



Quantitative versus Qualitative: Pest Risk Analysis in the UK and Europe including the European and Mediterranean Plant Protection (EPPO) system

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Summary

This paper focuses on the differences between fully quantitative and fully qualitative Pest Risk Analyses (PRAs) in light of some of the work of the UK PRA Team based at the Central Science Laboratory, York, UK. The World Trade Organisation (WTO) Sanitary and Phytosanitary (SPS) agreement requirement, for PRAs to be conducted within the framework of the relevant international standards, developed under the International Plant Protection Convention (IPPC), does not prescribe the methodology to be used. The development of national (UK) and regional (EPPO) standards for PRA within Europe has not led to a fully quantitative system. The UK system includes a relatively qualitative Summary PRA and a comprehensive Datasheet. The EPPO system includes a subjective scoring section which allows the analyst to produce a score for the relative risk of individual pests. The methodology of the EPPO system is illustrated by its use to assess the risks posed by *Watermelon silver mottle virus*, *Thrips palmi* and *Potato latent virus* to the EPPO region. Although a useful structure within which the analyst can compare the relative risk of individual pests, there are some problems with the system, especially in judging how the scores should be assigned. Whatever the pitfalls of the different methodologies, the management, production, development and communication of PRAs, whether qualitative, quantitative, or a mixture of both, should be fit for purpose and no more complex than is technically justified.

Introduction

The Plant Health Service of the Department for Environment, Food and Rural Affairs (DEFRA) in England and Wales is divided into 3 component parts. DEFRA's Plant Health Division (PHD) is responsible for plant health policy. The Plant Health and Seeds Inspectorate (PHSI) are responsible for "frontline" plant health including import and export inspection, eradication campaigns and enforcement. The Central Science Laboratory (CSL) is an executive agency of DEFRA and within it, the Plant Health Group provides scientific and technical support to PHD and the PHSI. The Group has approximately 111 staff in teams of bacteriologists, entomologists, mycologists, nematologists and virologists. The staff of the Group fulfil a number of related functions including, the identification of pests on plant and commodity samples submitted by the PHSI, the provision of advice on interceptions and outbreaks of pests and diseases, as well as a number of research and development projects linked to the plant health needs of the UK, European Union (EU) and the EPPO region.

Within the Group, the Plant Health Consultancy Team draws upon the experience of all the other teams to provide consultancy to PHD and the PHSI. The PRA sub-Team (hereafter referred to as

the PRA Team) carry out many different but related tasks. We produce individual PRAs for specified pests such as those intercepted in trade as well as annotated lists of pests on traded commodities, to facilitate imports and exports. We assess overseas countries commodity PRAs, also for trading purposes. In support of policy we assess quarantine pest and EPPO Alert Lists. Our work supports eradication and containment action, protected zone status in the EU and phytosanitary procedures. Research and development is conducted on specific pests, for example on *Tilletia indica* (see <http://www.planteforsk.no/prosjekter/karnalpublic>). Consultancy work includes assisting other countries with PRA and the development of PRA by developing national, regional (EPPO) and international (IPPC International Standards for Phytosanitary Measures – ISPMs) standards by consultation. The development of techniques for PRA includes the use of Geographic Information Systems (GIS), environmental modelling, economic and environmental analysis and pathway analysis.

Generic Risk analysis: Quantitative versus qualitative

Generically (across disciplines) risk analysis is described by Vose (2001) as “*the quantifying either qualitatively or quantitatively of the probability and potential impact of a risk*”

Generically, risk analysis involves:

- the identification of risk
- risk assessment
- risk management
- risk communication

Quantitative risk analysis is one of several tools which may be chosen by the decision maker when assessing risk. Providing a suitable model can be constructed and its data inputs realistically quantified this method can provide insight into problems surrounded by uncertainty, such as occurs in PRA.

The trend in the 21st Century is toward more quantitative methods. These are feasible and common in engineering and related disciplines. However, in biological disciplines, a lack of basic data is a limiting factor in using fully quantitative methods. In simple cases it may be possible that quantitative data are available for all points in the pathway of pest entry and establishment as well as economic loss, but this is unusual. Because of this trend, pest risk analysts may feel pressured into conducting fully quantitative PRAs.

However, it is important to ask the question:

“*Are quantitative PRAs better than qualitative?*”

The answer is two-fold (after Vose, 2001):

“*PRAs should be fit for purpose*”

“*A quantitative PRA that uses poor data, an incorrect model or an inappropriate technique is less scientific than a semi-quantitative/qualitative PRA based on good scientific data and other literature*”

Pest Risk Analysis: Quantitative versus qualitative

PRA methodology ranges from fully qualitative to fully quantitative (probabilistic risk analysis). A common approach is to “mix and match” using quantitative data where available and qualitative assessment where not. In developed countries the trend is towards using more quantitative approaches to PRA. This incurs significant increases in resources i.e.: trained and skilled staff, valid data, valid models, computing resources and time. It should be borne in mind however that most quarantine decisions do not require such effort. As such, in the UK we prefer to use a good qualitative system which is fit for the purpose for which it is intended. This system may include numeric data but in PRA parlance it would be considered to be qualitative.

Under the WTO SPS Agreement (Anon., 1994) it is a requirement that members shall ensure that their phytosanitary measures are based on an assessment of the risk to plant health, taking into account “*risk assessment*” techniques developed by the relevant international organisations. The WTO accepts all forms of risk analysis provided this is borne in mind. For plant health purposes the relevant international organisation is the Food and Agriculture Organisation of the United Nations (FAO) Secretariat of the IPPC and the techniques are those within the relevant ISPMs, i.e., ISPM no. 2 (Anon., 1996), “Guidelines for Pest Risk Analysis” and ISPM no. 11 (Anon., 2001a) “Pest Risk Analysis for quarantine pests”. The key point is that the IPPC is not prescriptive in PRA methodology as described within these ISPMs and below.

Within ISPM no. 11, advice is given on how the content of a PRA should be expressed. Conclusions on the probability of introduction (entry and establishment) and spread should be expressed in terms most suitable for the data, method of analysis and intended audience. These terms may be quantitative or qualitative, since either output is the result of a combination of both types of information. The conclusion on the assessment of potential economic consequences should be expressed in monetary values, but can be expressed qualitatively, or using quantitative measures without monetary terms. The conclusion of the pest risk assessment section can be quantitative or qualitative. The conclusion of the pest risk management section identifies measures to reduce the identified risk to an acceptable level and may be qualitative, except where a cost:benefit analysis of measures is deployed, to show the effectiveness and appropriateness of the measures which are chosen.

Whichever method of PRA is chosen there are 9 “commandments” to bear in mind (after Vose, 2001)

1. Do your homework (consult the literature, experts)
2. Let the problem drive the analysis (not the other way round)
3. Make the analysis as simple as possible
4. Identify all major assumptions
5. Be explicit on uncertainties
6. Be explicit on decision criteria and policy strategy
7. Document everything clearly and completely
8. Expose to peer review
9. Provide guidance to and ensure the results are understood by the decision maker

Initiation points for PRA

Under ISPM no. 11 (Anon., 2001a) there are three main initiation points for PRA.

These are:

1. The identification of a *pest* that may require phytosanitary measures
2. The identification of a *pathway* that presents a potential pest hazard
3. The review or revision of phytosanitary *policies* and priorities

These are further broken down into 18 sub-categories. A recent analysis of the work of the UK PRA Team showed that between January 1999 and 2002 a total of 109 PRAs were initiated by 12 of these routes. New interceptions were the single biggest initiator of PRAs accounting for 37% of those produced. In addition to the work of the PRA Team our sister Team, responsible for licensing researchers to work on exotic pest and plant species, produces many simpler PRAs to determine appropriate containment strategies.

Methodology for UK PRAs

In general, UK PRAs follow our standard in-house system (Baker *et al.*, 1999). The system covers all the main factors in ISPM no. 2 (Anon., 1996) and 11 (Anon., 2001a).

Table 1: Main topics for the UK PRA system

INITIATION
Pest identity
PRA area
PEST RISK ASSESSMENT
Present in UK/EU/EPPO ?
Present on EU/EPPO Quarantine Pest Lists or EPPO Alert List ?
Host Plants?
Geographical Distribution?
Potential for entry/establishment ?
Potential as a pest (or vector)? (<i>Includes economic/environmental loss</i>)
PEST RISK MANAGEMENT
Prospects for continued exclusion ?
Prospects for eradication?
Risk management options?
CONCLUSION
Summary of hazard
Summary of any necessary measures
Major uncertainties
REFERENCES

The key questions in this system can be answered briefly, or extended to a more detailed assessment of entry, establishment, impacts and risk management options. The conclusion ends

with a statement about the risk to the UK or across the EU Member States or the EPPO region, depending upon the defined PRA area. We may advise our policy makers, PHD, as to the extent to which the pest is appropriate for risk management, including whether to propose the pest for EU/EPPO quarantine or Alert listing. This style of PRA is often supported by a Datasheet with considerably more information in it, but the standard PRA allows the policy makers to reach a swift conclusion.

When a very detailed PRA is required, the full EPPO system may be utilised in addition to the UK system. In some cases, additional techniques, such as climatic mapping using CLIMEX (Sutherst & Maywald, 1999) and pest phenology models within a GIS or economic impact modelling may be employed.

The level of detail included in each PRA depends on:

- The urgency for the PRA to be produced
- The extent to which the threat posed by a pest is clear-cut
- The importance of the pest
- The likelihood of a dispute arising
- The amount of information available

Above all, a PRA should be fit for purpose. There is no need to conduct an extensive analysis if, for example, a pest has no host on which to develop or no pathway on which it can enter.

European and Mediterranean Plant Protection Organisation (EPPO)

EPPO is the Regional Plant Protection Organisation for 43 countries including all 15 Member States of the EU.

EPPO have published 4 standards related to Pest Risk Analysis including the Pest risk assessment system (Anon., 1997). This system does not include pest risk management although there is a separate standard for this (Anon., 2001b). In general the UK use this system when we are proposing that pests identified by the UK Summary PRA system should be listed as quarantine pests by EPPO and the EU.

EPPO Pest risk assessment system

The EPPO Pest risk assessment system (Anon., 1997) was devised by the EPPO PRA panel composed of specialists from EPPO member countries. This system provides instructions for analysing the risk posed by individual pests under the main headings of risk assessment, i.e. initiation, pest categorisation, introduction and economic impact assessment. It provides a simple system by which the analyst can decide whether a risk exists (Part A) and a way in which the risk can be quantified using a subjective scoring system, based on questions to which scores are given on a 1-9 scale (Part B). Expert judgement is used in interpreting the replies.

Part A follows the main concepts of the ISPM no. 2 (Anon., 1996) and is a qualitative system for deciding whether the pest poses a threat to the PRA area.

The format is a binary decision tree for a series of questions. The aim is to lead the analyst through the qualitative criteria for a quarantine pest.

The assessment can stop if the pest does not fulfil any one criterion for quarantine pest status as defined (Anon., 2001): “*A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled*”.

Having taken the pest through Part A and decided it fulfils the status of a quarantine pest the analyst takes the pest through Part B.

Part B of the EPPO system comprises many questions with replies expressed as scores on a 1 (low) to 9 (high) scale. Low scores are used for unlikely or low impact events while high scores are used for very likely or high impact events. Part B is subdivided into determining the probability of introduction (entry and establishment) and its potential economic impact if establishment occurred. The overall level of pest risk is expressed quantitatively as a score for introduction as well as one for the likely economic impact should the pest become established. The pest can then enter the separately published EPPO risk management system (Anon., 2001b).

The analyst determines how to score and what the scores mean, as well as how to present them. The analyst is advised that they may weight some questions higher than others. The scores can be assigned to individual pathways or hosts. Thus, the system can be used to compare different pests and pathways. The analyst determines how to arrive at an overall score of risk. EPPO does not prescribe a procedure for doing any of this.

It may not be possible to answer all the questions in Part B of the system since they may not be relevant, or information may not be available. In the first case this does not affect the assessment. In the second case the value of the assessment is reduced. Some questions (marked with an asterisk in the same section of the system) are considered to be more important than others. In view of all of this, at the end of the assessment the analyst is asked to comment on the available information, in the light of whether it is good quality and sufficient to answer the questions posed.

The key to the best use of Part B of the EPPO system however, is to ensure sufficient information is provided with the scores to justify how they were determined. This should include both scientific data and other sources of information. The analyst should ensure that all areas of uncertainty are described in the text.

EPPO Pest risk assessment system Part B: practice and problems with the scores

So, how does the scoring system work in practice and what problems does the analyst encounter?

The first section in Part B of the EPPO system refers to the risk of entry of a pest into the PRA area. The first question in this section asks the analyst to estimate the number of pathways on which the pest could enter the PRA area. There is no prescribed way to describe a pathway nor is there advice on the minimum information required to describe them. In phytosanitary terms a pathway is defined as “*any means that allows the entry or spread of a pest*” (Anon., 2001). A very basic description could be “*ornamental cut flowers from Thailand*”. Conversely, there is almost no limit as to the level of detail that could be used to describe a pathway. For practical purposes, the important factors used to distinguish between pathways should include a description of the commodity and the region of origin. A related question, asks whether the pest concentration at

origin is likely to be high (not likely scores 1, very likely scores 9). Again this is difficult to judge. For example, how does the analyst assess the concentration of a plant virus in the area of origin (?). Such data are rarely collected in some countries, let alone published in the scientific literature.

Other examples of scoring problems include questions under the establishment section. The number of host species may only be 1 in the PRA area but if the pest only affects 1 host in its normal geographic range, to give a low score would misrepresent and reduce the overall level of assessed risk. Another example of difficulty, is the last question in the establishment section, which asks for the frequency of the pest being introduced into new areas outside of its original range. The analyst could count the number of countries the pest has spread to, assuming that the more countries, the higher the score. But consider a pest that has spread within the continent of Asia - it could spread to many countries over a few thousand miles. The analyst is not sure whether the score should be more, or less, than a pest that has spread from China to Australia and the USA, just 2 countries, but in different hemispheres.

For 4 of the questions in the entry section a “yes” or “no” answer is required. These questions relate to the association of the pest with the pathway at origin, the survival of the pest in the country of origin under existing cultivation or commercial practices, as well as in transit, and transfer of the pest from the pathway to a suitable host. If the answer to any of these questions is “no”, then the pathway does not act as a means of entry and the analyst is asked to return to the beginning of Part B, to start answering questions again, for the next most important pathway.

The system continues with similarly phrased questions on a range of topics as listed below:

Entry

Survival: Of the pest in existing cultivation or commercial practices in the country of origin, of existing phytosanitary procedures, as well as in transit

Multiplication: Of the pest in transit

Commodity: Volume of movement of the commodity along the pathway; spread of its distribution through the PRA area, spread in time of arrival of different consignments *Transfer:* Of the pest from the pathway to a suitable host and whether the intended use of the commodity would aid pest introduction

Establishment

Hosts: Number of species of normal and alternate hosts (as appropriate) in the PRA area; distribution in the PRA area; whether the pest is recorded on crops in protected conditions elsewhere and whether wild plants would aid pest dispersal or help maintain pest populations

Vectors: Likelihood of the pest associating with a suitable vector

Abiotic factors: Similarity of climates in the PRA area and area of origin and of other factors e.g. soil type, environmental pollution, topography/orography; differences in crop environment; existing pest control practices in the PRA area

Competition/predation: Competition for ecological niches and effect of natural enemies.

Pest: Reproductive strategy and duration of life cycle; genetic adaptability; likelihood of low populations of pest establishing; possibilities for eradication; frequency of introduction into new areas.

Economic impact

Under this section the analyst can assess all of the identified hosts together or produce a separate assessment for each host. The analyst is asked to identify all of the hosts in the PRA area, noting whether wild or cultivated, field or glasshouse. In answering the subsequent questions, the analyst is asked to consider, for a pest transmitted by a vector, any damage that the vector may cause.

The questions fall under the following headings:

Pest in the current geographic area: Economic loss; environmental or social damage

Pest in the PRA area: Extent of the area likely to be damaged; speed of spread by natural means or with human assistance; containment of spread

Effect of the pest in the PRA area: Direct effect on crop yield and/or quality; effect on producer profits due to changes in production costs and yields; effect on consumer demand and export markets; other costs (e.g. statutory; research); effect on the environment or social damage

Control of the pest in the PRA area: Effect of natural enemies; ease of control; effect on existing biological or integrated systems; other undesirable side effects (e.g. human health or environment); likelihood the pest will develop resistance to pesticides

EPPO system Part B: Final evaluation

At the end of the procedure, the assessor will have 3 sets of scores.

The first set is for the section on entry; there may be separate sets of scores for 1 or several pathways. If no identified pathways are retained the probability of introduction is zero.

The second set is for the section on the risk of establishment.

The third set is for the section on economic impact. As with entry there may be separate sets of scores, in this case, for single, grouped or separate hosts (according to the manner of answering which the analyst has chosen).

Scores from each section may be combined, weighted and averaged in ways that enables the analyst who uses them consistently, to make comparisons between pests, pathways and hosts. No particular mode of calculation is specifically recommended by EPPO. Additionally, some questions are more important than others, and the analyst is asked to take this into account.

In conclusion, the analyst makes a separate estimate of the probability of introduction of the pest and its probable level of economic impact. Estimates of the probability of introduction and probable economic impact could be combined to produce a single estimate of pest risk. This could be

compared with one or several reference levels of risk to decide whether the pest should be considered to be a quarantine pest.

EPPO system: Examples of use by the UK PRA Team

The first UK use of the EPPO Pest risk assessment system after its publication in 1997 was for *Thrips palmi* (MacLeod, 1997, *unpublished*) and for one of a range of tospoviruses which it vectors, *Watermelon silver mottle virus* (WSMV) (Sansford, 1998 *unpublished*). *Thrips palmi* was assessed for the direct effect it has on plants resulting from feeding damage, rather than the additional effects it has a virus vector.

Interceptions of *T. palmi* in the EU occur regularly on a range of hosts. Thai orchids are the most common host on which EU interceptions have occurred (MacLeod & Baker, 1998).

A UK PRA for *T. palmi* conducted by Baker (Baker, CSL, *personal communication*) was re-evaluated in 1997 using the EPPO system, when the first interception of the pest was made in the UK on cut orchids from Thailand (MacLeod, 1997, *unpublished*).

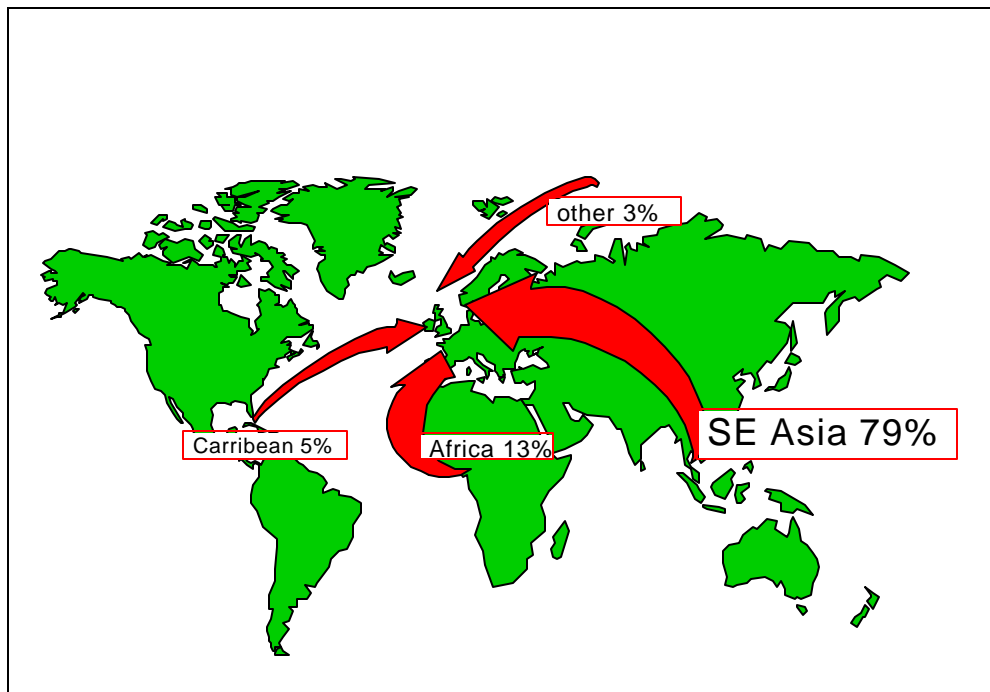
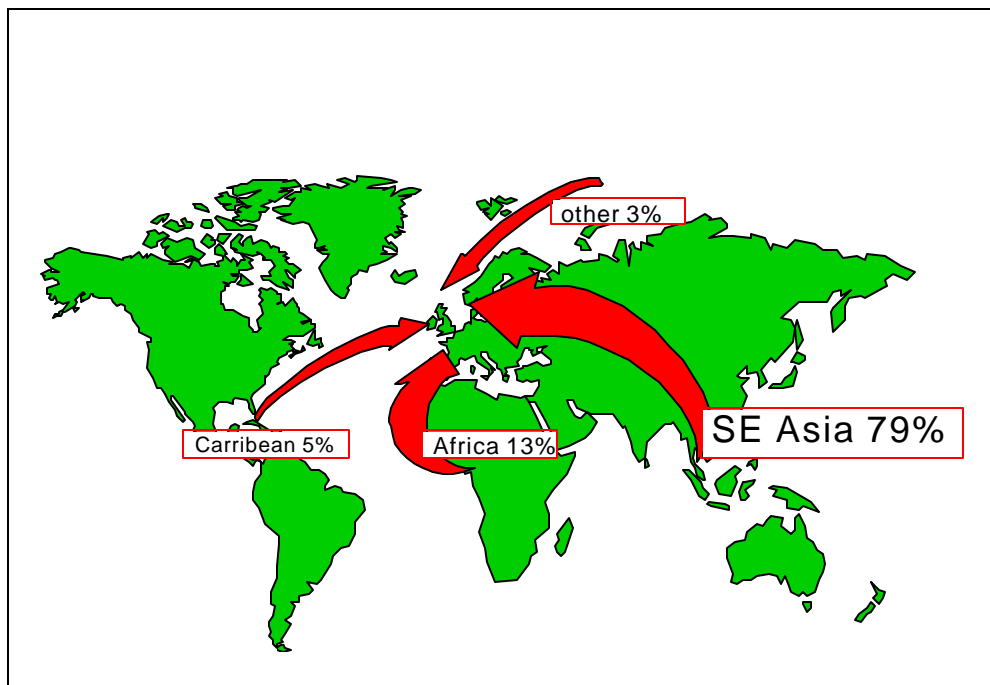


Figure 1: Origins of *Thrips palmi* interceptions by EU Member States: (1995 - 1997) (MacLeod & Baker, 1998)



Within Europe there have been several outbreaks of *T. palmi* in the Netherlands under glass which have been eradicated (Anon., 1997a) so we know the pest can survive in Europe, at least under protected conditions. Since 1978, extensive outbreaks have been reported (regularly) from Japan and since 1985 it has spread in the Caribbean region (Anon., 1997a). Much of the damage reported as occurring has been the result of direct feeding by *T. palmi* on a range of hosts, but there have been reports of virus-related devastation to watermelon and other crops, especially in Asia (in Sansford, 1998 unpublished).

Tospoviruses, such as *Watermelon silver mottle virus* are transmitted by a few thrips species, in a persistent circulative manner. Our understanding of the tospovirus genus is forever changing - a decade or so ago everything was classified as *Tomato spotted wilt virus*; at the time of the UK Summary PRA in 1997 and the subsequent use of the EPPO Pest risk assessment (Sansford, 1998 unpublished) there were thought to be seven viruses, now there are at least 13 (Barker, CSL, personal communication). The main subject of the 1997 assessment was *Watermelon silver mottle virus* (WSMV) since this was the most well-documented of the non-indigenous tospoviruses.

WSMV occurs in several Asian countries including Japan and Taiwan. Within the PRA the risk that *T. palmi* could acquire the virus by feeding on either of its natural hosts, melon and watermelon, survive transportation into Europe and then transmit it either to its natural hosts, or its experimental hosts, (which include several economically important glasshouse crops such as cucumber), was considered to be high. The potential economic losses to its natural hosts (melon and watermelon) in the southern EU Member States were thought to be substantial, since the virus causes foliar and fruit symptoms which reduce quality and yield of fruit. It was also possible that losses in cucumber

(an experimental host) could be significant.

The use of the EPPO system (Part B) gave the scores shown below for WSMV:

Mean of entry potential: 7.2

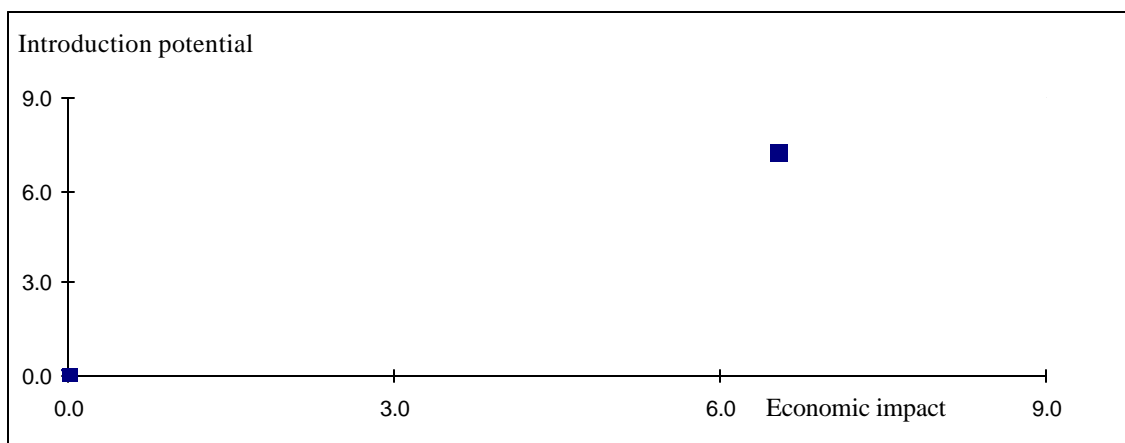
Mean of establishment potential: 7.4

Mean risk of introduction (entry and establishment) : 7.3

Mean risk of economic impact: 6.5

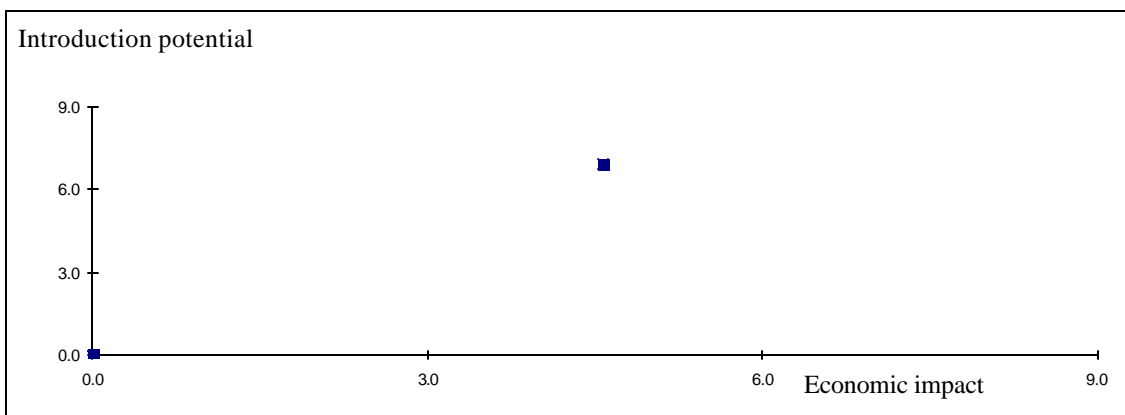
This can be graphically represented as shown below:

Figure 2: Potential risk of introduction and economic impact for *Watermelon silver mottle virus* using the EPPO Pest risk assessment system (Sansford, 1998, unpublished)



Similarly, the assessment of the risk posed by *T. palmi* as a direct pest is represented below.

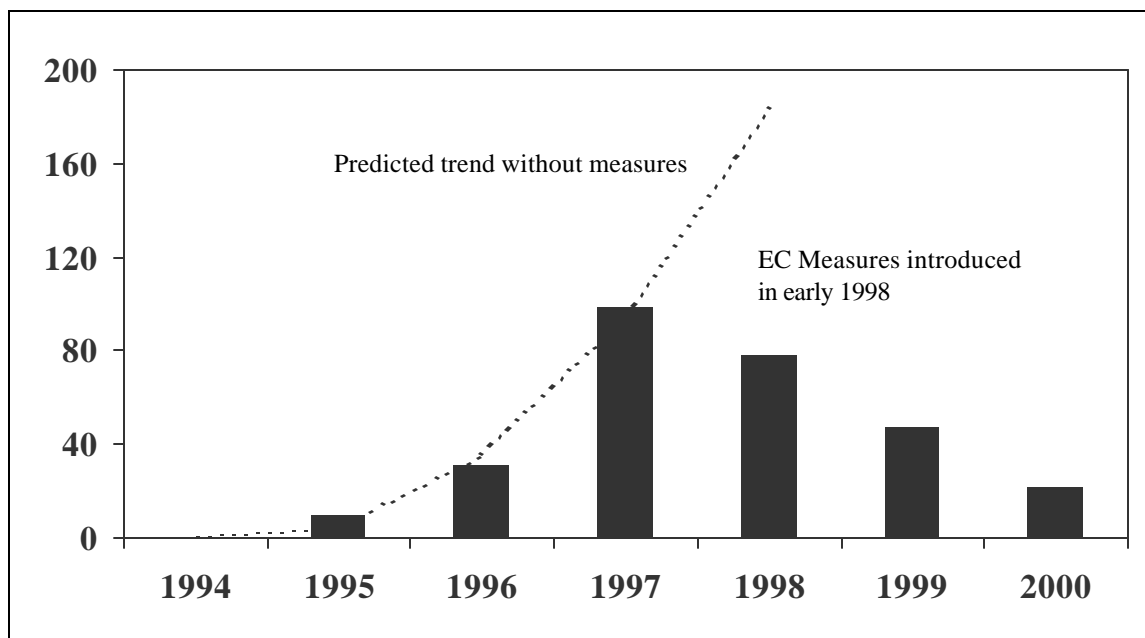
Figure 3: Potential risk of introduction and economic impact for *Thrips palmi* as a direct pest using the EPPO Pest risk assessment system (MacLeod, 1997, unpublished)



The outcome of the use of the EPPO system for WSMV was that the pest became listed as an A1 quarantine pest for the EPPO region. WSMV would need a vector in the region to express its damage potential. Its only known vector, *T. palmi* is absent from the EPPO region, and is an A1 quarantine pest for both the EU and for EPPO. As host plants of WSMV are little traded between continents, EPPO recommends that the main phytosanitary measure to be taken against WSMV is to continue to exclude its vector *T. palmi*. Additionally, the European Commission (EC) took specific measures against cut orchids from Thailand to exclude this pest. With the co-operation of the Thai Ministry of Agriculture (who undertook to educate and train orchid exporters in 1997 on pest control on flowers destined for export to Europe) new EC measures for orchids from Thailand were transferred to UK/EU legislation in 1998 (see MacLeod & Baker, 1998). This required place of production freedom or appropriate treatment to ensure freedom from Thysanoptera. Measures were also proposed to take action against plant material that may be harbouring WSMV. The EC is still considering what action to take (Bartlett, CSL, *personal communication*).

Looking in more detail at the number of interceptions of *T. palmi* (MacLeod, CSL, *personal communication*) (see Figure 4, below) it was found that although there were no interceptions of the pest in 1994, there were almost 100 in 1997. MacLeod added a simple power function curve to the data to show the trend. Although there were only 4 data points it was useful to visualise the trend. This appeared to show that without additional measures, by 1998 approximately 180 interceptions would be expected. The new measures described above were not considered to be onerous or unjustified and the consequence of their imposition can be seen in the decline in interceptions.

Figure 4: EU notifications of *Thrips palmi* on Thai orchids and the effect of the introduction of phytosanitary measures in 1997/1998 (MacLeod, CSL *personal communication*)



Another more recent example of the use of the EPPO PRA system is that of its use for a newly-described and poorly-documented virus of potatoes. *Potato latent virus* (PotLV), a recently described carlavirus (synonym Red La Soda virus) is not thought to be present in the EPPO

Region. Jeffries (2002, *unpublished*) used the EPPO Pest risk assessment system for the first time in 2002. The assessment was conducted as part of an EPPO exercise looking at the potential for facilitating imports of potatoes into Europe, trade in which is currently restricted. The EPPO Pest risk assessment for PotLV examined the risk from different routes of entry, which if trade were to be permitted in the future, appears to pose different risks. Conclusions of the scores assigned by Jeffries for Part B of the EPPO Risk assessment system for *Potato latent virus* are shown below:

Mean of entry potential for:

<i>Breeding material</i>	6.6
<i>Seed: Microplants/microtubers</i>	5.1
<i>Seed: Minitubers</i>	5.3
<i>Seed: Field-grown tubers</i>	6.3
<i>Ware</i>	6.2
<i>Mean of establishment potential</i>	7.7
<i>Mean of economic impact</i>	4.4

Jeffries found that the risk of entry of PotLV from breeding material posed the greatest threat. The risk of establishment was high and the potential economic impact moderate. Jeffries proposed that PoTLV should become a quarantine pest for the EPPO region.

The future of the EPPO system?

The EPPO system is being used by some pest risk analysts, but not all PRAs need to be so elaborate. The UK system can be just as effective at assessing plant health risks, especially when supported by a Datasheet.

We are still unsure as to what a 1 represents as opposed to a score of 9. Because the system uses scores, numbers can be manipulated, and average scores worked out for the whole system or for constituent parts of the system. This could be dangerous since some questions are more important than others. The merits of a weighting system for key questions have been discussed, but the key questions in each risk assessment could vary between organisms. Averaging scores for unrelated topics could be considered meaningless. In recent years risk analysts from around Europe have tested the system in an EPPO workshop and practiced using it. Naturally, they varied in how they interpreted some of the questions and were at variance when it came to assigning a score to the same questions (MacLeod, CSL *personal communication*). What is important however, is to ensure all of the scores are supported by well-documented information (both scientific and other) and all uncertainties are discussed, as part of the process of the use of the EPPO system.

Subjective assessments

Whatever method is used for PRA, there is uncertainty in the use of subjective estimates.

Problems causing uncertainty include (after Vose, 2001):

- data have never been collected

- data are out of date
- data are sparse or conflicting (experts have to use their own judgement)
- the pest being assessed is new

It is therefore advised that one or more experts are consulted when insufficient data are available to complete a PRA.

It is difficult to estimate the probability of the occurrence of a discrete event such as those encountered in PRA and some experts may be concerned at the prospect of assigning scores when they are uncertain.

One way to avoid this problem is, rather than use a direct scoring system, the analyst could use probability phrases and rank them e.g. (after Vose, 2001):

- almost certain
- very likely
- highly likely
- reasonably likely
- fairly likely
- reasonably unlikely
- highly unlikely
- very unlikely
- almost impossible

MacLeod & Baker (2002, *unpublished*) have attempted to assign descriptions of the 1 to 9 scores for some of the questions in the EPPO system, Part B.

The following example is from the section on entry. The analyst is asked to consider the frequency of trade along the commodity pathway.

1.11 How widely spread in time is the arrival of different consignments ?

<u>Score</u>	<u>Description: Frequency of commodity import</u>
1	once a year or less
2	more than once a year but only during one month of the year
3	during two different months of the year
4	up to 3 months of the year
5	up to 4 months of the year
6	up to 6 months of the year
7	up to 8 months of the year
8	up to 10 months of the year
9	up to every month of the year

MacLeod found when assessing imports of sweet peppers, (*Capsicum annuum*) between 1993 and 1997, the UK imported them from India only once per year and suggested that this be given a score of 1. Imports from Israel occurred on average during five months each year giving a score of 6 (range 4 to 6) and from Spain every month of the year (score = 9).

Perhaps the development of the system in this way would assist present and future risk analysts.

Future development of PRA

The future development of PRA depends upon information, since a PRA is only as good as the information upon which it is based. Scientific journals may be readily available in developed countries, but other information can be difficult to find. Trade statistics are very useful but often limited to major crops or major producers. Economic and financial data can be difficult to obtain, especially from the trade organisations, because of commercial sensitivities.

For invertebrate pests MacLeod and Baker (CSL *personal communication*) consider that (amongst other things) further areas of research for PRA include modelling pest spread after entry. The prediction of establishment potential for invertebrates is improving, based on thermal biology and climate, but more work is needed on the potential for pest spread. This links to studying the ecological interactions between competitors. CLIMEX (Sutherst & Maywald, 1999) is much criticised by some because it does not account for species interactions. Entomologists such as MacLeod and Baker see scope for systems such as CLIMEX, to develop more. It might, for example, be possible to use GIS to interpolate eco-climatic indices produced in CLIMEX at point sources over the landscape and to overlay host distribution and the distribution of competitors or other biotic factors to generate risk maps.

For plant pathogens, the use of such systems is fraught with difficulties because of the complex nature of abiotic factors in relation to host susceptibility and the lifecycle of the pathogen. To address this, the part-EC funded international project “*Karnal bunt risks*” has brought together an international team of researchers including economists, crop and disease modellers, mycologists, epidemiologists, GIS experts and pest risk analysts to develop a new PRA for *Tilletia indica* and ultimately to produce a new PRA framework for other plant pathogens (see <http://www.planteforsk.no/prosjekter/karnalpublic>).

Presenting, interpreting and managing PRA

Whatever the method used, the results of a PRA must be understandable, useful, believable and tailored to the problem in hand. Analysts and their managers should be properly trained in PRA. Managers need to understand:

- Management of PRA - sequence of activities, time and resources needed
- How to ensure the PRA is being produced properly
- What a PRA can/cannot do
- What outputs to ask for
- How to interpret, present and communicate a risk analysis and its results

Whether the PRA is quantitative or qualitative or a mixture of both, the analyst should guide the reader through the assumptions, results and conclusions. We should tailor the report to the reader and the problem and explain assumptions and areas of uncertainty.

But most important of all, whether qualitative or quantitative PRAs should be fit for purpose

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Quantitative versus Qualitative: PRA in the UK and Europe including the EPPO system

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Quantitative versus Qualitative PRA: Outline

- Quantitative vs. qualitative - pros and cons for pests
- UK CSL PRA subteam
- UK CSL PRA format (qualitative)
- EPPO PRA format (qualitative/semi-quantitative with a subjective scoring system)
- Specific examples of UK work: CSL/EPPO PRA system:
 - *Watermelon silver mottle virus*
 - *Thrips palmi*
 - *Potato latent virus*
- EPPO system - scoring problems
- PRA development and communication

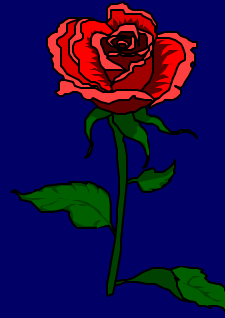
Alan Pemberton
Head of PRA sub-team



Claire Sansford: Pathology



Richard Baker: Entomology



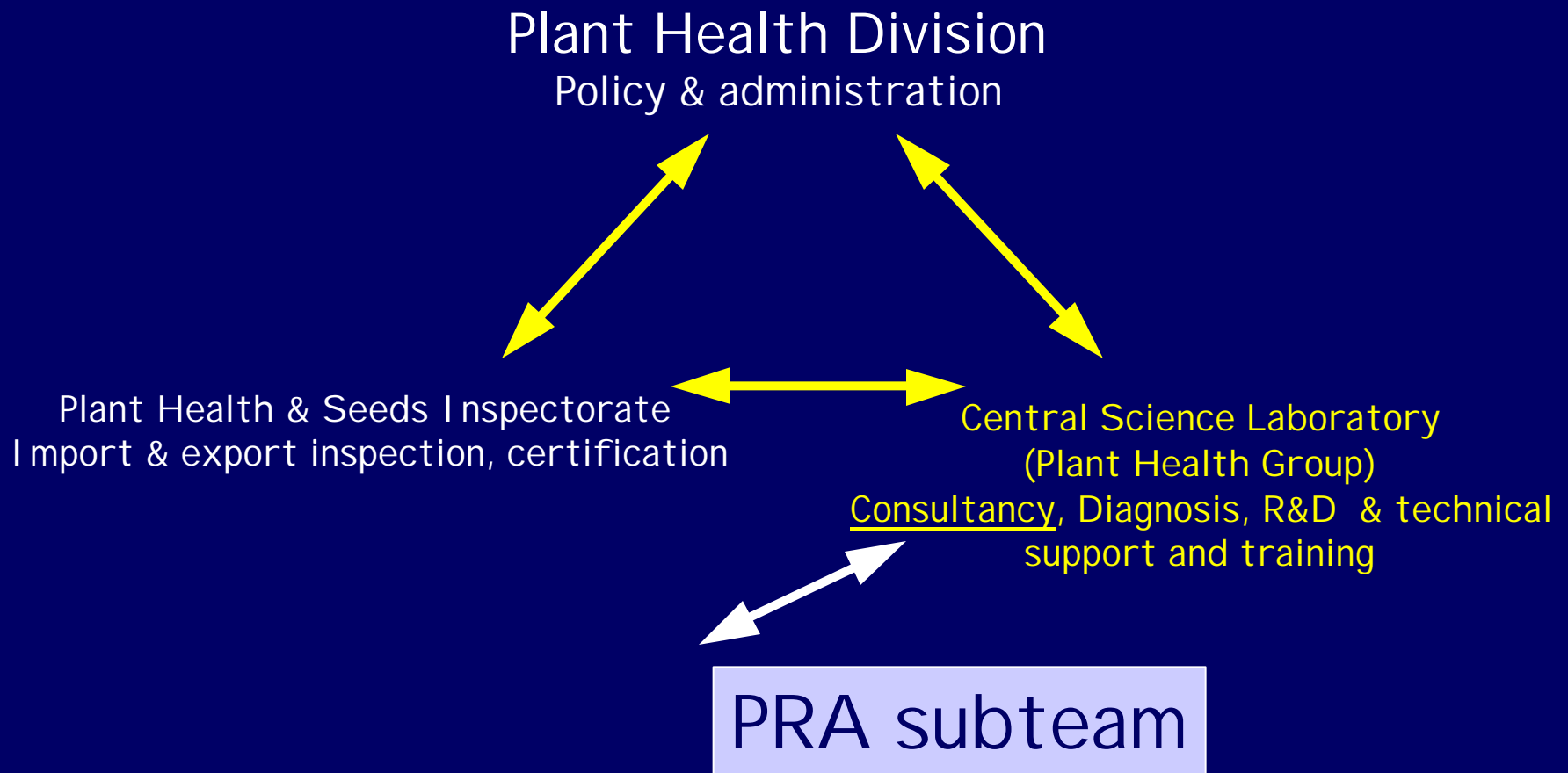
David Jones: Pathology



Alan Macleod: Entomology



DEFRA: Plant Health Service in England & Wales



Tasks of the CSL PRA subteam

PRAs

- Individual pests
- Commodity/pathway
- Support to UK/EU/EPPO policy
- R&D and Consultancy including peer review

PRA Development

- National/Regional (EPPO)/International Standards (FAO IPPC)
- Techniques

PRA Communication

Quantitative vs. Qualitative Risk Analysis

Generically (across disciplines)

Risk analysis is:

*the quantifying either qualitatively or quantitatively of the probability and potential impact of a risk**

It involves:

- the identification of risk
- risk assessment
- risk management
- risk communication

*Vose, 2001 "Risk analysis: A Quantitative Guide"; second edition (Wiley & Sons)

Quantitative vs. Qualitative

- **Quantitative** risk analysis is one of several tools which may be chosen by the decision maker when assessing risk
- Providing a suitable model can be constructed and its data inputs realistically quantified this method can provide insight into problems surrounded by uncertainty (such as occurs in PRA)

Quantitative vs. Qualitative

- **Generically**, the trend is toward more **quantitative** methods for risk analysis (*e.g engineering and related disciplines*)
- In biological disciplines however, there is a lack of basic **quantitative** data

Quantitative vs. Qualitative PRA

Question:

- Are *quantitative* PRAs better than *qualitative*?

Answers:

- PRAs should be fit for purpose
- A *quantitative* PRA that uses poor data, an incorrect model or an inappropriate technique is less scientific than a *semi-quantitative/qualitative* PRA based on scientific and other literature

Quantitative vs. Qualitative PRA

- PRA methodology ranges from fully **qualitative** to fully **quantitative** (probabilistic risk analysis)
- A common approach is to "*mix and match*" using **quantitative** data where available and **qualitative** assessment where not

Quantitative vs. Qualitative PRA

- As with generic risk analysis in developed countries the trend is towards more **quantitative** approaches to PRA
- **Resource implications:**
i.e.: trained & skilled staff, valid data, valid models, computing resources & time
- Most quarantine decisions do not require such effort
- The UK use a good **qualitative** system fit for purpose

WTO-SPS (1994) and International Plant Protection Convention (IPPC)

WTO-SPS:

...ensure phytosanitary measures based on assessment of risk to plant health taking into account risk assessment techniques developed by relevant international organisations

- WTO accepts all forms of risk analysis

FAO IPPC Secretariat:

- ISPMs: basis for phytosanitary measures applied by WTO Members under the SPS Agreement
- The IPPC & ISPMs not prescriptive in PRA methodology

I SPM no. 11: PRA for Quarantine Pests

May 2001 (1): Conclusions

- *Conclusions of introduction (entry and establishment) and spread should be expressed in **terms** suitable for the data, method of analysis and intended audience*
- *These **terms** may be **quantitative or qualitative**, since either output is the result of a combination of both types of information*

I SPM no. 11: PRA for Quarantine Pests May 2001 (2): Conclusions

- Economic consequences : express conclusion in monetary values; can be expressed *qualitatively* or as *quantitative* measures without monetary terms
- Pest risk assessment : conclusion can be *quantitative or qualitative*
- Pest risk management : conclusion could be *qualitative* except where a cost:benefit analysis of any proposed measures was used to determine appropriateness and effectiveness when it would *quantitative*

The Nine Commandments of all types of PRA (after Vose, 2001)

- 1 Do your homework (literature, experts, stakeholders)
- 2 Let the problem drive the analysis (*not the other way round*)
- 3 Make the analysis as simple as possible
- 4 I identify all major assumptions
- 5 Be explicit on uncertainties
- 6 Be explicit on decision criteria and policy strategy
- 7 Document everything clearly and completely
- 8 Expose to peer review
- 9 Provide guidance to and ensure the results are understood by the decision maker

Initiating PRAs in the UK

Initiation points as per ISPM 11:

- the identification of a **pest** that may require phytosanitary measures
- the identification of a **pathway** that presents a potential pest hazard
- the review or revision of phytosanitary **policies** and priorities

Initiating PRAs in the UK

- Within these 3 categories I SPM 11 lists 18 different ways in which PRAs can be triggered
- At CSL 109* PRAs were initiated by 12 of these routes over 2 years (to January 2002)
- Most (40) were due to new interceptions
- (*Additionally our sister subteam produces many simple PRAs to license researchers working on exotic pests and plant species)

Number of UK PRAs initiated by pests: Jan 1999 - Jan 2002

New Outbreak	8
New Interception	40
New Pest Risk identified by Research*	9
New Pest Introduction	1
New Pest Damage Report in an Area other than Area of Origin	0
Repeated Interceptions	5
Pest Import Request	8
New Vector Identified	0
GMOs	<u>0</u>
Total	71

*Plus many more simple PRAs to licence researchers

Number of UK PRAs initiated by pathways:
Jan 1999 - Jan 2002

New Commodity	9
New Trade Pathway	8
New Plant Species for Breeding/Research*	2
New Non-Trade Pathway	<u>0</u>
Total	19

*Plus many more simple PRAs to licence researchers

Number of UK PRAs initiated by policy:
Jan 1999 - Jan 2002

New UK Phytosanitary Measures	15
New EC/EPPO/FAO Phytosanitary Measures	3
Changes to Phytosanitary Procedures on Available or New Evidence	1
Disputes	0
Major national, international changes in Phytosanitary situations or borders	<u>0</u>
Total	19

UK PRA system (qualitative)

INITIATION

- Identity
- PRA area

PEST RISK ASSESSMENT

- Present in UK/EU/EPPO ?
- Present on EU/EPPO Quarantine Pest Lists or EPPO Alert List ?
- Host Plants?
- Geographical Distribution?
- Potential for entry/establishment ?
- Potential as a pest (or vector)?
(includes economic/environmental loss)?

PEST RISK MANAGEMENT

- Prospects for continued exclusion ?
- Prospects for eradication?
- Risk management options?

CONCLUSION

- Summary of hazard
- Summary of any necessary measures
- Major uncertainties

REFERENCES

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- PM 5/1(1) Check-list of information for PRA
- PM 5/2(1) PRA for action on interception of a pest
- PM 5/3(1) Pest risk assessment system
- PM 5/4(1) Pest risk management system

EPPO Pest Risk assessment system

- Devised by PRA panel
- Published in EPPO Bulletin
- Follows ISPM Guidelines on Pest Risk assessment
- Two parts - A and B

EPPO Pest Risk assessment system: Part A

- **Part A: Qualitative** = I SPM (1995) - no risk management
- Decides whether pest poses a risk to the PRA area
- **Format:** binary decision tree for a series of questions
- **Aim:** lead analyst through **qualitative** criteria for a quarantine pest
- **Stop:** if any 1 criterion for quarantine pest status is not fulfilled

EPPO Pest Risk assessment system: Part B

- Potential quarantine pest enters Part B
- Part B: Many questions
- Reply with scores - 1 (low risk); 9 (high risk)
- Sections introduction (entry & establishment)
economic impact
- "Pest risk" : score for introduction & economic impact
- Pest can then enter the risk management system

EPPO Pest Risk assessment system: Part B

- Scoring method and interpretation is up to the analyst
- Questions can be weighted
- Some questions may be left unanswered
- Scores can be given for individual pathways or hosts
- System does not provide estimates of introduction or economic impact in meaningful units
- EPPO does not prescribe a method for any of this
- Assumptions and uncertainty are described at the end

EPPO Pest Risk assessment system: Part B

- Outline of the process
- Examples of problems with scoring
- Three examples of the use of the system
 - *Watermelon silver mottle virus*
 - *Thrips palmi*
 - *Potato latent virus*

EPPO system: Part B - Entry (1)

- 1.1 Number of pathways the pest could be carried on?
(few = 1; many = 9)?
- 1.2 For each pathway, in descending order of importance, answer questions 1.3 – 1.13.
- NB: For 4 questions in this section if the answer is "no" the pathway does not act as a means of entry for the pest and the system returns directly to 1.2
- Go to 1.3

EPPO system: Part B - Entry (2)

- 1.3a Could the pest be associated with the pathway at origin?
 - if yes Go to 1.3b
 - if no Go to 1.2

(return to start of part B)
- 1.3b How likely is the pest to be associated with the pathway at origin?
 - (not likely = 1; very likely = 9)
- 1.4 High concentration of pest at origin?
 - (not likely = 1; very likely = 9)

EPPO system: Part B - Entry (3)

The system continues with questions on the following topics mainly requiring a 1 to 9 answer:

Survival of pest:

- Of existing cultivation or commercial practices in country of origin
- Of existing phytosanitary procedures
- In transit

Multiplication of pest :

- In transit

EPPO system: Part B - Entry (4)

Commodity:

- Volume of movement along pathway
- Spread of distribution through the PRA area
- Spread in time of arrival of different consignments

Transfer of pest:

- Transfer from pathway to a suitable host
- Use of commodity aiding introduction

EPPO system: Part B - Establishment (1)

Hosts:

- No. of species of normal and alternate hosts in PRA area
- Distribution in PRA area
- Pest recorded on crops in protected conditions elsewhere
- Wild plants aiding dispersal / helping maintain populations

Vectors:

- Likelihood of pest associating with suitable vector

EPPO system: Part B - Establishment (2)

Abiotic factors:

- Similarity of climates in PRA area and origin
- Similarity of other factors e.g. soil type, environmental pollution, topography/orography
- Differences in crop environment
- Existing pest control practices in PRA area

Competition / predation:

- Competition for ecological niche
- Effect of natural enemies

EPPO system: Part B - Establishment (3)

Pest:

- Reproductive strategy and duration of life cycle
- Genetic adaptability
- Likelihood low populations of pest will establish
- Possibilities for eradication
- Frequency of introduction into new areas

EPPO system: Part B - Economic Impact (1)

- Here the analyst can assess all hosts together or separately
- I identify all the hosts in PRA area:
wild, cultivated, field, glasshouse
- Pests with vectors:
consider direct damage by vector

EPPO system: Part B - Economic Impact (2)

The system continues with questions on the following topics requiring a 1 to 9 answer:

Pest in current area:

- Economic loss
- Environmental damage
- Social damage

Pest in PRA area:

- Extent of area likely to be damaged
- Speed of spread by natural means
- Speed of spread with human assistance
- Containment of spread

EPPO system: Part B - Economic Impact (3)

Effect of pest in PRA area:

- Direct effect on crop yield and /or quality
- Effect on producer profits due to changes in production costs, yields
- Consumer demand
- Export markets
- Other costs (e.g. statutory; research)
- Environment
- Social damage

EPPO system: Part B - Economic Impact (4)

Control in PRA area:

- Effect of natural enemies
- Ease of control
- Effect on existing biological or integrated systems
- Other undesirable effects (e.g. human health/environment)
- Likelihood pest develops resistance to pesticides

EPPO System Part B: Final evaluation (1)

The analyst has 3 sets of scores

Entry:

Separate sets of scores for 1 or several pathways

If no pathways retained - risk of introduction = 0

Establishment:

One set of scores

Economic impact:

Possibly separate sets of scores

For single, grouped or separate hosts

EPPO System Part B: Final evaluation (2)

The analyst has to decide how to use the scores

- Options include combining, weighting, averaging scores
- EPPO is not prescriptive in how to use the scores
- Consistent analyst uses system to compare pests, pathways and hosts

EPPO System Part B: Final evaluation (3)

The analyst has to:

- Estimate probability of introduction (a)
- Estimate probable level of economic impact (b)
- May combine a and b : one estimate of pest risk
- May compare with reference levels of risk
- Determine whether pest is of quarantine status

EPPPO system in practice: Tospoviruses

- Tospoviruses are transmitted by a few thrips species in a persistent circulative manner
- Tospovirus genus is constantly under revision
- All tospoviruses were once known as TSWV
- There are now 13+ viruses characterised, one of which is *Watermelon silver mottle virus*

Watermelon silver mottle virus

Vectors

- Vectored by *Thrips palmi*
- *Thrips palmi* is regularly intercepted in trade
- *Frankliniella occidentalis* is our main glasshouse thrips
- Research has shown *F. occidentalis* cannot transmit WSMV

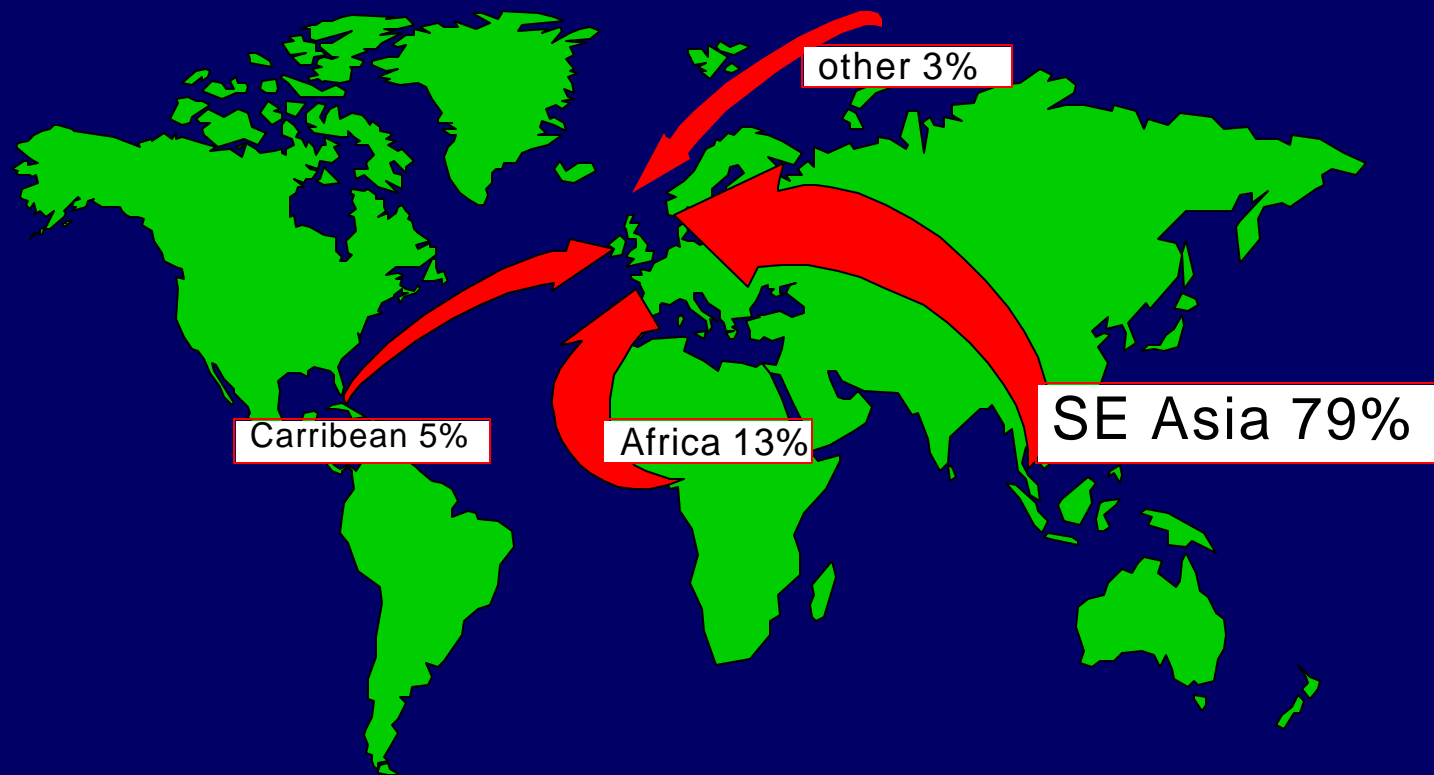
Thrips palmi



Thrips palmi as a virus vector

- 1997: 1st UK interception - cut orchids ex-Thailand
- Intercepted in the EU: several years on several hosts
- Mostly on Thai orchids
- Outbreaks in Netherlands under glass - eradicated
- EU/EPPO A1 listed pest
- Polyphagous non-indigenous vector of several non-indigenous tospoviruses
- Damage from direct feeding and virus transmission

Origins of *Thrips palmi* interceptions by EU Member States: (1995 - 1997)



Supplied by Alan MacLeod

WSMV: Symptoms on watermelon and melon

- Silver mottling and other foliar symptoms
- Chlorotic mottling on malformed fruits
- Reduced fruit set
- Stunting of plants

WSMV: Use of UK Summary PRA system

Host-range, losses, measures

- WSMV: Japan, Taiwan, (India, Brazil?)
- 100% losses on melon and watermelon
- Risk to natural hosts in southern Europe
- Experimental hosts include cucumber
- EC measures against *Thrips palmi* on orchids from Thailand and proposed against plant material likely to be harbouring the virus

EPPO system: Part B Introduction: WSMV

Sum of entry potential: 86

No. of questions answered: 12

Mean of entry potential: 7.2

Sum of establishment potential: 96

No. of questions answered: 13

Mean of establishment potential: 7.4

Sum of entry & establishment: 182

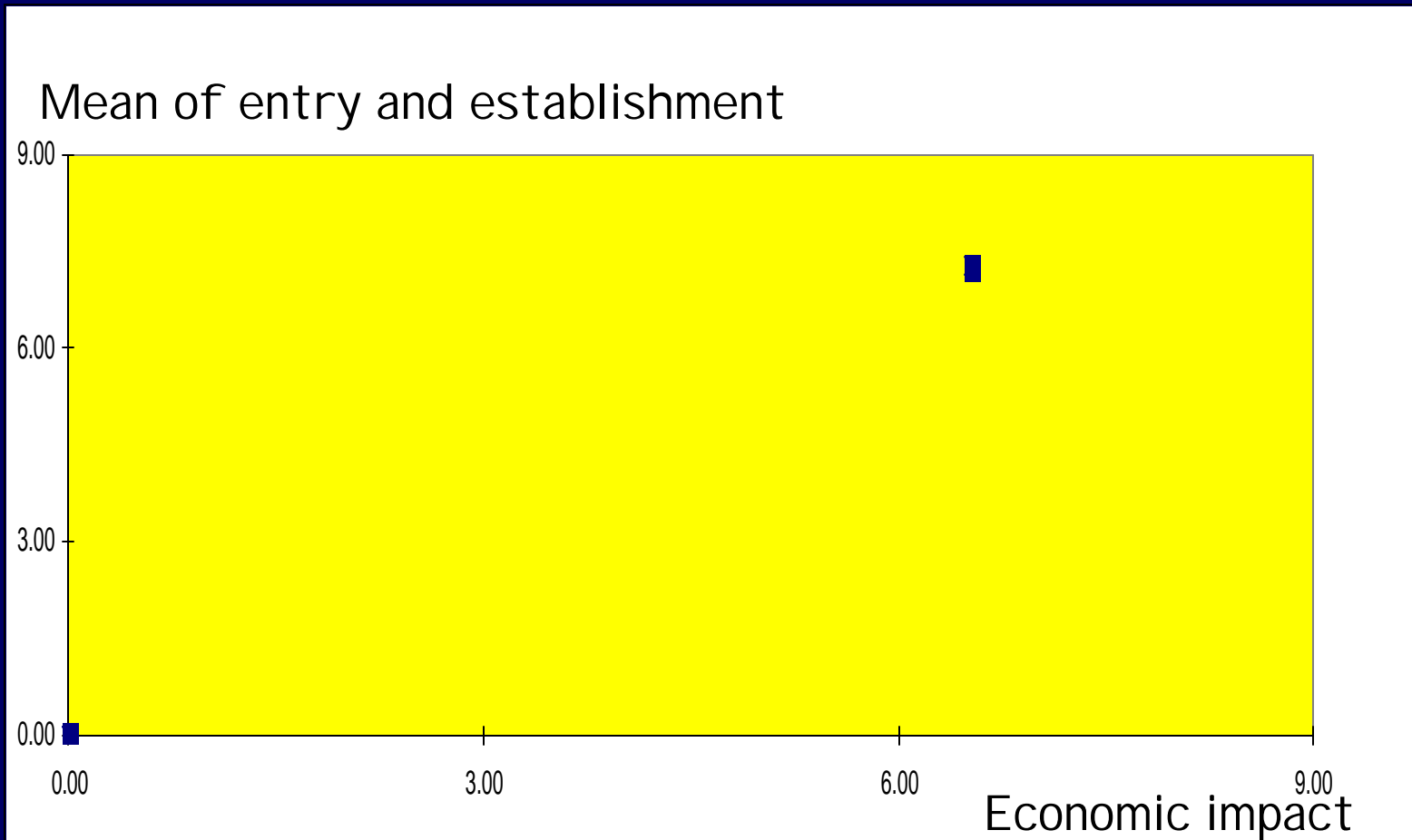
No. of questions answered: 25

Mean risk of entry and establishment: 7.3

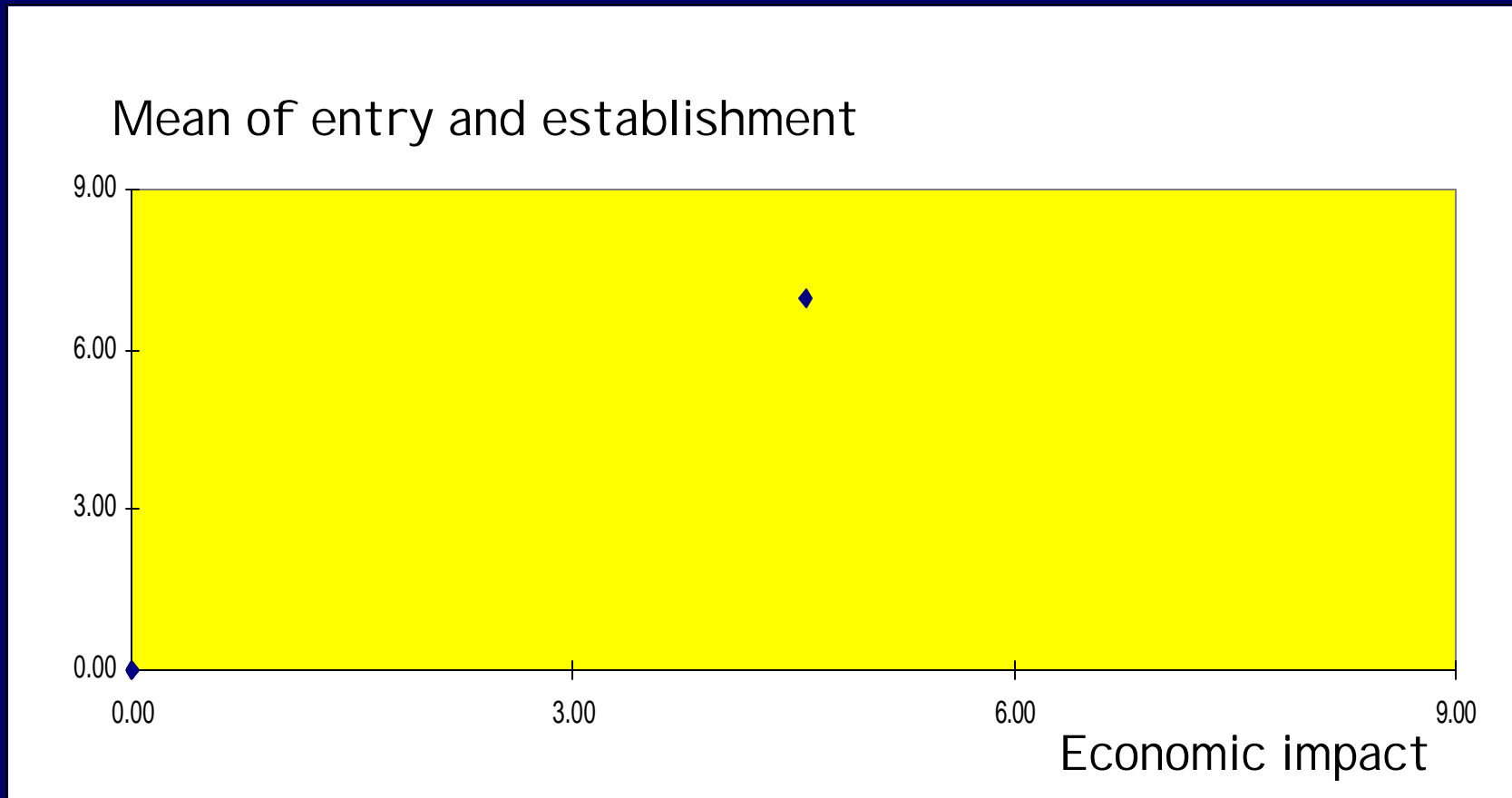
EPPO system: Part B - Economic impact WSMV

Total economic loss score:	124
No. of questions answered:	19
<u>Mean risk of economic impact:</u>	<u>6.5</u>

EPPO system: Part B - Overall assessment of risk for WSMV



EPPO system: Part B - Overall assessment of risk for *Thrips palmi* as a direct pest

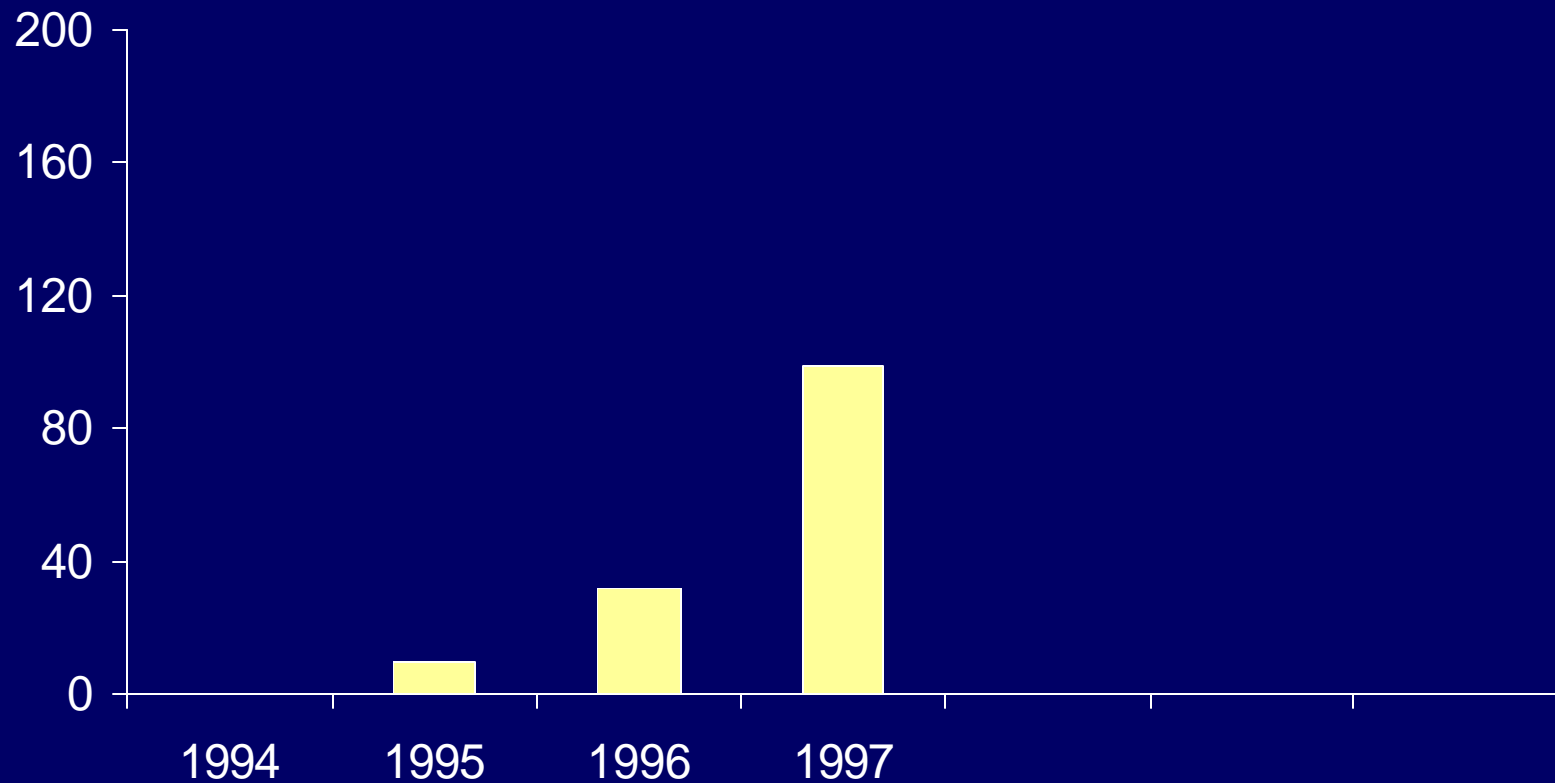


Scores supplied by Alan MacLeod

Outcome of EPPO PRA for WSMV

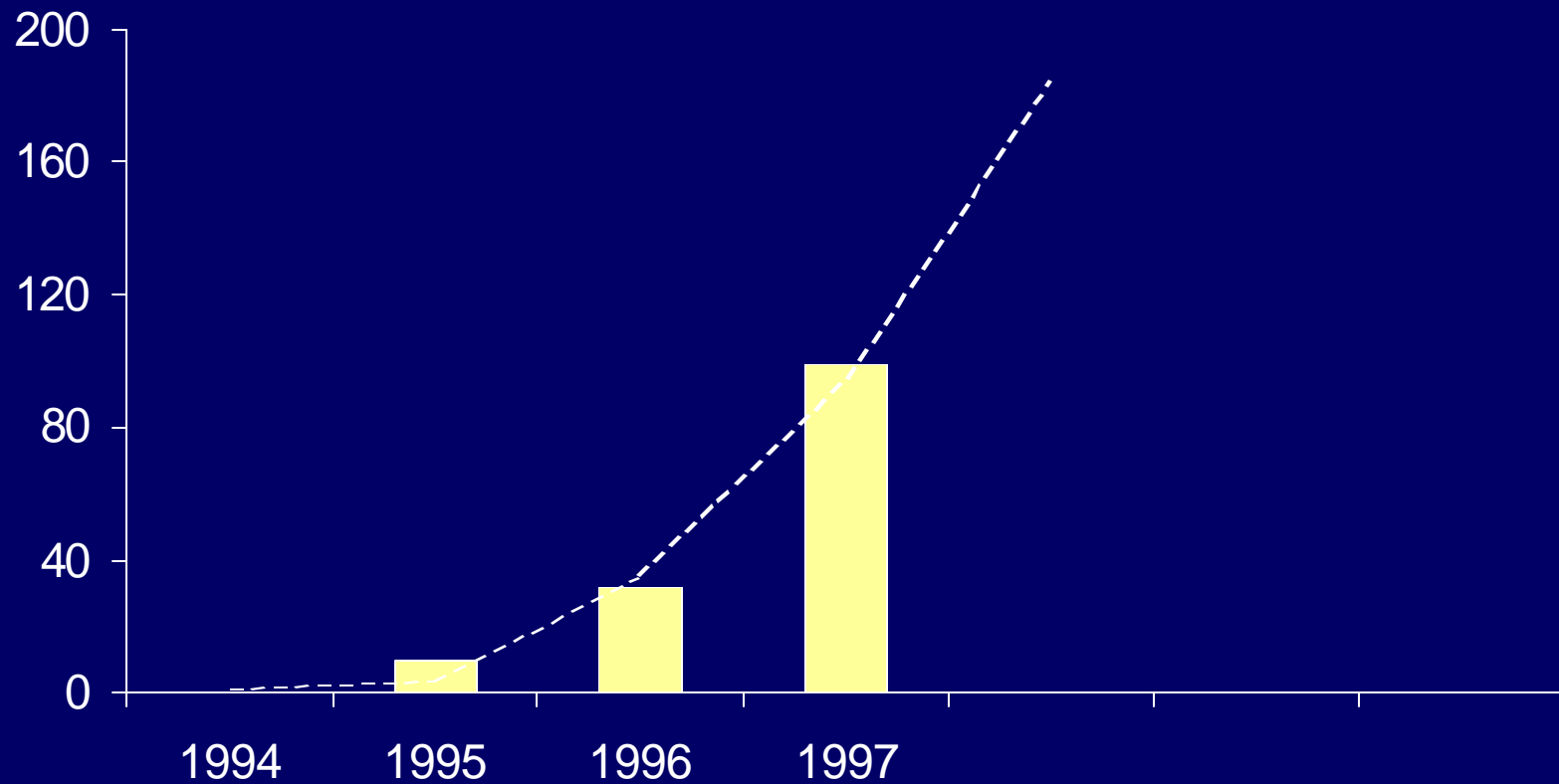
- WSMV became listed as an A1 pest for EPPO
- As its vector, *Thrips palmi* is an A1 pest and the main source of entry is via the vector, measures taken to exclude entry of *Thrips palmi* should prevent entry of WSMV

EU notifications of *T. palmi* on Thai orchids (1994 to 1997)



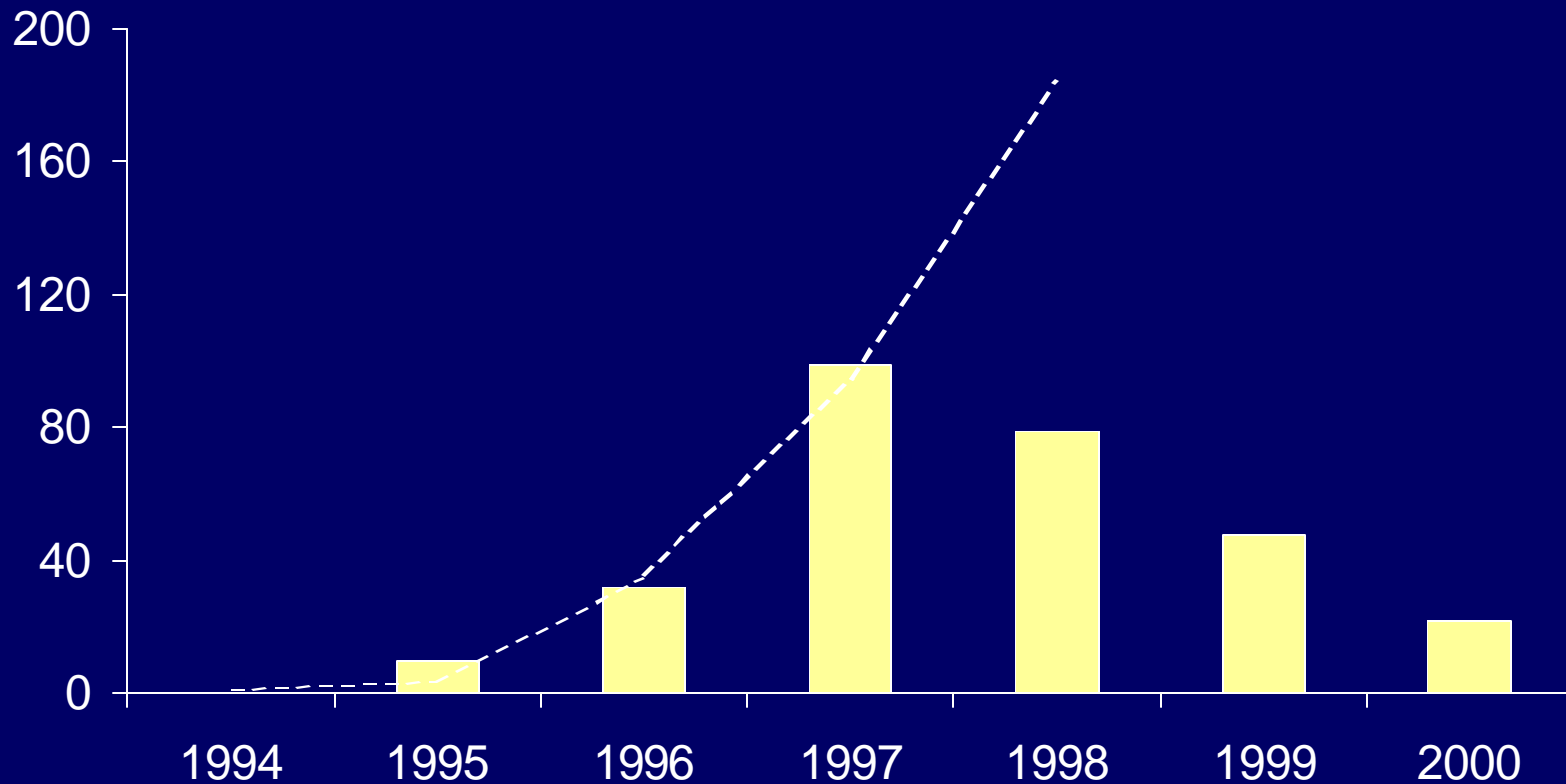
Supplied by Alan MacLeod

EU notifications of *T. palmion* Thai orchids (1994 to 1997 with trend line)



Supplied by Alan MacLeod

EU notifications of *T. palmi* on Thai orchids (1994 to 2000) (EC measures introduced 97-98)



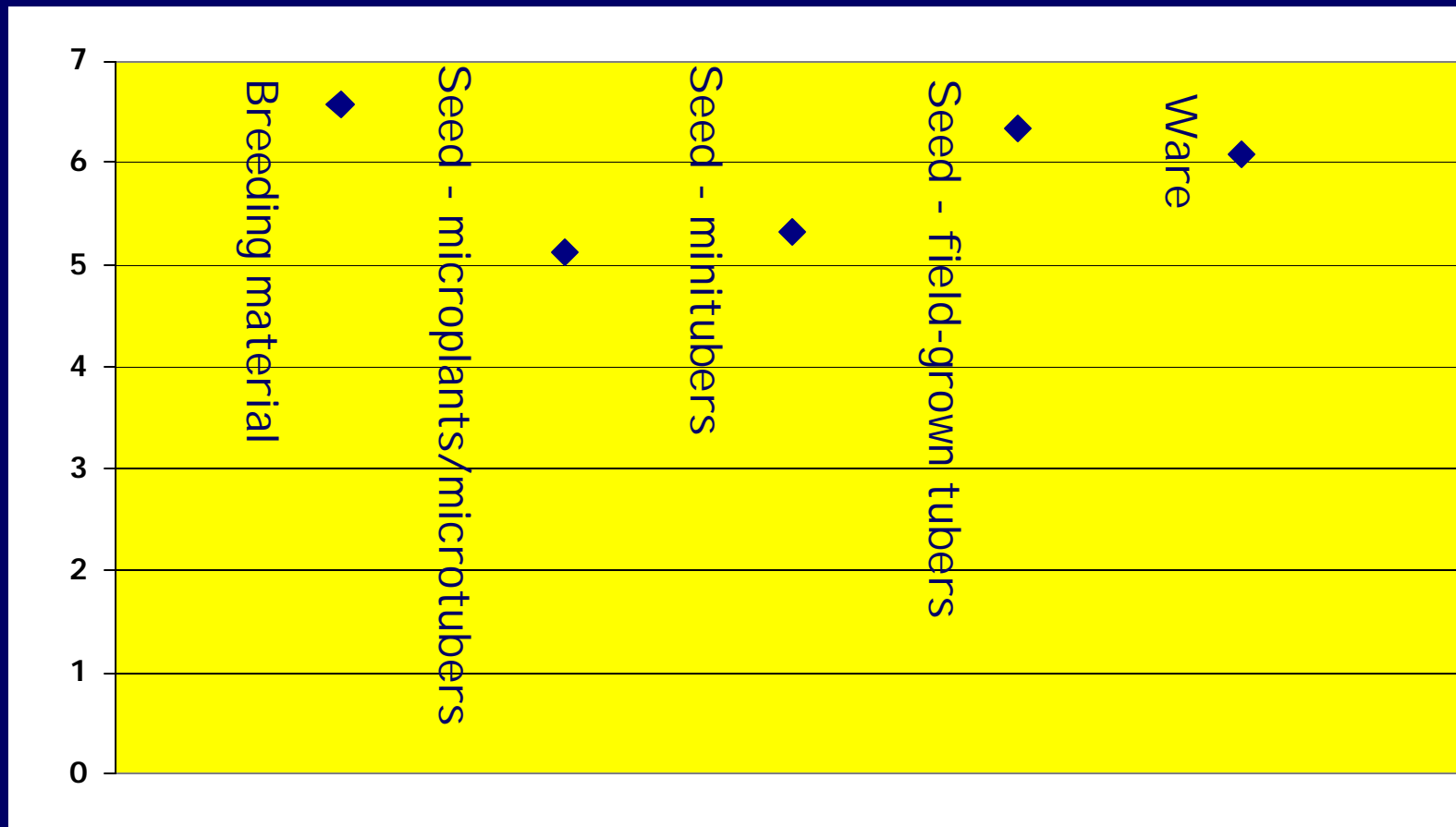
Supplied by Alan MacLeod

EPPO PRA for *Potato latent virus* (Jeffries, SASA)

- *Potato latent virus*, (synonym Red La Soda virus)
- Imports of potatoes into Europe are restricted
- Potential to import potatoes into Europe under discussion (EPPO)
- EPPO PRA for PotLV examined the risk of entry from different types of potato material

EPPO system Part B: *Potato latent virus*

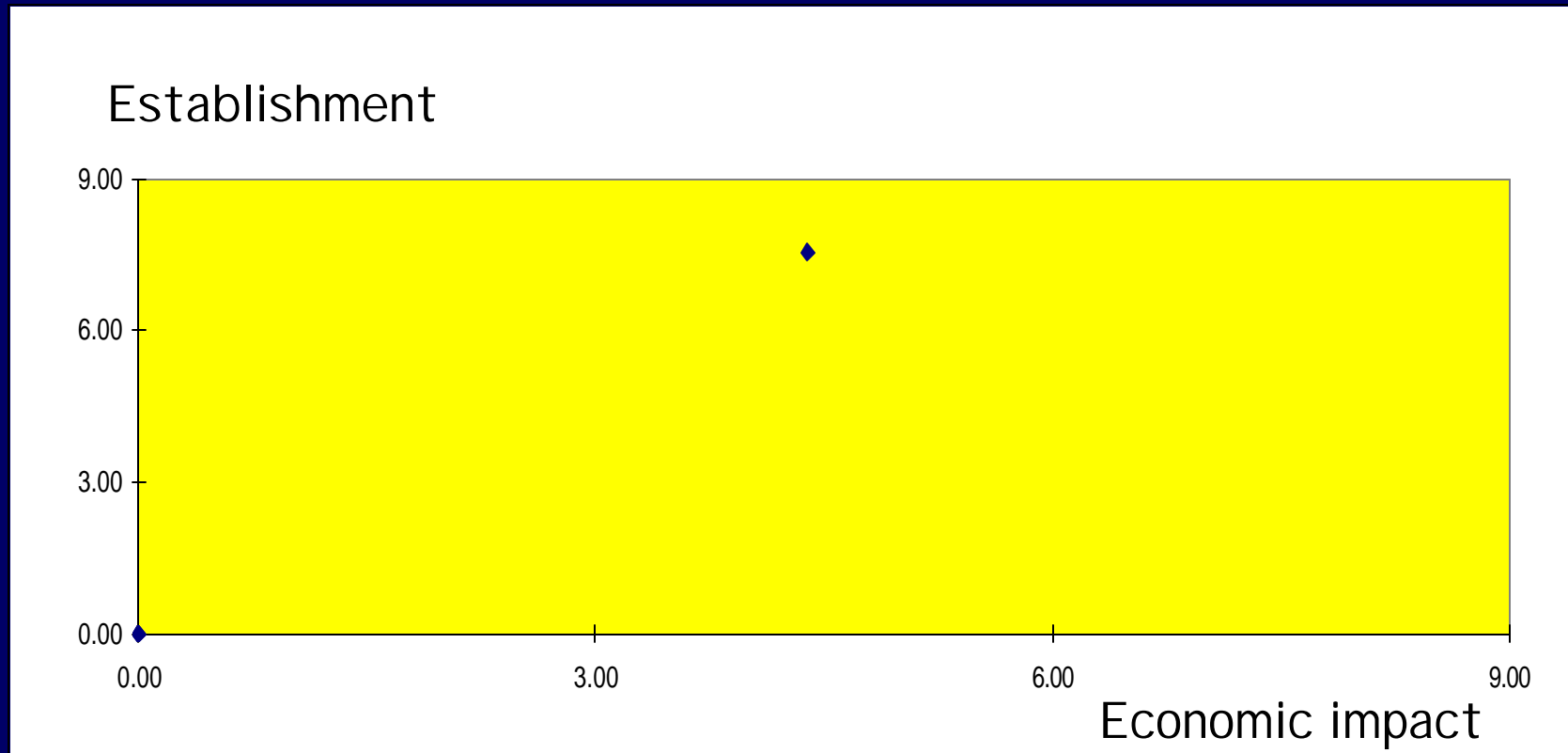
Risk of entry from different sources



Scores supplied by Colin Jeffries, SASA

EPPO system Part B: *Potato latent virus*

Risk of establishment and economic impact (all sources)



Scores supplied by Colin Jeffries, SASA

The future of the EPPO system?



The future of the EPPO system?

- Needs more explanation
- What do the scores mean ?
- Can risk analysts agree?

Uncertainty in subjective estimates

- Problems causing uncertainty include:
 - data never collected before
 - data out of date
 - data sparse (experts have to guess)
 - pest being assessed is new
- One would advise that one or more experts are consulted when insufficient data are available

Subjective estimations of discrete probabilities

- Difficult to estimate probability of occurrence of a discrete event either in quantitative or qualitative systems
- And it strikes fear into experts not used to hazarding a numeric guess

Subjective estimations of discrete probabilities

Rather than use a scoring system the analyst could use probability phrases and rank the answers from the experts they consult:

- almost certain
- very likely
- highly likely
- reasonably likely
- fairly likely
- reasonably unlikely
- highly unlikely
- very unlikely
- almost impossible

EPPO system: Part B alternative approach

1.11 How widely spread in time is the arrival of different consignments ?

Score	Description: Frequency of commodity import
1	once a year or less
2	more than once a year but only during one month of the year
3	during two different months of the year
4	up to 3 months of the year
5	up to 4 months of the year
6	up to 6 months of the year
7	up to 8 months of the year
8	up to 10 months of the year
9	up to every month of the year

Example: UK imports of *Capsicum annum*: (1993 to 1997)

- From India once per year (score = 1);
- Israel an average of five months each year (range four to six) (score = 6)
- Spain every month of the year (score = 9).

Future development of PRA (1)

- Information is the key
 - trade, economic data scarce
- Further research on complex areas of PRA
 - spatial and temporal modelling of pest spread
 - ecological interactions (between pests and predators)
 - use of CLIMEX and GIS to generate risk maps
 - EC/ International Karnal bunt project

co-operation: economists, crop & disease modellers, epidemiologists, mycologists, GIS experts & risk analysts to develop a new PRA for Karnal bunt and system for pathogens (EC funded: co-operation from USDA-ARS & NSW Agriculture)
- Quantitative risk analysis ?

Finally - presenting, interpreting and managing PRA

Whatever method, a PRA must be understandable, useful, believable and tailored to the problem

Analysts and managers should be properly trained

Managers need to understand:

- management of PRA - sequence of activities, resources
- quality control
- what a PRA can/cannot do
- what outputs to ask for
- how to interpret, present and communicate a PRA

The final product

Writing a PRA Report

- **Whatever method**, whether **quantitative** or **qualitative** or a mixture of both, the analyst should guide the reader through assumptions, results, conclusions
- Tailor the report to the reader and the problem
- Explain assumptions and areas of uncertainty

Whether qualitative or
quantitative, PRAs should be fit
for purpose



END

Thank you