 2018	Agreste Chiffres & Données Agriculture, 2019

[12] Cancels and replaces the figure of 12/11/2019

Petunia sp.	Yes	30 ha of developed area* in 2018 14% of French purchases by weight of expenditure (3rd leading potted plant purchased in France – 14% of the market in € out of 109.7 million quantities purchased)	F. Robert, Astredhor, personal communication, 2019 https://www.valhor.fr/fileadmin/A-Valhor/Valhor_Images/EtudesInfographiePlantesannuellesDonnees2018_Kantar.png
Nicotiana tabacum sp. (Tobacco)	Yes	2706 ha in 2018	Agreste Chiffres & Données Agriculture, 2019

* developed area = for a given species, the same area is counted as many times as there are harvests of the species over the period in question (definition according to agreste.agriculture.gouv.fr)

The host plants considered are tomatoes, peppers and aubergines, as well as other host plants (petunia, tobacco and wild plants).

Tomato

The Bretagne and Pays de la Loire regions are the leading production areas in France, followed by the Provence-Alpes-Côte d'Azur (PACA) region and, to a lesser extent, the Pyrénées-Orientales *département* and Nouvelle-Aquitaine region (soil-less glasshouses) (Figure 2) (Agreste Infos Rapides, 2017).

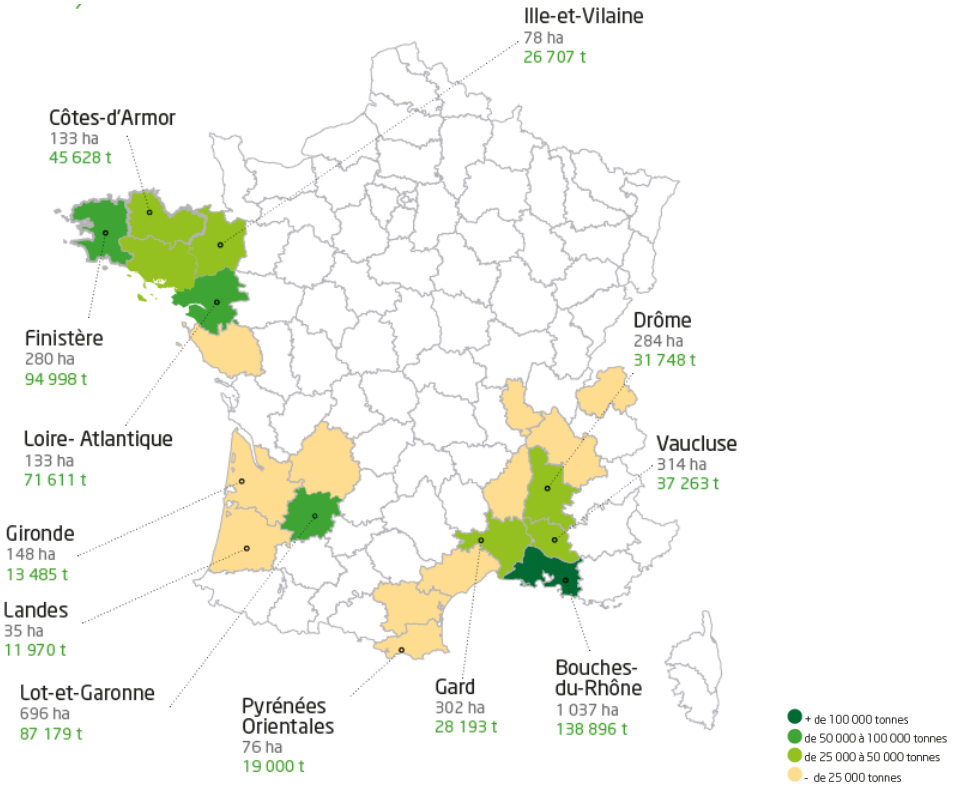

Figure 2. Breakdown of French tomato production in 2017

(Source: Agreste, development of FranceAgriMer key figures 2017 (2018))

Tomatoes are grown:

- in protected conditions: glasshouses (98% soil-less), unheated plastic/multi-span tunnels
- open-field for tomatoes for industrial processing (area: 75% in the south-east and 25% in the south-west, FranceAgriMer, 2018)
- small plots for amateur production and direct sale (APREL hearing).

In the regions of Bretagne and Pays de la Loire, tomato production is carried out almost exclusively in protected conditions. In the PACA region, 40% of tomato production is in protected conditions, the remainder is in the open field (APREL hearing).

The average plantation area in soil-less glasshouses is 3 hectares because producers mainly specialise in tomatoes (there is diversification into cucumbers in the Val Nantais). The average plantation area under plastic tunnels is 2 hectares per farm and concerns a large number of diversified vegetable producers (aubergine, winter salads, etc.) (APREL hearing).

The total area of tomatoes grown in France was 4,638 ha in 2018 (Table 4), i.e. 1.5% of the surface area under vegetable crops (total vegetable area was 307,778 ha in 2018, Agreste Chiffres & Données Agriculture, 2019). Total production was 683,804 tonnes for the same year, i.e. 12% of total vegetable crop production in 2018 in metropolitan France. Equivalent data for 2017 are shown in Figure 3.

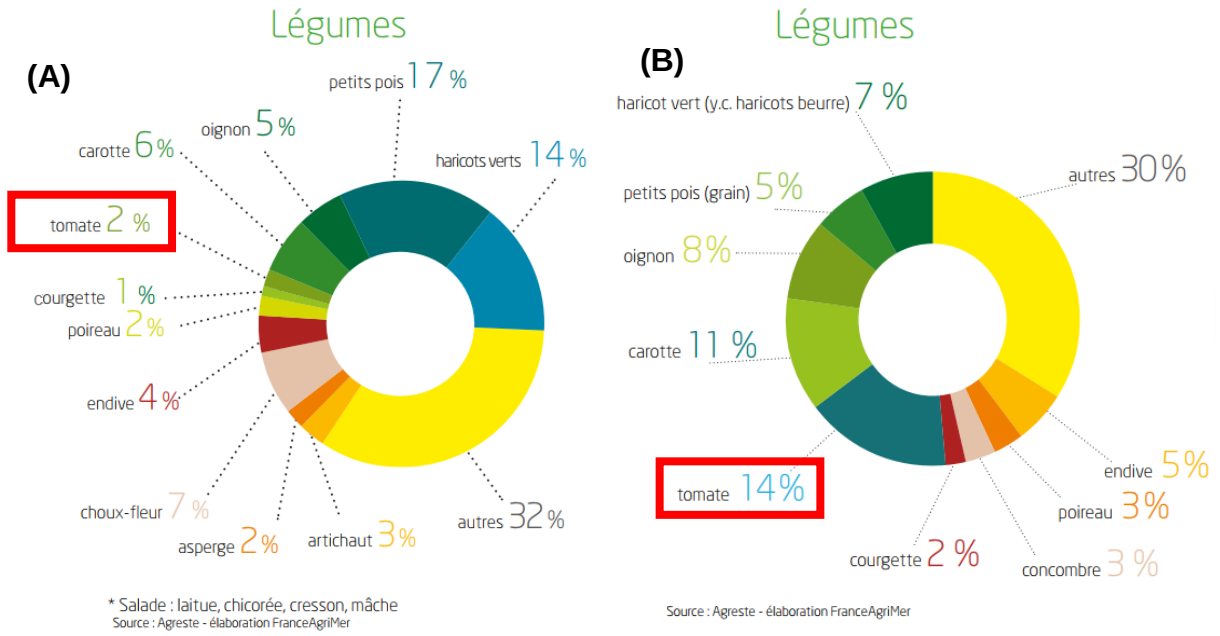

Figure 3. Production areas (A) and volumes (B): weight of different vegetable species in France in 2017

Caption: (A) : Légumes = Vegetables, Haricots verts = green bean, Petits pois = green pea, Oignon = onion, Carotte = carrot, Tomate = tomato, Courgette = courgette, Poireau = leek, Endive = endive, Choux-fleur = cauliflower, Asperge = asparagus, Artichaut = artichoke, Autres = other; (B) : Légumes = Vegetables, Haricot vert (y.c. haricot beurre) = green bean (including butter bean), Petit pois (grain) = green pea (seeds), Oignon = onion, Carotte = carrot, Tomate = tomato, Courgette = courgette, Concombre = cucumber, Poireau = leek, Endive = endive, Autres = other (Source: Agreste, development of FranceAgriMer key figures 2017 (2018))

Tomatoes are also grown in kitchen gardens, although their distribution in the PRA area is unknown. Nevertheless, the production volume was estimated to be 400,000 tonnes in 2018 (CTIFL, 2019). Based on the average production per plant (2.5 kg) and the average density (5 plants/m²), it is possible to estimate a surface area of 3,200 hectares in kitchen gardens.

In France, according to a survey carried out in 2013 by the Regional Service for Statistical and Economic Information (SRISE) of the Pays de la Loire Regional Directorate for Food, Agriculture and Forestry (DRAAF) on vegetable cultivation practices, the use of grafted tomato plants is widespread in soil-less production (87% over the whole country, 100% of the area in Pays de la Loire) (R. Bernard, SRISE DRAAF Pays de la Loire, personal communication).

To a lesser extent, when producing soil-grown tomatoes in protected conditions (e.g.: greenhouse), the use of grafted plants is very widespread (75% in the Pays de la Loire region and 50% nationally). Grafted plants seem to be used much less in soil-grown outdoor production.

Grafted plants are produced in three stages, generally carried out by the same nurseryman:

(1) emergence of the seedlings used for the rootstock and scion;
(2) grafting, carried out in workshops whose techniques differ according to the nurserymen, performed by specialised workers;
(3) growing of the grafted plant. Two months are needed to produce a grafted plant (compared to 3 weeks to one month without grafting).

Pepper

Peppers are grown in the southern regions of France, in particular in PACA (27%) followed by Nouvelle-Aquitaine (18%) and Centre (14%) (Disar, 2018), on a total area of 807 ha (Table 4).

Aubergine

Aubergines are mainly grown in the PACA region (26%) followed by Nouvelle-Aquitaine (24%) and Occitanie (21%) regions (Disar, 2018) for a total area of 536 ha.

Table 4. Statistics on tomato, pepper and aubergine crops in metropolitan France in 2017 and 2018

Vegetables	Developed area (ha)		Yield (100 kg/ha)		Harvested production excluding gardens (tonnes)		Harvested production that goes to processing excluding gardens (tonnes)	
	2017	2018	2017	2018	2017	2018	2017	2018
Aubergine	**473**	**536**	**551**	**522**	**26,073**	**27,984**		
Sweet peppers and chilli peppers	**809**	**807**	**345**	**375**	**27,887**	**30,292**	**-**	**-**
Open-field tomatoes for fresh or direct consumption	299	295	464	452	13,868	13,320	0	0
Open-field tomatoes for industrial processing	2,384	2,323	757	687	180,507	159,697	177,890	153,419
Greenhouse tomatoes	2,003	2,020	2,937	2,532	588,309	511,492	0	0
Total tomatoes	**4,686**	**4,638**	**1,670**	**1,476**	**782,684**	**684,509**	**177,890**	**153,419**

(not including seeds)
Source: Annual Agricultural Statistics 2017-2018, Agreste Chiffres & Données No. 2019-16 published in November 2019
- = no numerical data indicated

Moreover, the areas devoted to the production of tomato, pepper and aubergine seeds in France are minimal: seed production has occupied an average of 13.32 ha over the last five years for tomatoes, 3.4 ha for pepper and 0.56 ha for aubergines, which constitutes less than 0.2% of the total French area intended for the production of seeds of fine vegetable species (including tomato, pepper and aubergine) (Table 5).

Table 5. Areas (in ha) for the production of tomato, pepper and aubergine seeds in metropolitan France over the last 5 years

	2015	**2016**	**2017**	**2018**	**2019**
Tomatoes	16.2	11.47	10.64	18.42	9.9
Peppers	3.59	2.76	3.67	5.53	1.51
Aubergine	0.12	0.24	0.6	1.56	0.3
Total fine vegetables	10,748	11,145	9,776	10,217	NA

"Total fine vegetables" includes dill, various herbs, orache, artichoke, asparagus, aubergine, basil, beetroot, cardoon, carrot, celery, chervil, chia, leaf chicory, curled-leaved endive, broad-leaved endive, witloof/Belgian endive, broccoli, cabbage, Chinese cabbage, Brussels sprouts, Savoy cabbage, cauliflower, curly kale, kohlrabi, red cabbage, other cabbage, spring onion, chives, pattypan squash, cucumber, coriander, gherkin, butternut squash, courgette-squash, watercress, shallot, spinach, fennel, lettuce, lamb's lettuce, melon, turnip, onion, onion mother bulbs, sorrel, parsnip, watermelon, parsley, pepper, dandelion, leek, chard, other vegetables, turban squash, radish, rhubarb, rocket, thyme and tomato.

NA = not available

Source: GNIS (2019) and https://www.gnis.fr/etudes-donnees-statistiques-semences/

Other host plants

Petunias are ornamental plants found in non-agricultural areas (urban green spaces, local and industrial infrastructures), as they are used in flower beds in private gardens and in the public sector (e.g. in parks). The developed production area is estimated to be 30 ha and is scattered throughout the country (F. Robert, Astredhor, personal communication, 2019).

Tobacco is a regulated crop in France, with 2,706 hectares under cultivation in 2018. This area is spread over 45 *départements* (Figure 4) mainly in the south-west.

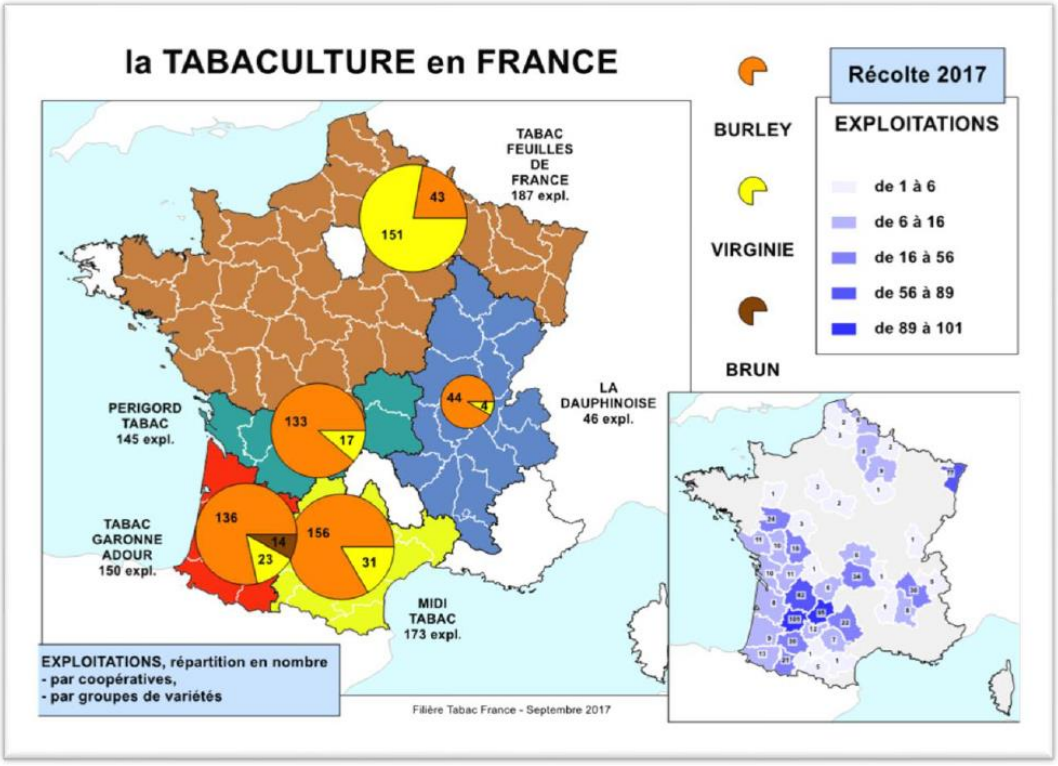

Figure 4. Map of tobacco cultivation in France in September 2017

(Source: France Tabac, agriculture.gouv.fr)

The species *Chenopodium* sp. and *Solanum nigrum*, experimental host plants of ToBRFV, are wild plants found throughout France. *Solanum nigrum* is considered a native plant in France (Figure 5). Only *Chenopodium quinoa* is grown on a small scale mainly for the consumption of its seeds but also as a medicinal plant and for the manufacture of essential oils.

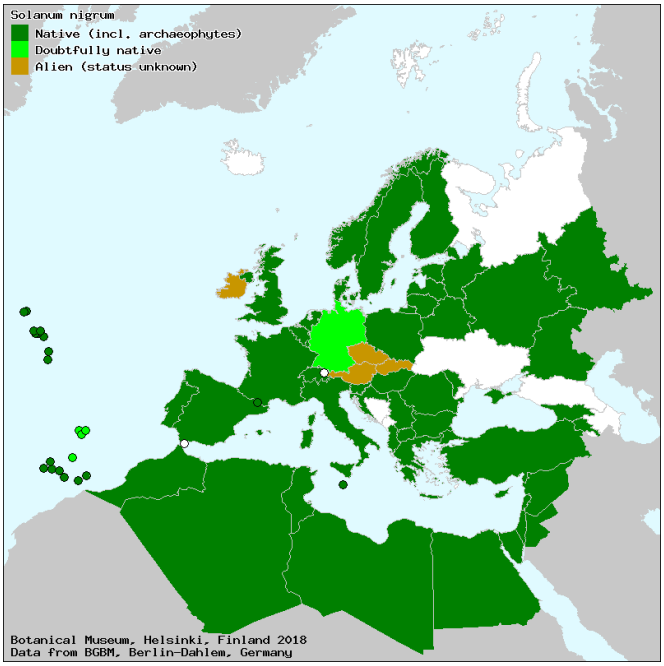

Figure 5. Map of European and Mediterranean distribution of *Solanum nigrum* showing its status

(Source: Euro+MED (2006-) http://euromed.luomus.fi/euromed_map.php?taxon=449446&size=medium)

2.2.8 Pathways for entry

The relevant pathways identified by the WG were:

- seeds
- plants for planting
- fruits
- other possible pathways: any inert media in contact with the crop and hives (commonly used for pollination)
- passengers carrying plant material or via shoes/clothing

2.2.8.1 Tomato, pepper and aubergine seeds

Regulations	Solanaceae seeds may be imported into the PRA area providing they meet special requirements with regard to other regulated pests (Directive 2000/29/EC). Implementing Decision (EU) 2019/1615 (Annex 3) stipulates that tomato and pepper plants for planting (including seeds) intended for the European Union must be accompanied by a phytosanitary certificate and fulfil one of the following requirements: (a) they originate in a third country free from ToBRFV (b) they originate in an area free from ToBRFV (c) where they originate in third countries or areas other than those referred to above: ○ In the case of seeds, they have been found free from ToBRFV following official sampling and testing on a representative sample using appropriate methods. Implementing Decision (EU) 2019/1615 stipulates that plants for planting (including seeds), originating within the Union territory, may only be moved within the Union if they are accompanied by a plant passport and fulfil one of the following requirements: (a) they originate in areas where the ToBRFV is known not to occur (b) in the case of seeds, they have been found free from ToBRFV following official sampling and testing on a representative sample using appropriate methods.
Interceptions	Interceptions of seeds from different origins are regularly reported in EUROPHYT for various reasons, such as non-compliance with particular requirements. Since 1 November, according to Implementing Decision (EU) 2019/1615, all tomato and pepper seeds and plants for planting introduced into the Union must be officially checked at the point of entry into the Union or at the place of destination, in accordance with the provisions laid down in Commission Directive 2004/103/EC. As a result of this, ToBRFV-contaminated seeds were intercepted during their introduction into the European Union from Israel in November 2019 (EUROPHYT, online database, 2019).

Flows

The quantities of tomato seeds imported into France are shown in Table 6. Overall, there has been a drastic reduction in seed imports into France over the last six years. The volumes of seeds imported from the same country also vary greatly from one year to the next. These variations are explained by the GNIS: "Seed imports are limited, so any variation has a noticeable effect, especially since 83% of imports are due to three companies. A change in strategy in one country can have a significant effect on developments from one year to the next. This was the case for one company that switched from China in 16/17 to India in 18/19." For this reason, and given the collapse in total volumes between 2015 and 2016, the analysis of these data focused on the last three years, where these volumes are of the same order of magnitude. Over the last three years, the tomato seeds imported into France have mainly been produced outside the EU, particularly in Asia (Vietnam, China, Thailand, India) with 81% of the average imported production since 2016. Nevertheless, it is important to note that there have been regular but low volumes of imports from Israel over the last six years. The main risk comes from imports from China, still significant although decreasing sharply, where the virus has been reported since 2018, and to a lesser extent from the regular low-volume imports from Israel.

Table 6. Import volumes (quintals) into France of tomato seeds by country of production since 2012

Imports in quintals	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	Average over the last three years	% over the last three years
India	10.61	24.81	26.53	28.37	9.77	0.78	0.59	3.71	28%
China	235.89	139.41	29.02	11.92	1.64	1.6	7.2	3.48	27%
Vietnam	2.87	605.27	4.65	3.95	1.76	3.76	2.28	2.60	20%
Thailand	4.48	0.42	1.28	24.09	0.61	0.84	0.84	0.76	6%
Guatemala	0.08	1.43	245.23	0	0.6	0.12	0	0.24	2%
Israel	0.46	8.72	0.23	6.72	0.19	0.24	0.11	0.18	1%
Turkey	0.46	0.58	0.15	0.07	0.06	0.13	0.03	0.07	1%
Brazil	5.38	1.1	1.59	75.1	0.05	0.02	0	0.02	<1%
Mexico	0.5		0	0	0.01	0	0.01	0.01	<1%
Jordan		0.01	0.01	0				-	-
Other	2.16	3.85	1.92	3.55	1.5	1.62	2.83	1.98	15%
Total:	**262.89**	**785.6**	**310.61**	**153.77**	**16.19**	**9.11**	**13.89**	13.06	100%

Source: GNIS (2019)
In grey, imports from contaminated countries, taking into account the occurrence of ToBRFV in these countries

Pepper seeds imported into France come mainly from Asia (China, Thailand, India, Vietnam), with 86% of imported seeds and to a lesser extent from South America (Peru, Chile, Brazil), with 6% of imports (Table 7). The at-risk imports are the small but regular volumes from Israel from 2013 onwards, as well as imports from China, Mexico and Turkey over the last two years.

Table 7. Import volumes (quintals) into France of pepper seeds by production country since 2012

Imports in quintals	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	Average	%
China	104.31	76.25	39.09	52.7	60.08	95.25	48.61	68.04	55%
Thailand	14.42	9.06	17.54	22.58	22.03	36.59	16.97	19.88	16%
India	19.15	1.66	9.76	11	11.28	11.41	38.32	14.65	12%
Madagascar				0.03	8.05	19.11	0.21	6.85	6%
Vietnam	2.3	3.76	4.79	2.3	3.71	5.44	2.05	3.48	3%
Peru	2.23	13.16	1.67	0.88	1.93	1.8	1.03	3.24	3%
Chile	2.03	4.34	2.97	1.82	1.47	8.61	1.41	3.24	3%
USA	0.07	0.26	4.31	1.61	0.05	0.32	0.61	1.03	1%
Brazil	4.16	0.05	0.67	0.04	0.23	1.24	0.51	0.99	1%
Israel	0.02	0.04	0.06	0.05	0.03	0.09	0.08	0.05	<1%
Jordan			0.09		0	0		0.03	<1%
Mexico	0	0	0.02	0.01	0.05	0.02	0	0.01	<1%
Turkey	0	0.03	0.03	0	0	0.01	0.02	0.01	<1%
Other	0.64	0.66	-0.02	0.31	2.08	1.82	1.11	2.31	2%
Total:	**149.33**	**109.27**	**80.98**	**93.33**	**110.99**	**181.71**	**110.93**	**123.83**	**100%**

Source: GNIS (2019)
In grey, imports from contaminated countries, taking into account the occurrence of ToBRFV in these countries

More than half of the aubergine seed imports into France come from Asia: 60% from China (country where ToBRFV has been present since 2018) and Thailand. Minor volumes are imported regularly from Israel, where ToBRFV has been present since 2014 (Table 8).

Table 8. Import volumes (quintals) into France of aubergine seeds by production country since 2012

Imports in quintals	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	Average	%
China	27.46	23.26	9.24	23.9	7.08	42.58	22.35	22.27	41
Thailand	4.14	4.77	16.93	8.53	3.02	24.25	11.69	10.48	19
Burkina Faso	1.42	0	0	2.7	17.83	21.04	19.2	8.88	16
Madagascar	0	0	0	7.83	2.01	4.95	7.33	3.16	6
Benin	0	0	0	0.63	18.26	0.6	0	2.78	5
India	5.86	0.66	0.95	1.01	1.08	6.55	2.3	2.63	5
Peru	0.48	0.96	0	1.99	3.09	1.74	2.12	1.48	3
Côte d'Ivoire	0	0	0	0	0	0	6.2	0.89	2
Vietnam	0.07	0	0.01	0.04	0.77	0.62	2.46	0.57	1
Turkey	0.5	0.1	0.06	0.1	0.31	0.69	0.45	0.32	1
Chile	0.04	0.25	0.21	0.4	0.45	0.21	0.55	0.30	1
Israel	0	0.06	0.01	0.02	0.04	0.08	0.01	0.03	<1%
Other	0.47	0.01	0.01	0.32	0.37	0.66	0.49	0.33	<1%
Total:	**40.44**	**30.01**	**27.42**	**47.49**	**54.29**	**103.99**	**75.15**	**54.11**	**100%**

Source: GNIS (2019)
In grey, imports from contaminated countries, taking into account the occurrence of ToBRFV in these countries

Association at origin

- If production takes place in a contaminated area, the probability of the virus being associated with seeds from contaminated plants is very high (Dombrovsky & Smith, 2017).
- Tobamoviruses are found in the outer coat of the seed (external tissue) and to a lesser extent in the albumen. For ToBRFV in Italy, the only data available show that 8% of the seed lots tested were infected[13].
- According to the Mexican authorities, the introduction and spread of ToBRFV may be due to and facilitated by commercial seed imports. They noted in particular the coincidence between the first detections of ToBRFV in Israel and the dates on which seed lots were introduced from Israel into Mexico. These imports take place throughout the year, increasing the likelihood of contaminated seeds spreading over a large part of the country. Thus, out of 165

[13] https://www.hortidaily.com/article/9079340/prevention-is-the-best-defence-for-tobrfv/

	seed lots of tomato (*Solanum lycopersicum*) and pepper (*Capsicum annuum*) imported into Mexico in 2018 and tested, 60 were positive[14]. ○ The effectiveness of seed treatments against other viruses found in external tissues (e.g. PepMV) has not been shown for the disinfection of ToBRFV. However, these treatments could still disinfect the seeds if ToBRFV is found on the surface but not deep within.
Survival/increase in prevalence during transport	Survival during transport is very likely. During transport, the low metabolic activity of the seeds reduces multiplication of the virus. Prevalence can be considered stable for viral particles present in the albumen or cotyledons. Viral particles cannot multiply on the seed surface.
Transfer	The rate of virus transmission from a contaminated seed to a seedling is low to zero (Dombrovsky and Smith, 2017). For ToBRFV in Italy, the only data available show a transmission rate to seedlings of 0.29% (Davino, 2019) (data currently in publication).
Likelihood of entry	**Very likely**
Sources of uncertainty	○ current management conditions at the origin: consideration, application and effectiveness of surface treatment ○ transmission rate of ToBRFV ○ extrapolated responses from the characteristics of other species of the genus *Tobamovirus*

Application of the regulations reduces the overall assessment of risk

14 https://issuu.com/cesavesonora/docs/1_antecedentes_e_identificacion_tom;
http://sinavef.senasica.gob.mx/Eventos/DetalleEvento.aspx?item=12;
http://sinavef.senasica.gob.mx/ALERTAS/inicio/pages/archive-main.php?querystring=tomato%20brown%20rugose&pag=3#

2.2.8.2 Tomato, pepper and aubergine plants for planting

Regulations	The introduction of plants of *Solanaceae* intended for planting, other than seeds and products listed in Annex III, Part A, items 10 (Tubers of *Solanum tuberosum* L., seed potatoes), 11 (Plants of stolon- or tuber-forming species of *Solanum* L. or their hybrids, intended for planting) or 12 (Tubers of species of *Solanum* L. and their hybrids), shall be prohibited from third countries, with the exception of European and Mediterranean countries (Directive 2000/29/EC). Special requirements apply to these plants depending on the pest status of the country of origin with regard to certain harmful organisms such as *Ralstonia solanacearum* for example. Implementing Decision (EU) 2019/1615 (Annex 3) stipulates that tomato and pepper plants for planting intended for the European Union must be accompanied by a phytosanitary certificate and fulfil one of the following requirements: (a) they originate in a third country free from ToBRFV (b) they originate in an area free from ToBRFV (c) where they originate in third countries or areas other than those referred to above: ○ In the case of plants for planting, they have been produced on a production site known to be free from ToBRFV on the basis of official inspections carried out at the appropriate time to detect ToBRFV, and are derived from seeds which either (i) originate in areas free from ToBRFV or (ii) have undergone official testing on a representative sample using appropriate methods, and have been found to be free from ToBRFV. Implementing Decision (EU) 2019/1615 stipulates that plants for planting, originating within the Union territory, may only be moved within the Union if they are accompanied by a plant passport and fulfil one of the following criteria: (a) they originate in areas where the ToBRFV is known not to occur (b) In the case of plants for planting, they originate in a production site where ToBRFV is known not to occur on the basis of official inspections carried out at the appropriate time to detect ToBRFV, and are derived from seeds which either (i) originate in areas free from ToBRFV or (ii) have undergone official testing on a representative sample using appropriate methods, and have been found to be free from ToBRFV.
Interceptions	Since 1 November 2019, according to Implementing Decision (EU) 2019/1615, all tomato and pepper seeds and plants for planting introduced into the Union must be officially checked at the point of entry into the Union or at the place of destination, in accordance with the provisions laid down in Commission Directive 2004/103/EC. To date, ToBRFV has not been found on plants during these checks (according to the EUROPHYT database accessible online for the year 2019).

Flows	Data not available: there is no CN8 code for imports of plants for planting of *Solanum lycopersicum* or *Capsicum* spp. to characterise origins, quantities and frequencies. However, interceptions of seedlings carried out at EU level show that there have been flows of various origins in recent years (EUROPHYT available online). According to APREL, tomato plants are mainly produced in France. Nevertheless, grafted plants have been imported into the Bretagne region from the Netherlands or Great Britain. In addition, there is a pathway for grafted plants from Sicily that are grown in France. Lastly, there is a pathway for importing tomato and pepper plants from Spain to France (G. Castrillon, personal communication).
Association at origin	○ If production takes place in a contaminated area, the probability of the virus being associated with the plant is high, since the virus is present in all plant organs ○ There is no treatment/cultivation practice able to reduce the viral load/prevalence in the plant ○ Prophylactic measures against viruses transmitted by contact have proved to be effective (e.g. pepino mosaic virus). Similar measures applied to ToBRFV, still to be defined, could reduce the association of the virus with materials.
Survival/increase in prevalence during transport	Survival during transport is likely. Seedlings are usually transported for a short period of time, less than 24 h in refrigerated trucks (APREL hearing); therefore, an increase in prevalence is unlikely. However, it could increase if consignments of infected plants are transported and handled together with consignments of healthy plants, especially during loading/unloading.
Transfer	Transfer is very likely: a vector for transfer is unnecessary and the products are intended for planting
Likelihood of entry	**Very likely**
Sources of uncertainty	○ no quantification of current flows from contaminated regions ○ the lack of any guarantee as to current management conditions at origin, in particular consideration and application of GSPP standards and the use of prophylactic measures suited to ToBRFV ○ extrapolated responses from the characteristics of other species of the genus *Tobamovirus*

Application of the regulations on this entry pathway (tomatoes and peppers) reduces the overall assessment of risk

With comparable flow volumes, the likelihood of entry through plants is higher than through seeds. Nevertheless, international trade, and especially trade in tomato and pepper seeds towards the PRA area, is greater than imports of plants for planting from European and Mediterranean countries, which seem to be non-existent or limited to a few producing countries in the EU (such as the Netherlands, Great Britain, Italy, Spain). These data lead the WG to place seeds as the entry pathway posing the greatest risk.

2.2.8.3 Tomato, pepper and aubergine fruits

Regulations	Directive 2000/29/EC lays down special requirements for imports of tomato and aubergine fruits into the European territory as regards *Keiferia lycopersicella*. For *Capsicum* fruits originating in certain third countries, the requirements are in respect of *Anthonomus eugenii* and *Thaumatotibia leucotreta*. There are therefore no special requirements with regard to viruses for this entry pathway. Implementing Decision (EU) 2019/1615 does not concern imports of tomato fruits, pepper and aubergine (Annex 3).
Interceptions	Interceptions of tomato fruits from different origins are regularly reported in EUROPHYT for various reasons (administrative non-compliance, detection of harmful organisms such as *Tuta absoluta*, etc.). The same is true for peppers, which can carry fruit flies for example. As a reminder, fruits are not concerned by Implementing Decision (EU) 2019/1615. Nevertheless, ToBRFV-contaminated tomato fruits were intercepted during their introduction into the European Union from Egypt in November 2019 (EUROPHYT, online version, 2019).
Flows	Tomato fruits imported into France come mainly from Morocco (55%) and from the following European countries: Spain, Belgium, the Netherlands and Italy (41%). Of these countries, Italy has been contaminated with ToBRFV since 2018 and the Netherlands and Spain since 2019 (Table 9).

Table 9. Volumes of imports into France of fresh tomatoes between 2016 and 2018 (CN8 code 07020000, per 100 kg)

Quantity in 100 kg	2016	2017	2018	Average	%
MOROCCO	2,852,312	2,840,056	3,029,685	2,907,351.0	55%
SPAIN	1,341,530	1,228,494	1,389,978	1,320,000.7	25%
BELGIUM	593,447	489,959	297,995	460,467.0	9%
NETHERLANDS	327,035	271,451	298,251	298,912.3	6%
ITALY	78,850	64,616	62,864	68,776.7	1%
POLAND	62,323	52,416	57,401	57,380.0	1%
TUNISIA	49,127	41,014	54,693	48,278.0	1%

Source: Eurostat
Countries exporting less than 1% are not mentioned in this table
In grey, imports from contaminated countries, taking into account the occurrence of ToBRFV in these countries

Over the last three years, almost 98% (97.8%) and 96% (95.98%) of imported peppers (CN8 codes 07096010 and 07096099 respectively) have come from countries not contaminated by ToBRFV between 2017 and 2018 (Tables 10 and 11). Small volumes were imported from Germany (where ToBRFV was declared present in 2018 and subsequently eradicated). However, more than half of the peppers (CN8 code 07096010) come from the Netherlands and Spain, where ToBRFV has been present since 2019. Such import volumes from these two countries therefore constitute a risk in the future.

Table 10. Volumes of imports into France of sweet peppers, fresh or chilled, between 2016 and 2018 (CN8 code 07096010, per 100 kg)

Quantity in 100 kg	2016	2017	2018	Average	%
SPAIN	1,018,097	980,895	988,817	995,936.3	65%
MOROCCO	280,999	274,508	349,911	301,806.0	20%
NETHERLANDS	63,109	76,090	96,758	78,652.3	5%
BELGIUM	81,315	79,122	37,966	66,134.3	4%
GERMANY	42,532	45,447	49,266	45,748.3	3%

Source: Eurostat
Countries exporting less than 1% are not mentioned in this table
In grey, imports from contaminated countries, taking into account the occurrence of ToBRFV in these countries

Table 11. Volumes of imports into France of peppers of the genus *Capsicum* or of the genus *Pimenta*, fresh or chilled, between 2016 and 2018 (excluding codes for processing and the CN8 code 07096010) (CN8 code 07096099 per 100 kg)

Quantity in 100 kg	2016	2017	2018	Average	%
MOROCCO	122,136	121,661	125,974	123,257.0	85%
SPAIN	8,931	8,706	13,616	10,417.7	7 %
DOMINICAN REPUBLIC	3,246	2,976	3,402	3,208.0	2%
GERMANY	4,718	562	1,038	2,106.0	1%

Source: Eurostat
Countries exporting less than 1% are not mentioned in this table
In grey, imports from contaminated countries, taking into account the occurrence of ToBRFV in these countries

<table>
<tr><td></td><td>Over the last three years, aubergine imports into France have mainly come from Spain (81% on average), a country where ToBRFV was not present in 2018. The remaining imports have come from other European countries, with minor volumes in 2018 from Germany and Italy (countries where ToBRFV has been described since that year) (Table 12).

Table 12. Volumes of imports into France of fresh or chilled aubergines between 2016 and 2018 (CN8 code 07093000, per 100 kg)
<table>
<tr><th>Quantity in 100 kg</th><th>2016</th><th>2017</th><th>2018</th><th>Average</th><th>%</th></tr>
<tr><td>SPAIN</td><td>412,916</td><td>387,323</td><td>414,726</td><td>404,988.3</td><td>81%</td></tr>
<tr><td>BELGIUM</td><td>39,012</td><td>36,188</td><td>14,992</td><td>30,064.0</td><td>6%</td></tr>
<tr><td>NETHERLANDS</td><td>16,775</td><td>18,775</td><td>33,803</td><td>23,117.7</td><td>5%</td></tr>
<tr><td>GERMANY</td><td>14,061</td><td>16,254</td><td>17,266</td><td>15,860.3</td><td>3%</td></tr>
<tr><td>ITALY</td><td>12,411</td><td>13,184</td><td>11,158</td><td>12,251.0</td><td>2%</td></tr>
</table>
Source: Eurostat
Countries exporting less than 1% are not mentioned in this table
In grey, imports from contaminated countries, taking into account the occurrence of ToBRFV in these countries</td></tr>
<tr><td>Association at origin</td><td>○ All parts of the fruit carry the virus
○ Contaminated fruits that are asymptomatic or show very few symptoms may enter commercial trade
○ There is no known effective, approved treatment that targets the fruit surface</td></tr>
<tr><td>Survival/increase in prevalence during transport</td><td>It is very likely that the infectivity of the virus is maintained during transport. The prevalence of ToBRFV may increase if consignments of infected fruit are transported and handled together with consignments of healthy fruit, especially during loading/unloading.</td></tr>
<tr><td>Transfer</td><td>- The probability of virus transfer from fruit intended for consumption to greenhouse plants in production is quite low. This transfer could take place if the same company packages imported tomatoes and locally-produced tomatoes.
- The transfer could also take place, with low probability, via people present on a farm (farm workers, technicians, etc.) if they consume fresh fruit imported from at-risk areas.
- There is no crossover between plants for planting and fruit for consumption because the plants do not pass through the cooperatives that package the fruit (APREL hearing)</td></tr>
<tr><td>Likelihood of entry</td><td>Moderately likely
The WG considers that entry of ToBRFV via contaminated fruit is less likely than entry via plants and seeds.</td></tr>
</table>

	In addition, the volumes imported into the PRA area from countries reporting the presence of ToBRFV (Netherlands, Italy) are regarded as low, thus reducing the risk.
Sources of uncertainty	○ Transfer ○ Phytosanitary status of countries exporting fruit to France

As fruit is not included in the new regulations, this pathway becomes the one presenting the greatest risk.

Other possible pathways: any inert media in contact with the crop

- Any container used to transport fruit or plants will present a similar risk of entry to the materials being transported.

Human activity: passengers carrying plant material or via shoes/clothing

- Passengers bringing back infected plants, seeds or fruits constitute a pathway with a risk equivalent to the materials being transported.
- Visitors between risk areas and PRA area are liable to carry the virus on all inert media.

In the absence of regulations, there is a high likelihood of ToBRFV entering the PRA area via imports of seeds and plants for planting.

Nevertheless, the regulation introduced on 1 November 2019 provides for a mandatory check for ToBRFV on plants for planting and seeds from third countries or circulating within the EU. There is no obligation to check for ToBRFV on susceptible plant material other than tomato and pepper, or fruits intended for consumption. Although implementation of this legislation will help reduce this risk from plants for planting and seeds, the risk of entry is still moderate in view of the risk posed by fruits intended for consumption. These will not be checked because (i) they are not covered by the current legislation and (ii) contaminated fruits may enter commercial channels as they may be asymptomatic or show very few symptoms.

The sources of uncertainty are related to the import volumes of tomato, pepper and aubergine plants (the host plant status of the latter remains to be confirmed) for planting, the behaviour of ToBRFV in particular in terms of transmission, and the effectiveness of seed treatments.

Overall rating of the likelihood of entry	*Low* ☐	*Moderate* ☒	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* ☒	*High* ☐

2.2.9 Likelihood of establishment outdoors in the PRA area

Rating of the likelihood of establishment outdoors	*Low* ☐	*Moderate* ☐	*High* ☒
Rating of uncertainty	*Low* ☐	*Moderate* ☒	*High* ☐

Note: For the likelihood of outdoors establishment in the PRA area, only open-field tomato crops were considered. Due to their production specificity, the vast majority of pepper and aubergine productions are grown in protected conditions (except for organic farming, which is done in open field).

The likelihood of establishment was assessed for open-field tomatoes taking into account the following:

- In 2018, the cultivation of open-field tomatoes in France for fresh consumption and industrial processing purposes represented 2,618 hectares or nearly 57% of the total tomato production area (Agreste Chiffres & Données Agriculture, 2019). These crops are mainly concentrated in the south-east of France.
- The cultivation of tomatoes (as well as peppers) grown in private gardens and on balconies should also be taken into account in this expert appraisal, even if no figures are available.

- Tomato varieties for industrial processing grown in the open field lack tobamovirus resistance genes and are susceptible to ToBRFV.
- Climate is not a limiting factor in the development of the virus.
- Cultivation practices favour the burial of plant debris in the soil at the end of the growing period, thus maintaining the virus in contaminated areas (very long survival of the virus with persistence of infectivity).
- Nevertheless, human activities are limited for open-field crops compared to greenhouse crops on commercial farms. These activities contribute little to the likelihood of establishment.
- The establishment of ToBRFV on open-field crops has only been observed in Mexico, but in many situations: the extensive nationwide campaign conducted in 2019 revealed the presence of the virus in 20 of the country's 32 states, representing 53 contaminated municipalities. Of all the detections of ToBRFV in these 53 municipalities, 55.82% of the positive samples came from open-field production (32.2% from greenhouses and 11.98% from seed lots)[15].
- Herbaceous ToBRFV host plants such as *Chenopodium murale* or *C. quinoa* or *Solanum nigrum* for example, or certain ornamental species such as *Petunia hybrida*, are found outdoors in the PRA area. Nevertheless, these species have experimental host status and have so far never been described as naturally infected.

In view of this evidence, the likelihood of ToBRFV becoming established outdoors in the PRA area is considered high in areas with extensive tomato, pepper and aubergine crops and where host plants are available. Uncertainty is moderate due to doubts about the infection status of potential reservoir plants in the current area of distribution.

2.2.10 Likelihood of establishment in protected conditions in the PRA area

Rating of the likelihood of establishment in protected conditions	*Low* ☐	*Moderate* ☐	*High* ☒
Rating of uncertainty	*Low* ☒	*Moderate* ☐	*High* ☐

For tomatoes, peppers, and aubergines grown in protected conditions, the likelihood of establishment is assessed in the same way as outdoor establishment with one exception, namely the frequency of human activities. In addition, on these farms, the intensive handling, the high density of plants grown in protected conditions and the highly efficient means of virus transmission favour the establishment of ToBRFV.

The likelihood of establishment was assessed for tomatoes grown in protected conditions taking into account the following:

- Area: in 2018, greenhouse tomato cultivation in France represented 2,020 hectares, i.e. nearly 43% of the total tomato production area (Agreste Chiffres & Données Agriculture, 2019). This production is mainly distributed in the areas of Bretagne, Val Nantais, Pays de la Loire and Pyrénées-Orientales.
- In the study conducted by Luria *et al.* (2017), all tomato varieties tested experimentally were found to be susceptible to ToBRFV, including F1 hybrids carrying tobamovirus resistance

[15] http://sinavef.senasica.gob.mx/Eventos/DetalleEvento.aspx?item=12; http://sinavef.senasica.gob.mx/ALERTAS/inicio/pages/archive-main.php?querystring=tomato%20brown%20rugose&pag=3#

genes (*Tm-1, Tm-2, Tm-2²* genes). These varieties are mainly used in the PRA area in tomato crops intended for consumption produced for more than 30 years. It is therefore likely that most tomato varieties and F1 hybrids grown in France for the production of fruits intended for consumption are susceptible to ToBRFV.

- The climate is favourable for development of the virus.
- On these farms, the intensive handling, the high density of greenhouse plants and the highly efficient means of virus transmission favour the establishment of ToBRFV. In soil-less culture, the average density is 2.3 to 2.5 stems/m² at the start of the growing period (3 stems/m² at the end); this figure can rise to 3.6 to 4 stems/m² depending on the type (APREL hearing). In glasshouses, planting generally takes place in October/November for a harvest beginning in February and continuing until October (long cycle), then the plants are uprooted and there is a cleanout period of one month (October) before replanting for a new cycle. Production is shifted from March to October under unheated plastic tunnels (shorter cycle) (there is sometimes planting in February with slight heating).
- Observed establishment of the virus in greenhouses in the current area of distribution as described, for example, in Germany, Mexico, Israel and Italy.

In view of this, the likelihood of ToBRFV becoming established in protected conditions in the PRA area is considered to be high. Uncertainty is low.

2.2.11 Spread in the PRA area

Rating of the magnitude of spread	*Low* ☐	*Moderate* ☐	*High* ☒
Rating of uncertainty	*Low* ☒	*Moderate* ☐	*High* ☐

Natural spread

As previously stated in Section 2.2.4, the main means of spread of ToBRFV (which can be qualified as natural spread) is mechanical transmission by contact between plants. In general for tobamoviruses, the high density of plants in crops, the frequency of passage, the stability of the virus and the efficiency of contact transmission facilitate the rapid development of outbreaks. Studies on the spread of tobamoviruses in a tomato crop showed that TMV and ToMV, after spreading along a row, became generalised throughout the whole plot. In the absence of prophylactic measures, it is estimated that 35 days after the crop has been set up, the percentage of infected plants reaches 100% (Astier *et al.*, 2001). For ToBRFV, this rapid transmission along the rows in a greenhouse was also described by Davino (personal communication via questionnaire) in Italy and by Alkowni in Palestine (personal communication via questionnaire).

Natural transmission involving phloem-feeding vectors has not been described in tobamoviruses. Nevertheless, transmission by mechanical contact between pollinating insects harbouring tobamoviruses on their body surface (abdomen, legs, etc.) and plants is possible. In particular, mechanical transmission via bumblebees has been demonstrated for ToBRFV (Levitzky *et al.*, 2019).

Runoff water is a potential carrier of infectious viral particles.

Human-assisted spread

- Long-distance spread occurs from the movement of seeds, plants for planting, and fruits.
- Within production sites, humans can contribute to the mechanical transmission of ToBRFV via grafting activities and all plant handling. Indeed, the cultivation of tomatoes and peppers in protected conditions requires a huge number of handling operations (disbudding, tying, picking, etc.). For example, in places where fruits intended for consumption are produced,

two to three operations a day may be carried out by workers (trellising, pinching, etc.), unlike in the production of tomatoes for industrial processing, where few interventions are required. Workers may also be required to move from one greenhouse to another according to needs. These activities help the virus spread rapidly within a farm.

- For soil-less crops, harvesting teams and equipment are not shared among producers, except for the trucks that transport harvested fruit to the centralisation cooperative for storage. The fruits are packed in single-use cardboard boxes, and wood shavings are used for fragile fruit. For open-field production, harvesting equipment is often shared between producers and by the same cooperative (APREL hearing).
- Most hives, mainly of bumblebees marketed for tomato pollination, are not retrieved afterwards. They are for single use or may be moved around by the same producer. A contaminated hive in one production unit is therefore liable to contaminate the whole farm.
- Moreover, recycled materials used for collecting fruits (plastic crates, wooden boxes, etc.) and transporting plants for planting (pallets, plastic crates with one or two extensions, etc.) from nurseries, move between sites by means of shared vehicles (trucks), contributing to the spread of the virus between production establishments.
- While the persistence of infectivity of tobamoviruses on inert media has been documented, this survival time for ToBRFV is not currently known. For the production of tomatoes for industrial processing, harvesting equipment is often shared between producers in the same cooperative (APREL hearing).
- The movement of seasonal workers and pickers between sites and across borders is not proven; however, an operator (technical advisor) can transport ToBRFV by moving from an infected farm to a healthy farm.
- Burial or composting of contaminated plant debris after cultivation allows the spread of tobamoviruses via contaminated soil (Smith and Dombrovsky, 2019), particularly by shoes, travellers and long-distance transport.

Large-scale spread by traded plants has been illustrated in Mexico and Israel.

In Mexico, according to the presentations (PowerPoint – web links) produced by the Mexican Ministry of Agriculture, the primary cause of spread of the virus in the country seems to be from seeds. The extensive nationwide campaign carried out revealed the presence of the virus in 20 of the country's 32 states, representing 53 contaminated municipalities. ToBRFV has been found in the main tomato- and pepper-producing regions and in particular in the states of Sinaloa, Yucatán, Tamaulipas, Zacatecas, Michoacán, Cuanajuato, Jalisco and Baja California (Figure 6).

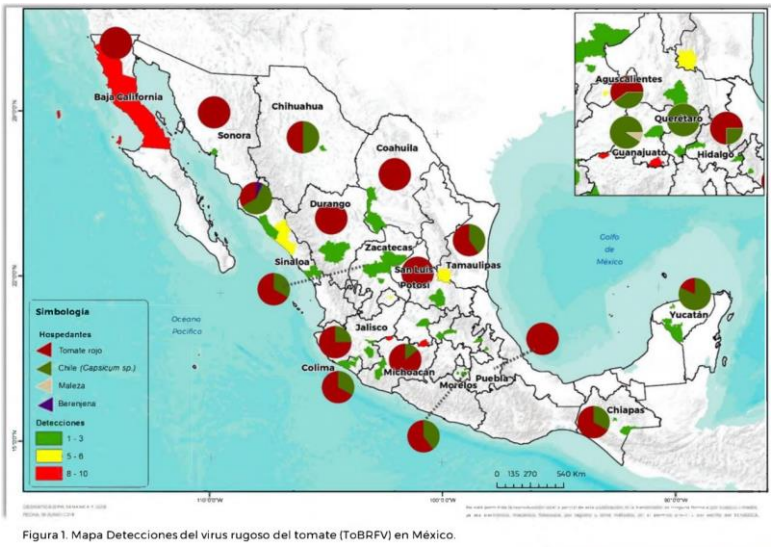

Figure 6. ToBRFV detection map in Mexico

Caption: Host plants (pies): red = tomato, green = pepper, grey = weeds, purple = aubergine; Number of cases detected (geographical areas): green = 1 to 3, yellow = 5 to 6, red = 8 to 10 (Source: Infos SENASICA, 2019)

In southern Israel, the first report of ToBRFV infecting tomatoes was made between October and November 2014 in the village of Ohad. This outbreak was not treated immediately and in February 2015, the disease spread to new tomato crops in southern Israel (Melilot, Beit Ezra and Achituv), probably due to visits by agronomists and professional inspectors or through the entry of contaminated untested plants or seeds. After seven months, the disease spread to the Ramat Negev region. Later, the disease spread to the Arava Valley in the south-east and the Beit Shean region in north-eastern Israel (Luria *et al.*, 2017; Figure 7).

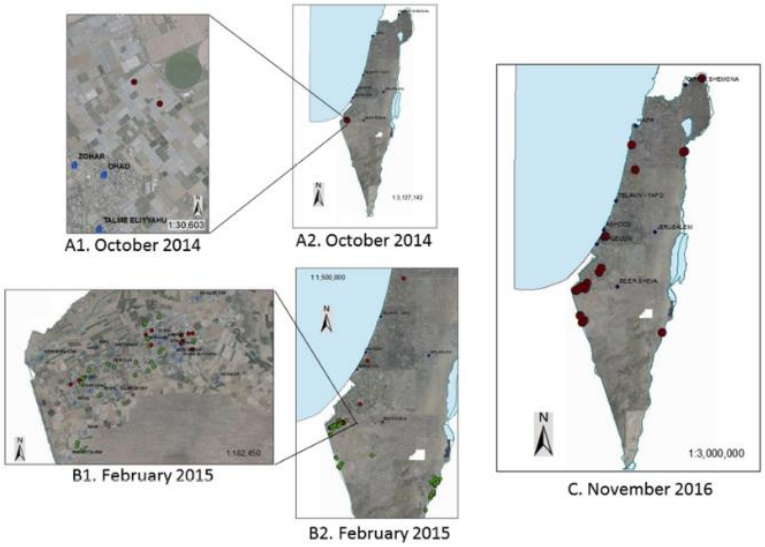

Figure 7. Monitoring the distribution of the new tobamovirus disease in tomatoes grown in greenhouses in Israel

Caption: Monitoring the distribution of the new tobamovirus disease in tomatoes grown in greenhouses in Israel. A1-A2, The outbreak incident of viral infection in greenhouses of Ohad village in September-October 2014. A1 Detailed picture of the infected area and surroundings. A2, The isolated occurrence of the disease depicted in Israel's map. B1-B2, Tomato disease spread as detected by the official Israeli PPIS survey on February 2015. B1, Detailed picture of the infected areas and surroundings. B2, Enlarged picture of the surroundings. C, The up to date disease status across the country in November 2016. Red dots represent positive detection of the virus tomato plants in the infected growing area. Blue dots represent negative detection of the virus in tomato plants. (Source: Luria *et al*., 2017).

2.2.12 Impact in the current area of distribution

Rating of the magnitude of impact in the current area of distribution	*Low* ☐	*Moderate* ☐	*High* ☒
Rating of uncertainty	*Low* ☒	*Moderate* ☐	*High* ☐

Impacts

The impacts associated with ToBRFV are mainly economic.

No data on the quantification of damage in terms of yield losses are mentioned, but incidence measurements are available. The term incidence can be interpreted as the rate of diseased plants in a production area, a contamination rate that is likely to have a negative impact on the yield or market value of the fruit. It is important to remember that for plants grown under protected conditions, such as tomatoes, annual yield fluctuations are normally very small and a yield loss of more than 10% can be regarded as having a massive impact (according to the EPPO Decision-support scheme for quarantine pests 11-17053 PM5/3 (5)).

The sources of uncertainty are related to the diversity of cultivars (cvs.) and their susceptibility to ToBRFV, the range of incidences that varies between different sites, and the virus reporting or detection times during the growing cycle. For example, the incidence varies depending on when it is measured (at the beginning or end of the cycle). In its current area of distribution, the incidence of the disease ranges from 10 to 100%. The impact of ToBRFV described by the different countries is as follows:

In southern Israel, the first report of ToBRFV infecting tomatoes was made between October and November 2014 in the village of Ohad, on cvs. Mose and Ikram, non-grafted or grafted on cv. Arnold rootstock, grown in six greenhouses under anti-insect netting (50-mesh, or 300 µm) on a single farm on 30 acres (about 12 ha) of land. Symptomatic plants showed a slight mosaic pattern on the leaves, occasionally accompanied by leaf narrowing and yellow spotted fruits (representing 10-15% of the fruits of a symptomatic plant) (Luria *et al.*, 2017).

In Jordan (Jordan Valley), in April 2015, a cv. Candela tomato crop grown in greenhouses showed mild foliar symptoms at the end of the season, but strong rugose symptoms on fruits that greatly affected the market value of the crop. The incidence of the disease was close to 100% (Salem *et al.*, 2016). Similar symptoms were observed on peppers during the winter growing periods of 2015 and 2016: all symptomatic samples tested revealed infection with tobacco mild green mosaic virus (genus *Tobamovirus*) and half of them with ToBRFV (Salem *et al.*, 2016).

In Mexico, the virus was first described in tomatoes and peppers in September-October 2018 in the states of Michoacán and Guanajuato. In 2019, an extensive nationwide campaign revealed the presence of the virus in 20 of the country's 32 states, representing 53 contaminated municipalities. Of all the detections of ToBRFV in these 53 municipalities, 55.82% of the positive samples came from open-field production, 32.2% from greenhouses and 11.98% from seed lots. It is important to stress that the virus was detected at all phenological stages of the crop, from flowering to fruiting, with symptoms present in 55% of infected plants (SENASICA News, 2019 and [16]).

In Palestine, in the north of the West Bank (Qalqilya, Jenin and Tubas districts), tomatoes - especially cvs. Ikram and Azmeer – showed symptoms reminiscent of those caused by TMV, in some cases affecting up to 100% of plants: ToBRFV was positively identified on all these symptomatic plants.

16 http://sinavef.senasica.gob.mx/Eventos/DetalleEvento.aspx?item=12; http://sinavef.senasica.gob.mx/ALERTAS/inicio/pages/archive-main.php?querystring=tomato%20brown%20rugose&pag=3#

Although pepper is not mentioned as being affected in Palestine, a photograph of symptoms on this plant suggests that pepper plants have been found to be infected (Alkowni *et al.*, 2019).

In the United States (September 2018), no data on the incidence of ToBRFV in the infected greenhouse in California is described (Ling *et al.*, 2019).

In Germany, 25 hectares and 50,000 plants were affected. Because ToBRFV was detected late in the season (early October 2018), the impact was limited (around 10% of tomatoes grown in the affected greenhouses showed symptoms). All affected plants were destroyed and the greenhouses disinfected, along with all surfaces and objects in contact with the tomato crop. The disease is considered to be eradicated (EPPO Reporting Service, 2019c).

In Italy, approximately 10-15% of tomatoes grown in six greenhouses in Sicily (late 2018) and in one 30,000 m² hydroponic greenhouse in Piedmont (May 2019) were affected, although no severe symptoms on fruits were observed (EPPO Reporting Service 2019d and 2019b respectively).

In Turkey, Fidan *et al.* (2019) stated that the disease was reported from 27 diseased tomato samples taken from two greenhouses (of which around 20% of the total area of 0.7 ha showed symptoms) in the region of Antalya, the main centre for off-season tomato production in Turkey, in January 2019. Symptoms observed were leaves with chlorotic mosaic, mottling, rugosity and occasional narrowing, as well as necrotic spots on the peduncle, calyces and petioles, and the fruit was rough with chlorotic and necrotic patches.

In China, the infection rate of ToBRFV was estimated to be around 50% in three tomato greenhouses (4000 m^2) in the east of the country in Shandong province (April 2019). Severe symptoms on fruits were observed (Yan *et al.*, 2019).

In the United Kingdom, leaf mosaic symptoms in a tomato production greenhouse in Kent (southern England) in July 2019 were associated with ToBRFV. No information on the impact of the virus in this production area was described (Skelton *et al.*, 2019).

In Greece, symptomatic tomatoes were observed in a production greenhouse (1500 m^2) in August 2019 in the region of Chania (island of Crete), with the proportion of infected plants reaching 80%. The presence of ToBRFV was confirmed in September 2019 and official investigations were carried out in Crete to search for other outbreaks and determine its origin (NPPO of Greece).

In Spain, in October 2019, symptoms of apical chlorosis associated with ToBRFV were observed on 0.25% of the plants in a 1.38 hectare tomato production greenhouse (EPPO Reporting Service, 2019e)

In the Netherlands in November 2019, the NPPO of the Netherlands reported that two production greenhouses (on their second harvest) covering an area of 12 ha were infected. Fourteen more positive results from other greenhouses are awaiting confirmation, which would bring the area affected to 345 ha. The first report described cross-infection with PepMV, delayed fruit ripening and 8% of fruits showing symptoms on the 3 ha of greenhouses (NPPO NL, 2019).

Control measures

Possible control measures are generally chemical, genetic, cultivation practices/operations and biocontrol. For ToBRFV:

- Chemical: there is currently no effective virucidal compound without a phytotoxic effect.
- Genetic: no sources of resistance have so far been deployed in crops. Tolerances and even resistances have reportedly been identified in tomatoes and are currently being assessed.
- Biocontrol: no ToBRFV control methods using macro-organisms, microbial mediators, plant defence stimulators or premunition have been described. Premunition (or cross-protection), which consists in infecting susceptible plants with an attenuated strain, has been used in the past to control ToMV. This artificial inoculation, applied to the plants before planting, provides protection against possible infection by more aggressive strains of the same virus. Controlling ToBRFV by premunition is not currently feasible since no naturally attenuated strain, or strain artificially modified with mutagenic agents to make it hypovirulent, has been described.

Existing control measures are mainly prophylactic. In the countries concerned in its current area of distribution, different control measures have been applied:

In Mexico, the country where the situation is of greatest concern, regulated material includes tomato, pepper and aubergine seeds, seedlings and cuttings, whether in greenhouses, the open field or nurseries. The measures applied are regulatory or prophylactic.

- According to the regulatory measures, when regulated plant material is imported, the accompanying phytosanitary certificate must state that it is free from ToBRFV and a sample must be sent to an accredited laboratory or to the national reference laboratory for virus analysis. The consignment is then only permitted to enter the country if the test is negative. For example, several tomato seed lots were analysed in 2018 and 2019. Twenty-two and 97 tomato seed lots were found positive in 2018 and 2019 respectively. At the same time, 223 seed lots were declared negative: 34 lots of aubergine, 94 of tomato and 105 of pepper. The origins of these different lots were not indicated (SADER-SENASICA, 2019).

  Mexican farms concerned by regulated material must be notified to the competent services and must have appropriate sanitary measures and facilities in place. Traceability has been strengthened with regard to the origin of propagated material, mainly through the creation of a positive list of establishments authorised to market regulated plant material, the tracking of propagated material by the establishment (labelling of lots, records of cultivation and marketing) and regular inspections by SENASICA officials, which are documented in written reports. If necessary, checks with PCR analyses are carried out. Material leaving the establishment must also be notified to the authorities and obtain a movement permit (SADER-SENASICA, 2019).
- There are several types of prophylactic measures, which include both crops grown in protected conditions and in the open field:
  - Strict cleaning of facilities (greenhouse), including equipment for trellising and staking of crops (greenhouse and open field) using benzoic acid-based products;
  - Restricted access with foot baths and protection against insect movements;
  - Washing and disinfection of hands, clothing, tools, equipment, agricultural materials used in farm work, and containers used during harvesting activities;
  - Work tools must be exclusive to each greenhouse building or each field;
  - A cleanout period or crop rotation with non-susceptible species.

In the event of suspicion or discovery of the presence of the virus, the material should be destroyed by incineration after being left to dry on site, and after informing the authorities (SADER-SENASICA, 2019).

In Israel, it was not possible to implement an eradication programme quickly enough, leading to the disease spreading throughout the country. At present, the disease is established in most facilities growing tomatoes in protected conditions in Israel and a national disease management programme has been put in place (Luria *et al.*, 2017).

No details are given in the publications about any actions taken following the reports in Palestine. Nevertheless, the reply to the questionnaire sent states that all plants in the greenhouse were incinerated but not immediately after the identification of ToBRFV (O. Alabdallah, personal communication via questionnaire).

The same is true in Jordan, where no information is given on the follow-up in the field in response to these reports, nor on the extension (or not) of the virus in subsequent years.

In the United States, all plants in the affected greenhouse were destroyed (Ling *et al.*, 2019). The disease is considered to be eradicated.

In Germany, all plants in the contaminated greenhouses as well as the substrates were incinerated. The greenhouses were disinfected with benzoic acid (Menno Florades®), along with all surfaces and

objects in contact with tomato production[17]. The disease is considered to be eradicated (EPPO Reporting Service, 2019c).

In Italy, phytosanitary measures have been applied to contain the outbreak in Sicily, including uprooting and burning of infected plants and disinfection of facilities. In Piedmont, these same measures have led to ToBRFV being eradicated (EPPO Reporting Service, 2019f).

In Turkey, eradication measures have been applied in a demarcated area including the infected area. Surveys are being carried out to detect the presence of ToBRFV in tomato and pepper production areas throughout the country (EPPO Reporting Service, 2019g).

In China, measures to combat ToBRFV have not been mentioned.

In the United Kingdom, all plants in the affected greenhouse were destroyed by the grower in accordance with National Plant Protection Organisation guidelines (Skelton *et al.*, 2019)

In Greece, phytosanitary measures have been implemented, in particular the complete destruction of greenhouse plants by incineration followed by decontamination of structures with 0.5% NaClO (C. Varvieri, Benaki Institute, personal communication).

In Spain, phytosanitary measures have been taken to eradicate the disease. Investigations were also conducted in six production greenhouses that received the same seed lot as the contaminated greenhouse (EPPO Reporting Service, 2019e).

In the Netherlands, strict hygiene measures are applied at production sites, including restricted access, and disinfection or replacement of clothing, machinery, equipment, surfaces and packaging materials. For all fruit harvested at the place of production, hygiene measures are applied even in the packaging area, including disinfection of packaging material. After removal of the crop and cleaning of the greenhouse, the production site will be monitored, mainly through laboratory testing, to verify the absence of the virus in the following crop. Specific monitoring will be intensified, targeting both neighbouring companies and those using the same packaging station (NPPO NL, 2019).

2.2.13 Potential impact in the PRA area

Rating of the magnitude of impact in the area of potential establishment	*Low* ☐	*Moderate* ☐	*High* ☒
Rating of uncertainty	*Low* ☒	*Moderate* ☐	*High* ☐

In view of:

- Cultivation practices in the PRA area. In the PACA region, fear of the arrival of ToBRFV in tomato greenhouses in 2019 changed crop management and behaviour by professionals in the sector. In particular, there was better control of the entry/exit of agricultural equipment and of visitor movements in greenhouses (C. Goillon, APREL, personal communication).
- The lack of any chemical (no effective plant protection products), genetic (not yet available) and biocontrol (no beneficial organisms, no premunition) solutions.
- The extent of the damage observed in the virus's current area of distribution, especially in Israel and Mexico, as described in Section 2.2.12.
- The importance of the tomato on the French market:
  - The tomato is the most popular vegetable consumed by the French in volume, with just over 13.9 kg per household per year[18].

17 https://www.landwirtschaftskammer.de/landwirtschaft/pflanzenschutz/gemuesebau/tobrfv.htm

18 https://www.lesfruitsetlegumesfrais.com/fruits-legumes/legumes-fruits/tomate/carte-identite

- Tomatoes are by far the leading vegetable crop in France with 712,000 tonnes produced in 2018, ahead of carrots with 535,000 tonnes. France is the fifth largest producer of tomatoes in Europe.
- At the production stage, turnover in 2016 was more than 6 billion euros for the entire "Fruit and Vegetable" sector, including about 3 billion euros for fresh vegetables (FranceAgriMer, 2018).
- In 2016, there were 30,900 farms specialising in vegetable production. This figure was 30,860 in 2010, of which 32% (i.e. 9,790 farms) were growing tomatoes (Agreste, Recensement Agricole 2010).
- The tomato is also a very important vegetable-patch hobby crop. It was estimated to account for 400,000 tonnes in 2018[19] (Ctifl, 2019).
- Production of peppers is more limited, with 31,000 tonnes per year.
- With regard to the relative export weight in value of different vegetables (excluding potatoes), tomatoes come first with 26% of the total weight of exports in 2017 (Figure 8). Nevertheless, not all these tomatoes are necessarily produced in France and may be re-exports. In any case, and besides the probable production losses, the presence of ToBRFV in France could reduce export markets to countries whose regulations would require virus-free production sites or commodities with specific requirements.

- Other host plants may also be concerned, such as pepper and aubergine, in terms of yield losses rather than export losses, as these vegetables probably account for less than 1% of export weight.

The potential impact in the PRA area is estimated to be high with low uncertainty.

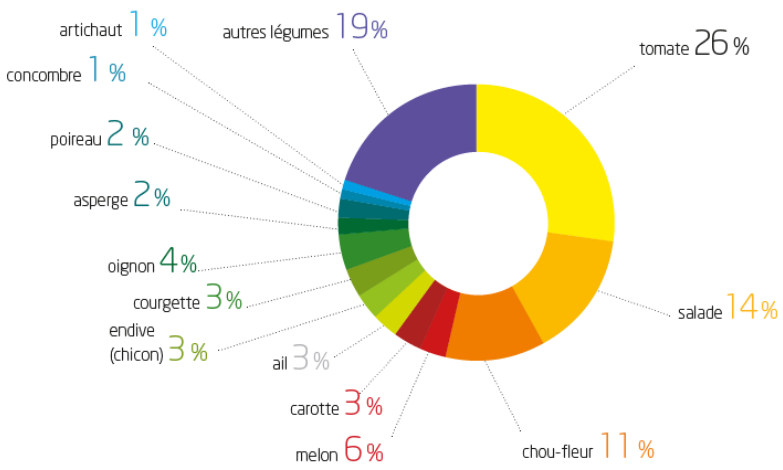

Figure 8. Relative weight in value of different vegetables in exports (excluding potatoes) (average 2008 to 2017)

Caption: Artichaut = artichoke, Concombre = cucumber, Poireau = leek, Asperge = asparagus, Oignon = onion, Courgette = courgette, Endive = endive, Ail = garlic, Carotte = carrot, Melon = cantaloupe melon, Choux-fleur = cauliflower, Salade = lettuce, Tomate = tomato, Autres légumes = other vegetables (Source: GTA/French Customs, development of FranceAgriMer key figures 2017 (2018))

19 http://www.ctifl.fr/DocPdf/Kiosque/Etude/tomatejardinsfamiliaux19.pdf?17/09/2019%20155119

2.2.14 Identification of the endangered area

The endangered area is an area where ecological factors favour the establishment of a pest whose presence in the area will result in economically important loss.

As a reminder, the area of potential establishment where an impact will occur includes both commercial production areas and private gardens where host plants are grown. However, the endangered area may be restricted to areas of large-scale production or marketing of tomatoes (in protected or open-field conditions), as well as areas of pepper production. These are mainly the regions of western France (Bretagne, Pays de la Loire), Provence-Alpes-Côte d'Azur and Nouvelle-Aquitaine.

2.2.15 Overall assessment of risk

In the absence of phytosanitary measures, the overall risk of ToBRFV for the PRA area is estimated to be high with moderate uncertainty.

Indeed, in the absence of regulations, there is a high likelihood of ToBRFV entering the PRA area via imports of seeds and plants for planting. Nevertheless, the legislation introduced on 1 November 2019 provides for a mandatory check for ToBRFV on plants for planting and seeds from third countries or circulating within the EU. There is no obligation to check for ToBRFV on susceptible plant material other than tomato and pepper or fruits intended for consumption. Although implementation of this legislation will help reduce this risk from plants for planting and seeds, the risk of entry is still moderate in view of the risk posed by fruits intended for consumption, because (i) they are not covered by the current legislation and (ii) contaminated fruits may enter commercial channels as they may be asymptomatic or show very few symptoms. The risk of entry associated with the market for seeds purchased on the Internet by private individuals must also be considered but is not quantifiable. The sources of uncertainty are related to the import volumes of tomato, pepper and aubergine plants for planting (the host plant status of the latter remains to be confirmed), the behaviour of ToBRFV in particular in terms of transmission, and the effectiveness of seed treatments.

The likelihood of establishment of ToBRFV is rated as high, both in protected conditions and outdoors in regions where tomato and pepper are grown, with low to moderate uncertainty, due to doubts about the infection status of potential reservoir plants in the current area of distribution. The magnitude of the spread in the PRA area is estimated to be high with low uncertainty. This spread will take place naturally through contact between plants and via human activities: by movements of seeds, plants for planting and fruits; and through contact by the handling of materials, for example cultivation tools (stakes, pruning shears, grafting knives, pollinating hives, etc.) and marketing equipment (pallets, cardboard boxes, packaging, etc.).

The economic impact caused by ToBRFV in its current area of distribution is estimated to be high, given the percentages of contamination reported at the different sites in the virus's current area of distribution. It is likely that these high levels of contamination will affect yields and marketability of fruits, even though no data on yield losses are currently available. In the event of entry and establishment in the PRA area, the magnitude of the impact in the area of potential establishment is also estimated to be high with low uncertainty, especially in the endangered area.

New information or data from scientific reports or studies that may be published in the coming months will no doubt help reduce the overall uncertainty of this risk assessment, which reflects the knowledge of this new virus at the time of finalisation of the report.

In view of these points, some management measures have been recommended.

2.3 Step 3. Pest risk management

2.3.1 Phytosanitary measures

2.3.1.1 Regulations on ToBRFV

Since 1 November 2019, ToBRFV has been subject to Commission Implementing Decision (EU) 2019/1615 of 26 September 2019 establishing emergency measures to prevent the introduction into and spread of this virus within the EU (Annex 3). This emergency legislation is in line with the new European plant passport, which will enter into force on 14 December 2019 and will focus mainly on the traceability of raw materials.

This Decision should be temporary and apply until 31 March 2022, enabling it to be reviewed before that date.

This legislation provides for every case of the virus in Europe to be made public. It takes into account the successful eradication of the virus from an infected production greenhouse in 2018 in Germany.

For tomato and pepper producers, specific measures apply, as the introduction and spread of the virus in the EU is prohibited.

Producers are required to report positive cases (mandatory notification). In the event of infection with ToBRFV, it is up to each Member State to determine whether measures should be taken if the virus is found in production crops.

EU Member States are also obliged to carry out an annual national survey, including laboratory tests, to detect the presence of the virus. The procedures for setting up these surveys are outlined in the Implementing Decision (Annex 3).

Note from the WG:

The Implementing Decision is a phytosanitary measure that reduces the risk at entry through the testing of seeds, which must certify their "virus-free" status. In this respect, the WG recommends that detection and identification of ToBRFV be carried out.

The annual surveys recommended by the Implementing Decision will make it possible to determine the occurrence of ToBRFV in the PRA area. They will also allow early detection of a virus that produces symptoms that are not very visible or characteristic at the onset of infection, and will therefore allow management measures to be taken more quickly.

However, the current legislation (Implementing Decision (EU) 2019/1615) does not provide for specific requirements for fruits on entry. Lastly, the scope of these emergency measures does not include mandatory control measures in the event of detection of ToBRFV outbreaks.

In view of these points, the following section will be organised around proposals for management measures to prevent the entry of ToBRFV.

If the host plant status of aubergine is validated, the regulations will need to be extended to cover the at-risk pathways for aubergine seeds and plants.

2.3.1.2 Options for preventing the entry of ToBRFV into the PRA area

2.3.1.2.1 Prohibition of pathways

In view of the risk analysis presented in this document, no pathway (seeds, seedlings or fruits) should be totally prohibited from import at present or in the near future.

2.3.1.2.2 Special requirements on pathways for entry

The three pathways for entry are discussed: seeds, seedlings and fruits.

The WG's recommendations will add to/supplement/clarify the requirements cited in the legislation (Implementing Decision (EU) 2019/1615) for the seed and seedling pathways.

2.3.1.2.2.1 Seeds and seedlings of tomato and pepper rootstocks and varieties

2.3.1.2.2.1.1 At the place of production

Compliance with the specifications of Good Seed and Plant Practices (GSPP) for both seeds and seedlings is recommended, although they do not cover ToBRFV, as these specifications can be suitably adapted to ToBRFV[20].
This standard, originally developed by the professionals themselves to combat the introduction and spread of *Clavibacter michiganensis* subsp *michiganensis* (Cmm), aims to control water, personnel, equipment and plant propagation material; this management is based on a risk analysis, regular monitoring of the material and recognition of the risk on a daily basis with the implementation of management protocols, traceability, etc. Companies applying this standard are independently audited and certified.
Among other things, at the place of seed production, periodic analyses should be carried out on the parents and the F1 hybrids ready for sale.

2.3.1.2.2.1.2 After harvest, during transport

- Cleaning and disinfecting seeds: the effectiveness of treatments applied to seeds against other viruses found in external tissues (e.g. immersion for 3 h in a 10% sodium phosphate solution to remove PepMV (Córdoba-Sellés *et al.*, 2007)) has not been described for the disinfection of ToBRFV. However, these treatments could still disinfect the seeds if ToBRFV is indeed found only on the seed surface and not deep within;
- Avoiding simultaneous handling in the same vehicle (loading/unloading) of plants from an at-risk greenhouse/area and plants from a greenhouse/area where the risk is absent.

2.3.1.2.2.1.3 After entry of consignments

- On entry, carry out ToBRFV detection and identification tests on tomato and pepper seeds and plants if seeds have been imported from contaminated countries or regions. Ensure that the analyses are carried out by an accredited laboratory;
- Use seeds that are pulp-free and properly disinfected;
- Reinforce the traceability of materials.

Note: It is important to note that these recommendations, which concern imports for commercial purposes, cannot be applied to reduce the risk associated with e-commerce seed purchases by individuals.

2.3.1.2.2.2 Tomato and pepper fruits

If the host plant status of aubergine is validated, the recommendations should be extended to this species and any host plant as well as tomato and pepper.

2.3.1.2.2.2.1 At the place of production

The WG recommends a specific requirement for imports of tomato and pepper fruits: tomato and pepper fruit imports must originate from a production site not contaminated with ToBRFV.

2.3.1.2.2.2.2 After harvest, during transport

- Avoid simultaneous handling in the same vehicle (loading/unloading) of fruits from an at-risk greenhouse/area and plants from a greenhouse/area where the risk is absent.

20 https://www.gfactueel.nl/Glas/Nieuws/2019/11/GSPP-kijkt-naar-aanpak-van-ToBRFV-495302E/

2.3.1.2.2.3 After entry of consignments

- Apply appropriate virus decontamination treatment to reusable packaging material only, especially containers.

2.3.1.3 Options for surveillance in the PRA area

A surveillance plan should be put in place in all EU Member States, in accordance with the new legislation in effect since 01.11.2019.
National biological surveillance consists of two complementary procedures for mobilising diagnoses:
1- The aim of programmed surveillance is to guarantee the country's disease-free status, to assess the phytosanitary situation and to detect, where appropriate, outbreaks of ToBRFV by prioritising the most susceptible plant species (tomatoes, peppers) of economic importance and/or located in geographical areas identified as being most at risk.
It is mainly based on official surveillance. The new EU Plant Health Regulation, which will be applicable from December 2019 to replace Directive 2000/29/EC, will increase the share of self-checks by producers in the form of a plant health control plan. This will take the form of regular surveillance of growing areas and written traceability detailing observations, diagnoses and results of plant health analyses obtained on the farms.
For example, in Belgium, several regional horticultural monitoring centres, namely the Proefstation voor de Groenteteelt (Sint-Katelijne-Waver), the Proefcentrum (Hoogstraten) and Scientia Terrae (Sint-Katelijne-Waver), recommend preventive screening for ToBRFV depending on the production areas (Proefstation voor de Groenteteelt, Proefcentrum and Scientia Terrae, 2019). Each sample should consist of a pool of 10 different plants, taken from 10 different rows in the greenhouse, half of which is leaves from the tops of the plants (if this is not possible, the Dutch laboratories also recommend taking the calyx of the fruit) and half of which is roots.
Depending on the size of the farm, a minimum of two samples/ha should be taken if the farm is >5 ha and at least three samples/ha if it is smaller.
If any suspicious symptoms are observed, a sample of this plant should be taken, preferably from its head. A sample of plants should also be taken from another part of the greenhouse where no suspicious symptoms are visible.

2- The purpose of event-driven surveillance is early detection of symptoms of regulated and/or emerging pests in the country. This surveillance is based on spontaneous reports of suspected detection by individuals, professionals or observers, outside their scheduled activities.

2.3.1.4 Management options for production sites in the PRA area

It is important to remember that there are currently no recommendations for control measures in the PRA area.

2.3.1.4.1 Prevention

Among the possible control measures (genetic, biocontrol, chemical, cultivation practices), with the exception of prophylactic measures, there seem to be no options available:

- There is not yet any genetic control available against ToBRFV, although resistance research is ongoing, especially in Israel. F1 tomato cultivars highly resistant to ToMV and TMV may be severely affected by this new virus. Known resistance genes, especially *Tm-2*^{2}, provide no protection against ToBRFV. Note that it has been reported that some tomato varieties can develop high virus levels without expressing symptoms (Luria *et al.*, 2017). These varieties can then unknowingly become a source of ToBRFV inoculum for susceptible tomato or pepper plants. Lastly, symptoms may vary depending on environmental and growing conditions, especially light and temperature.
- Control using biocontrol (macro-organisms, microbial mediators, plant defence stimulators, premunition) is not yet possible and no effective virucidal compound without a phytotoxic effect is known.

Prophylactic measures have been suggested to limit the risk of introduction of tobamoviruses and ToBRFV into farms. There are multiple recommendations and exhaustive sources of information on applicable prophylactic methods for tobamoviruses proposed by risk assessment agencies or advisory bodies for tomato crops:

- The "Hygiëneprotocol tomaat en paprika/peper versie 2.0. Voor de mechanisch overdraagbare plantpathogenen ToBRFV en Clavibacter" hygiene protocol issued by the Glastuinbouw Nederland, GroentenFruit Huis en Plantum (2019);
- "Tomato brown rugose fruit virus" issued by the Proefstation voor de Groenteteelt Sint-Katelijne-Waver, Proefcentrum Hoogstraten Meerle, Scientia Terrae en LAVA;
- "Tomato Brown Rugose Fruit Virus" published on the Agriculture and Horticulture Development Board (AHDB) website[21] and written by FERA;
- "Cultures maraîchères en serre, Fiche technique : Virus du fruit rugueux brun de la tomate (ToBRFV)" [Vegetable crops in greenhouses, Technical data sheet: ToBRFV][22] issued by the Quebec Plant Protection Warning Network (RAP, Canada)
- "Protocole sanitaire à appliquer dans le cadre de la prévention et de la lutte contre les maladies de la tomate transmises par contact" [Health protocol to be applied for the prevention and control of tomato diseases transmitted by contact] (APREL[23]/Chambre d'Agriculture 13/DRAAF-SRAL PACA 16.08.2019), as well as the communication sheets published for advisers and technicians, agricultural employees, producers, nurseries and agricultural suppliers.

In the following sections, the requirements are repeated when their implementation is of great importance in relation to the risk posed by ToBRFV in particular and in direct relation to the characteristics of this virus.

Given the effective means of spread of ToBRFV by contact and the persistence of its infectivity, good hygiene practices should be observed:

- Enter crops wearing only new/unused clothing, as reused clothing may have been contaminated by eating tomatoes in a private setting (home, canteen, restaurant) or by visiting contaminated nurseries or greenhouses; protective clothing such as protective gowns or coveralls should be preferred and should remain inside the greenhouses after use.
- Disinfect:
    - hands before and after handling plants;
    - work shoes or boots before entering and leaving the greenhouse;
    - transport and spraying trolleys and all other moving objects that come into contact with the crop;
    - working tools (pruning shears, etc.) ideally after working on each plant, using benzoic acid-based substances, for example, authorised for the disinfection of tools and structures and in accordance with the application recommendations, and whose effectiveness against viruses and viroids has been demonstrated; the feasibility of this measure remains low. All compounds with equivalent properties authorised for use in the PRA area can be used;
    - greenhouses at the end of the growing period.

21 https://ahdb.org.uk/knowledge-library/tomato-brown-rugose-fruit-virus

22 https://www.agrireseau.net/legumesdeserre/documents/100299/cultures-maraicheres-en-serre-fiche-technique-virus-du-fruit-rugueux-brun-de-la-tomate-tobrfv

23 https://aprel.fr/

2.3.1.4.2 In the event of suspicion and/or detection of an outbreak

The authorities of some countries, such as Belgium, have already issued recommendations on the measures to be put in place if the virus is detected. Indeed, if the virus is detected in crops for consumption, the following measures will be imposed by the Federal Agency for the Safety of the Food Chain (FASFC): destruction of contaminated plants and neighbouring plants, application of strict hygiene measures and thorough cleaning and disinfection during crop rotation. This will be assessed and followed up on a case-by-case basis, especially for the first reports.

It should be pointed out that the successful eradication of ToBRFV in Germany was due to the rapid implementation of control measures, i.e. the destruction of all plants grown in the contaminated greenhouses. This success was undoubtedly facilitated by the occurrence of the virus at the end of the growing period[24].

2.3.1.4.2.1 In the presence of suspect plants

- If tobamovirus symptoms occur in a variety with known resistance (and especially *Tm-2*^{2}), the probability of the virus being ToBRFV is greater;
- As a precautionary measure, mark out an area that includes suspect plants and surrounding plants;
- Take all sanitary precautions when handling them, in the same way as with known tobamovirus or *Clavibacter michiganensis* infections;
- Have detection and identification tests carried out by accredited analytical laboratories for verification.

2.3.1.4.2.2 In the presence of infected crops

- Manage each infected greenhouse as a separate unit;
- Restrict greenhouse access to authorised persons only;
- Organise the direction of workflow or operations by starting with healthy greenhouses and going to contaminated greenhouses last of all;
- Apply all good practices described generally for prevention (disinfection of tools, materials, hands and shoes with an appropriate disinfectant, wearing of unused work clothes, etc.).

2.3.1.4.2.2.1 For the current production crop

- Plants should be uprooted from the production unit and destroyed by burning (after authorisation), as asymptomatic plants may not be disease-free. Composting may be insufficient for the safe inactivation of the virus according to Noble and Roberts (2004), who studied the impact of composting on the conservation of tobamoviruses. They showed that composting for more than 20 days was needed to reduce the number of TMV viral particles below detection limits. Knowing that maximum compost temperatures exceed 68°C, they also showed that TMV and ToMV were inactivated over time in the compost, even at temperatures below 50°C. However, temperature heterogeneity within the compost may allow plant pathogens to survive in colder parts, especially in systems where the compost is not turned. This can be an important risk factor when composting vegetable waste.
  However, in the Netherlands, the authorities allow composting on condition that the process, including storage post-composting, lasts at least 6 months and that the compost is not used for growing tomatoes or peppers. Tunnel and outdoor composting is permitted. In the case of outdoor composting, the compost heap must be turned at least three times and after each turn the temperature in the compost heap must reach at least 60°C for a minimum of 24

[24] https://www.gfactueel.nl/Glas/Achtergrond/2019/11/Duitsland-Aanpak-ToBRFV-succes-bron-onbekend-498254E/

hours. Composting must take place at a destruction site approved by the Dutch authorities (Glastuinbouw Nederland, GroentenFruit Huis en Plantum, 2019).

- A cleanout period (total absence of planting) on the production site must be established and complied with; indications on the duration of the cleanout period vary according to the authorities and to authors. The ToBRFV hygiene protocol of the Glastuinbouw Nederland, GroentenFruit Huis en Plantum (2019) recommends that a greenhouse should be kept empty of all crop residues for at least eight days at a temperature of 15°C. In Belgium, the recommended cleanout period should last at least four weeks (Proefstation voor de Groenteteelt, Proefcentrum and Scientia Terrae, 2019). Given that tobamoviruses can survive at least several months on inert media, the recommended duration of the cleanout period is difficult to quantify. The success of this measure depends largely on the application of hygiene measures (cleaning) to remove ToBRFV from culture substrates.

2.3.1.4.2.2.2 After the plants have been removed

Disinfection and thorough cleaning when changing crops is of crucial importance. ToBRFV is extremely persistent in soil, plant debris and plant juices, and even on inert materials. Even after the crop and substrate have been removed from the greenhouse, special attention must still be paid to removing all organic remains from access routes. In every case, the infrastructure must be properly cleaned and disinfected, first with water and detergent.
The different ToBRFV management strategies depend on the nature of the materials involved. The text below cites examples from several literature sources, both scientific and non-scientific. The effectiveness of these management measures against ToBRFV remains to be proven.
For example, in soil, several products have been shown to be effective against other tobamoviruses such as TMV (Smith and Dombrovsky, 2019). Chlorine is cited as an effective soil treatment[25].

Tobamovirus-contaminated equipment can be sanitised using disinfectants. Li *et al.* (2015) tested 16 disinfectants against several viruses including ToMV and TMV. They showed that 2% Virkon and 10% bleach (NaClO) had the greatest effect against these viruses. Bleach has also been shown to be effective in disinfecting equipment contaminated with CGMMV (Smith and Dombrovsky, 2019).

Lewandowski *et al*. (2010) showed the effectiveness of a 20% (weight/volume) solution of skimmed milk powder with 0.1% Tween 20 or a 1/10 dilution of 0.6% bleach to completely eliminate transmission of TMV to petunias.

Heat disinfection has also been tested against tobamoviruses[26]. In Great Britain, Cambridge Hok[27] proposes a steam sterilising unit for disinfecting equipment at 95°C for 5 min. This unit, similar to a shipping container, can be set up on a farm within three weeks. The company says that high-temperature treatment is the best way to ensure that the risk of virus infection is eliminated.

2.3.1.4.2.2.3 Conclusion on the chances of eradicating an outbreak

Eradication of the virus is likely to be successful if there is immediate action with total destruction of plants in a production unit, such as a greenhouse, coupled with strict hygiene measures. This measure is highly effective because this approach has already been implemented in Germany (at the end of the growing period). It should be understood that the feasibility of this drastic management measure will inevitably depend on when in the production cycle the virus is detected, taking into account the consequences of such destruction in terms of the economic losses generated.

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[25] https://www.youtube.com/watch?v=vNdzKEDgah4&feature=youtu.be

[26] https://www.hortidaily.com/article/9139375/steam-sterilisation-unit-developed-to-fight-tobrfv/

[27] www.cambridgehok.co.uk; http://www.tomatonews.com/en/tobrfv-quarantine-status-in-effect-from-1-november_2_819.html

If such measures are not applied, risk management switches to a containment scenario, with the aim of limiting the virus's spread by applying hygiene measures and restricting the movement of contaminated plant material. In view of the situation in Israel and Mexico, the WG has doubts about the success of a containment strategy.

2.3.1.5 Risk communication

Since early 2019, much information has been relayed by the organisations supporting the producers: awareness of prophylactic measures is essential and seems to have been applied in this sector, which has already been affected by other high-impact health crises in the past (PepMV, TYLCV, *Tuta absoluta, Clavibacter michiganensis*, etc.).

2.3.2 Uncertainty

The sources of uncertainty are:

- the rate of transmission from seeds to seedlings
- the location of ToBRFV on the surface of seeds
- the status of aubergine as a ToBRFV host plant
- quantification of flows of tomato and pepper plants for planting
- the lack of any guarantee as to current management conditions at the origin, in particular consideration and application of GSPP standards and the use of prophylactic measures suited to ToBRFV
- the transfer of ToBRFV from fruits to crops
- the effectiveness of seed treatments
- the infection status of potential reservoir plants in its current area of distribution and their role in maintaining the virus from year to year
- the diversity of affected cultivars and their susceptibility to ToBRFV,
- the range of incidences that varies between different sites, and the reporting or detection times during the growing cycle

New information or data from scientific reports or studies that may appear in the coming months will no doubt help reduce the overall uncertainty of this risk assessment, which reflects the knowledge of this new virus at the time of finalisation of the report.

2.3.3 Remarks

The WG's recommendations concerning future areas of research are:

- Develop ToBRFV-resistant or tolerant varieties
- Select attenuated strains of ToBRFV for assessing premunition
- Assess the host status of aubergine and characterise the virus's host range
- Assess the seed transmission rate
- Determine the effectiveness of genes at the L locus in terms of resistance in pepper
- Study the impact of multiple infections on the severity of symptoms

3 Conclusions of the Working Group

Summary of the Express Pest Risk Analysis for Tomato brown rugose fruit virus
PRA area: metropolitan France
Describe the endangered area: high-density tomato production regions (in protected conditions and in open fields) and pepper production regions, more specifically the regions of western France (Bretagne, Pays de la Loire), Provence-Alpes-Côte d'Azur and Nouvelle-Aquitaine.
Main conclusions • **Overall assessment of risk**: In the absence of phytosanitary measures, the overall risk of ToBRFV for the PRA area is estimated to be high with moderate uncertainty. Indeed, in the absence of regulations, there is a high likelihood of ToBRFV entering the PRA area via imports of seeds and plants for planting. Nevertheless, the regulation introduced on 1 November 2019 provides for a mandatory check for ToBRFV on plants for planting and seeds from third countries or circulating within the EU. However, there is no obligation to check for ToBRFV on susceptible plant material other than tomato and pepper or fruits intended for consumption. Although implementation of this legislation will help reduce this risk from plants for planting and seeds, the risk of entry is still moderate in view of the risk posed by fruits intended for consumption, because (i) they are not covered by the current legislation and (ii) contaminated fruits may enter through commercial channels as they may be asymptomatic or show very few symptoms. The risk of entry associated with the market for seeds purchased on the Internet by private individuals must also be considered but is not quantifiable. The likelihood of establishment of ToBRFV is rated as high, both in protected conditions and outdoors in regions where tomato and pepper are grown, with low to moderate uncertainty. The magnitude of the spread in the PRA area is estimated to be high with low uncertainty. This spread will take place naturally through contact between plants and via human activities: by movements of seeds, plants for planting and fruits; and through contact by the handling of materials, for example cultivation tools (stakes, pruning tools, grafting knives, pollinating hives, etc.) and marketing equipment (pallets, cardboard boxes, packaging, etc.). The economic impact caused by ToBRFV in its current area of distribution is estimated to be high, given the percentages of contamination reported at the different sites in the virus's current area of distribution. It is likely that these high levels of contamination will affect yields and marketability of fruits, even though no data on yield losses are currently available. In the event of entry and establishment in the PRA area, the magnitude of the impact in the area of potential establishment is also estimated to be high with low uncertainty, especially in the endangered area. New information or data from scientific reports or studies that may be published in the coming months will no doubt help reduce the overall uncertainty of this risk assessment, which reflects the knowledge of this new virus at the time of finalisation of the report. • **Phytosanitary measures**: Specific requirements are recommended for fruit imports, which should come from production sites declared free of ToBRFV. A surveillance plan is recommended to determine the pest status of the PRA area. If infected plants are reported in a production unit, eradication is recommended by taking immediate action to destroy all the plants in the production unit, coupled with strict hygiene measures including a cleanout period. If such measures are not applied, risk management switches to a containment scenario, with the aim of limiting the virus's spread by applying hygiene measures and restricting the movement of contaminated plant material. In view of the situation in Israel and Mexico, the Working Group has doubts about the success of the containment strategy. Communication efforts targeting producers are also recommended.

Phytosanitary risk for the *endangered area* *(Individual ratings for likelihood of entry and establishment, and for magnitude of spread and impact are provided in the document*)	High ☒	Moderate ☐	Low ☐
Level of uncertainty of assessment (See Q17 for the justification of the rating. *Individual ratings of uncertainty of entry, establishment, spread and impact are provided in the document*)	High ☐	Moderate ☒	Low ☐

Other recommendations:

- *Research is recommended to reduce uncertainty, particularly on the range of host plants and the rate of seed transmission*

Date of validation of the collective expert appraisal report by the Working Group *[and by the Expert Committee if there is no CES summary in the first part]*: 26 November 2019

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4.3 Legislation and Regulations

Council Directive 2000/29/EC of 8 May 2000 on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community.

Commission Implementing Decision (EU) 2019/1615 of 26 September 2019 establishing emergency measures to prevent the introduction into and the spread within the Union of Tomato brown rugose fruit virus (ToBRFV) (notified under document C(2019) 6826).

ANNEXES

Annex 1: Formal request letter

anses
agence nationale de sécurité sanitaire
alimentation, environnement, travail
Connaître, évaluer, protéger

2019-SA-0080

Décision N° 2019-04-123

AUTOSAISINE

Le directeur général de l'Agence nationale de sécurité sanitaire de l'alimentation, de l'environnement et du travail (Anses),

Vu le code de la santé publique, et notamment son article L. 1313-3 conférant à l'Anses la prérogative de se saisir de toute question en vue de l'accomplissement de ses missions,

Décide :

Article 1er.- L'Agence nationale de sécurité sanitaire de l'alimentation, de l'environnement et du travail se saisit afin de réaliser une expertise dont les caractéristiques sont listées ci-dessous.

1.1 Thématiques et objectifs de l'expertise

Evaluation du risque simplifiée du *Tomato brown rugose fruit virus* pour la France métropolitaine.

1.2 Contexte de l'autosaisine

Grâce à la veille sanitaire réalisée par les membres du Comité d'Experts Spécialisé de l'Anses « Risques biologiques pour la santé des végétaux » et nos agents Anses, une alerte nous est parvenue concernant un virus émergeant de la tomate : le *Tomato brown rugose fruit virus*.

Le *Tomato brown rugose fruit virus* (ToBRFV) est un tobamovirus émergent dont les premiers signalements datent de 2014 en Israël et de 2015 en Jordanie sur des tomates produites sous serre. En 2018, il a été également signalé au Mexique (où il est en cours d'éradication) et aux Etats-Unis où il a été éradiqué la même année. Au sein de l'Union européenne (UE), il a été signalé en Allemagne en 2018 (Rhénanie-du-Nord-Westphalie, où il est en cours d'éradication) et en Italie (Sicile) début 2019. Ce virus a été décrit également dans le bulletin de santé du végétal – Provence Alpes Côte D'Azur en décembre 2018. Il a été ajouté à la liste d'alerte de l'OEPP (Organisation Européenne et Méditerranéenne pour la Protection des Plantes) en janvier 2019 et il a fait l'objet d'une fiche d'alerte émise par le Laboratoire de la Santé des Végétaux (LSV_2019_03_0027).

Les plantes hôtes principales du ToBRFV sont la tomate (*Solanum lycopersicum*) et le piment (*Capsicum* sp.). Les dégâts observés sur tomate en production sous serre incluent des chloroses, des mosaïques et des marbrures sur les feuilles, ainsi que des taches nécrotiques sur les pédoncules, calices et pétioles des fleurs. Les fruits présentent des taches jaunes ou brunes, avec des symptômes

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de rugosité caractéristiques, et peuvent être déformés et avoir une maturation irrégulière, et ainsi devenir non commercialisables. L'incidence de la maladie varie entre 10 et 100% de fruits atteints selon les sites. Des symptômes similaires ont également été observés sur les fruits de *Capsicum* sp. au Mexique.

Le mode de dissémination des virus appartenant au genre *Tobamovirus* est particulièrement efficace. La transmission est mécanique par simple contact direct entre les plantes ou via les mains, les outils de travail, les vêtements, les insectes pollinisateurs, les oiseaux, l'eau d'irrigation. Les semences peuvent également transmettre les tobamovirus. Enfin, ces virus sont très stables : ils peuvent en effet survivre plusieurs mois sur des supports inertes sans perte de pouvoir infectieux. Ces caractéristiques épidémiologiques rendent les tobamovirus redoutables dans les cultures à haute densité de plantation comme les cultures conduites sous serre.

La résistance durable portée par les gènes *Tm-2/Tm-2²* et déployée dans les variétés de tomates de production depuis les années 1970 a permis une réduction considérable des impacts négatifs liés à d'autres tobamovirus (Tomato mosaic virus et Tobacco mosaic virus principalement). Or, ces gènes sont inefficaces contre le ToBRFV. L'absence de résistance chez la tomate met donc particulièrement en péril cette filière de production jusque-là épargnée.

1.3 Questions sur lesquelles portent les travaux d'expertise à mener

Compte tenu de l'importance de la filière de production de tomates sous serre en France, du fort caractère infectieux de ce virus et de la sensibilité de la tomate, de la succession des signalements dans des sites de production sur plusieurs continents et plus particulièrement au sein de l'UE et de l'absence de mesure réglementaire vis-à-vis de ce virus qui pourrait engendrer des filières d'entrée à risque, il vous est demandé de réaliser une évaluation de risque simplifiée du ToBRFV afin de :

(i) évaluer la probabilité d'introduction et de dissémination du ToBRFV et l'ampleur des impacts économiques potentiels sur le territoire français métropolitain,
(ii) proposer des options de mesures de gestion en cas de risque inacceptable pour la filière de production.

1.4 Durée prévisionnelle de l'expertise

La réalisation de l'expertise se fera sur une durée de huit mois pour une validation des analyses et conclusion par le CES en session plénière de novembre 2019 au plus tard.

Article 2.- Un avis porté par le CES « Risques biologiques pour la santé des végétaux » sera émis et publié par l'Agence à l'issue des travaux.

Fait à Maisons-Alfort, le 25 AVR. 2019

Dr Roger Genet
Directeur général

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Annex 2: Questionnaire

This questionnaire was sent to the authors of scientific publications concerning reports of the first cases of ToBRFV until September 2019.

Epidemiology

- Has the ToBRFV entry pathway been identified (seed lots, contaminated plants for planting)?
- Has the disease progression in crops, compared to other tobamoviruses (e. g. ToMV / tomato), been estimated? If so, how is it evolving?
    - along the rows? at random?
    - at what speed?
- How do you explain the difference between the incidences observed among all reports: 10 and 20% (Germany, Italy and Turkey) vs 100% (Israel, Jordan)? Is this due to
    - Surveillance and/or early detection of ToBRFV in Germany, Italy and Turkey?
    - A limited disease progression in the plant due to the Tm2-2 resistance (compared to to tomatoes without resistance genes)?
    - Other reason?
- Experimental inoculation:
    - What were observed on inoculated leaves/ systemic leaves on tomato, chili pepper, nicotiana, other hosts?
    - How long does it take for symptoms to appear on these hosts?
- Spread via seeds: any transmission rate?

Prevention / Control

- Which diagnostic tests do you think are most appropriate to identify the virus?
    - Pre-screening by electronic microscopy, ELISA (Agdia serum)?
    - Precise identification of ToBRFV:
        - Generic primers “Li” or “Menzel” and sequencing?
        - Specific primers “Luria”?
- Were Infected plants rapidly eliminated after identification of ToBRFV?
- Which plants were eliminated in greenhouses : symptomatic plants only? Neighbouring plants and rows? All the plants in the greenhouse?
- How were the plants eliminated (incineration, other?)
- What virucidal product was used to decontaminate greenhouses/structures/materials after plant elimination?
- Is the effectiveness of seed decontamination procedures for ToBRFV (NaClO, HCl, Na3PO4, others...) known?
- Have new tomatoes been or will they be replanted in the same greenhouses?
- Do we already have an idea of the effectiveness of the entire procedure put in place to eliminate ToBRFV, making it possible to consider replanting tomatoes?
- What means of communication have you put in place to inform professionals in the tomato/pepper sector?

Annex 3: Implementing Decision (EU) 2019/1615

30.9.2019 EN Official Journal of the European Union L 250/91

COMMISSION IMPLEMENTING DECISION (EU) 2019/1615

of 26 September 2019

establishing emergency measures to prevent the introduction into and the spread within the Union of Tomato brown rugose fruit virus (ToBRFV)

(notified under document C(2019) 6826)

THE EUROPEAN COMMISSION,

Having regard to the Treaty on the Functioning of the European Union,

Having regard to Council Directive 2000/29/EC of 8 May 2000 on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community [1], and in particular the third sentence of Article 16(3) thereof,

Whereas:

(1) Tomato brown rugose fruit virus ('the specified organism') is a harmful organism currently not listed in Annex I or Annex II to Directive 2000/29/EC.

(2) However, in late 2018 Germany and Italy reported outbreaks of the specified organism on tomato crops in their territories and of the measures taken to control it. A pest risk analysis carried out by Italy has demonstrated that the specified organism and its damaging effects could be of significant plant health concern to the Union, in particular for *Solanum lycopersicum* L. and *Capsicum annuum* production.

(3) Member States should therefore ensure that any person having under their control plants which may be infected with the specified organism is informed about its potential presence and the measures to be taken.

(4) Member States should furthermore carry out annual surveys for the presence of the specified organism in their territories, to ensure a more pro-active approach against the establishment and spread of that organism.

(5) In view of the evidence from Germany and Italy and of the spread of the specified organism in a rising number of third countries, susceptible specified plants for planting, including seed, should be subject to specific measures when introduced into the Union and should be accompanied by a phytosanitary certificate.

(6) Those specific measures should provide for the timely detection of the specified organism in the Union territory, requirements for the introduction into the Union of the specified plants for planting, including seed, as well as official checks to be conducted at the introduction of the specified plants for planting including seed into the Union.

(7) Such measures are necessary to ensure an enhanced protection of the Union territory from the entry, establishment and spread of the specified organism.

(8) In order to allow the responsible official bodies and the professional operators to adapt to those requirements, this Decision should apply from 1 November 2019.

(9) This Decision should be temporary and apply until 31 March 2022 to allow for its review before that time.

(10) The measures provided for in this Decision are in accordance with the opinion of the Standing Committee on Plants, Animals, Food and Feed,

[1] OJ L 169, 10.7.2000, p. 1.

HAS ADOPTED THIS DECISION:

Article 1

Definitions

For the purposes of this Decision, the following definitions shall apply:

(a) 'specified organism' means Tomato brown rugose fruit virus (ToBRFV);

(b) 'specified plants for planting' means plants for planting, of *Solanum lycopersicum* L. and *Capsicum annuum*;

Article 2

Prohibition of introduction and movement within the Union

The introduction into, and movement within, the Union of the specified organism shall be prohibited.

Article 3

Detection or suspected presence of the specified organism

Member States shall ensure that any person having under its control plants which may be infected with the specified organism is immediately informed of the presence or the suspected presence of the specified organism, of the possible consequences and risks, and of the measures to be taken to prevent the establishment and spread of the specified organism.

Article 4

Surveys of the specified organism in the territories of the Member States and identification

1. Member States shall conduct annual surveys for the presence of the specified organism on host plants in their territory.

2. Those surveys shall be carried out by the responsible official body, or under official supervision of the responsible official body. Those surveys shall include laboratory testing and shall be based on sound scientific and technical principles with regard to the possibility to detect the specified organism.

3. Member States shall notify the Commission and the other Member States, by 31 January of each year, of the results of the surveys that were carried out in the preceding calendar year.

Article 5

Movement of the specified plants for planting within the Union

The specified plants for planting, originating within the Union territory, may only be moved within the Union if they are accompanied by a plant passport prepared and issued in accordance with Commission Directive 92/105/EEC [2] and if they fulfil one of the following requirements:

(a) they originate in areas where the specified organism is known not to occur;

(b) in the case of plants for planting, other than seeds:

  (i) they originate in a production site where the specified organism is known not to occur on the basis of official inspections carried out at the appropriate time to detect that organism; and

  (ii) they derive from seeds which either originate in areas free from the specified organism or have undergone official testing for the specified organism on a representative sample using appropriate methods, and have been found, in these tests, to be free of the specified organism;

(c) in the case of seeds, official sampling and testing for the specified organism has been carried out, on a representative sample using appropriate methods, and they have been found, in these tests, to be free of the specified organism.

[2] Commission Directive 92/105/EEC of 3 December 1992 establishing a degree of standardisation for plant passports to be used for the movement of certain plants, plant products or other objects within the Community, and establishing the detailed procedures related to the issuing of such plant passports and the conditions and detailed procedures for their replacement (OJ L 4, 8.1.1993, p. 22).

Article 6

Requirements for the introduction into the Union of the specified plants for planting

Specified plants for planting shall only be introduced into the Union if they are accompanied by a phytosanitary certificate referred to in Article 13(1)(ii) of Directive 2000/29/EC and if they fulfil one of the following requirements:

(a) The specified plants for planting shall originate in a third country free from the specified organism, as established by the national plant protection organisation concerned, in accordance with the relevant International Standards for Phytosanitary Measures. That information shall be stated in the phytosanitary certificate under 'Additional Declaration'.

(b) The specified plants for planting shall originate in an area free from the specified organism, as established by the national plant protection organisation concerned, in accordance with the relevant International Standards for Phytosanitary Measures. The name of that area shall be stated in the phytosanitary certificate under 'place of origin'.

(c) Where the specified plants for planting originate in third countries or areas other than those referred to in points (a) and (b), they shall fulfil the following requirements:

(i) in the case of specified plants for planting, other than seeds:

— they have been produced in a production site which is registered and supervised by the national plant protection organisation in the country of origin and known to be free from the specified organism on the basis of official inspections carried out at the appropriate time to detect that organism; and

— they derive from seeds which either originate in areas free from the specified organism or have undergone official testing for the specified organism on a representative sample using appropriate methods, and have been found, in these tests, to be free of the specified organism. Reference to the testing shall be included under 'Additional Declaration' of the phytosanitary certificate.

Information ensuring the traceability of the specified plants for planting to their site of production shall be available;

(ii) in the case of seeds, official sampling and testing for the specified organism has been carried out, on a representative sample using appropriate methods, and they have been found, in these tests, to be free of the specified organism. Reference to the testing shall be included under 'Additional Declaration' of the phytosanitary certificate.

Article 7

Official checks at introduction into the Union

All consignments of specified plants for planting introduced into the Union shall be officially checked at the point of entry into the Union or at the place of destination as provided for in accordance with Commission Directive 2004/103/EC (3).

Article 8

Date of application

This Decision shall apply from 1 November 2019.

Article 9

Date of expiration

This Decision shall apply until 31 March 2022.

(3) Commission Directive 2004/103/EC of 7 October 2004 on identity and plant health checks of plants, plant products or other objects, listed in Part B of Annex V to Council Directive 2000/29/EC, which may be carried out at a place other than the point of entry into the Community or at a place close by and specifying the conditions related to these checks (OJ L 313, 12.10.2004, p. 16).

Article 10

Addressees

This Decision is addressed to the Member States.

Done at Brussels, 26 September 2019.

For the Commission
Vytenis ANDRIUKAITIS
Member of the Commission

Annex 4: Relevant illustrations

Symptoms on tomatoes (plants and fruits) in Israel (2017)

Fig 1. Naturally infected tomato plants. (A-C) Symptomatic mosaic pattern on leaves of cluster tomato plants cv. Mose. **(C)** Narrowing leaves of cluster tomato plants. **(D)** Dried peduncles and calyces on cherry tomato plants cv. Shiran leading to fruit abscission. **(E)** Necrotic symptoms on pedicle, calyces and petioles cv. Ikram. **(F)** Typical fruit symptoms with yellow spots cv. Mose. **(G-I)** Variable symptoms of tomato fruits cv. Odelia. **(G)** The typical disease symptoms. **(H)** Symptoms of mixed infections by the abundant TSWV and the new tobamovirus isolate. **(I)** Unique symptoms of the new tobamovirus isolate found at a single location at Sde-Nitzan village.

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Source: Luria et al., 2017

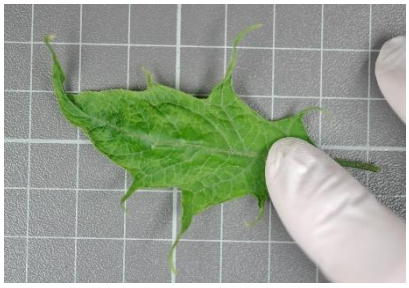
Symptoms on peppers in Mexico

Source: SADER SENASICA

Symptoms on tomatoes in Israel (2019)

Source: Gentit, ANSES, personal communication

Symptoms of mosaic (natural infection, Israel 2019) and narrowing (experimental infection, France 2019) on tomato leaves



Source: Gentit and Visage, ANSES, personal communication

Annex 5: Tracking of report updates

Date	Page	Description of the change
06/12/2019	20	Replacement of the figure on "Global distribution of ToBRFV in November 2019" (dated 12/11/2019) by "Global distribution of ToBRFV in December 2019" (dated 06/12/2019) following the update of the virus distribution by the EPPO GD and the report of its presence in Spain

Notes

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