th Department for Environment Food & Rural Affairs

A review of the quarantine status of *Bemisia tabaci* in Great Britain

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Executive summary

A review of the statutory measures relating to tobacco whitefly *Bemisia tabaci* (Hemiptera: Aleyrodidae) has been conducted. It has been prompted by ongoing interceptions of the pest on imported plants, outbreaks in ornamental crops in GB and new information about of the pest and the associated plant pathogenic viruses from other parts of the world. The review consists of a summary of scientific and technical evidence, a presentation of options to strengthen or relax current restrictions and an assessment of the associated costs and benefits.

Bemisia tabaci is the name given to a complex of species of morphologically indistinguishable whiteflies. It is a glasshouse and open-field pest with a worldwide distribution. It is highly polyphagous, with the potential to not only cause damage in its own right but also vector a large number of potentially damaging plant viruses. It is a quarantine pest in Great Britain, and Northern Ireland has EU Protected Zone (PZ) status for the pest. In GB, *B. tabaci* is one of the most frequently intercepted pests on imported plants and plant products. There have been outbreaks of the pest in GB every year since it was first detected in 1987. Most outbreaks have been in ornamental crops, especially poinsettia crops, but there have also been occasional outbreaks in protected edible crops including herbs, cucumbers, peppers and tomatoes plus outbreaks in interior landscapes such as botanic gardens and butterfly houses.

Bemisia tabaci is established outdoors in areas of southern Europe with a Mediterranean climate and established in glasshouses in northern Europe. In the Mediterranean region, it is a major pest of outdoor and protected crops of Cucurbitaceae and Solanaceae. Feeding by *B. tabaci* causes chlorotic spotting, growth distortion, and premature leaf drop, and the egestion of honeydew can lead to the growth of sooty moulds. These impacts can cause cosmetic damage to ornamental crops. The most important impact of *B. tabaci* is its role as a vector of numerous plant viruses, especially in crops of Cucurbitaceae and Solanaceae. In the absence of statutory measures, the potential cost of an outbreak of *B. tabaci* at a tomato or cucumber grower could be high, but the potential cost to the industry as a whole is considered to be low because outbreaks are likely to be short lived, occasional and limited in geographical scale.

The main aim of the current policy for *B. tabaci* is to reduce the risk of outbreaks of the pest and associated viruses in protected crops of aubergines, cucumbers, peppers and tomatoes. Other benefits of the policy are that 1) nurseries and garden centres receive cleaner plants that are less likely to lead to outbreaks; 2) the *B. tabaci* free status can facilitate exports to some markets. Statutory measures to prevent and eradicate *B. tabaci* come at a cost to importers of plants and plant products, ornamental plant nurseries, protected edible crop growers, locations with heated interior landscapes and the cost to government for enforcing the measures.

The four policy options being presented for consideration and comment are:

- Maintaining existing policy, continuing to regard *B. tabaci* as a quarantine pest, with requirements on the import of certain plants
- Strengthening the current requirements by removing some of the riskier options for importing plants
- Changing the regulatory status of *B. tabaci* to make it a Regulated Non-Quarantine Pest with a zero tolerance for the pest on high-risk ornamental plants, Cucurbitaceae and Solanaceae, and a 0.5% tolerance on poinsettia plants for retail
- Limiting any statutory measures to consignments of plants with the highest risk of being infected with quarantine viruses

An indicative economic analysis has been carried out. Strengthening the current requirements has been projected to lead to greater overall costs, but would reduce the risk of outbreaks and establishment of the pest in protected environments. The RNQP option and de-regulation option limiting action to the quarantine viruses are projected to lead to lower overall costs, but would come with an increased risk of *B. tabaci* outbreaks and establishment in protected environments.

Acronyms used in this document

EFSA	European Food Safety Authority
EPPO	European and Mediterranean Plant Protection Organisation
MEAM1	'Middle East-Asia Minor 1' species of *B. tabaci*
MED	'Mediterranean' species of *B. tabaci*
NPPO	National Plant Protection Organisation
PZ	Protected Zone
ToLCNDV	tomato leaf curl New Delhi virus
TYLCV	tomato yellow leaf curl virus

Legislation relevant to this document

The Plant Health (Phytosanitary Conditions) (Amendment) (EU Exit) Regulations 2020', Statutory Instrument 2020/1527

Aim

The purpose of this review is to evaluate the current regulations relating to *Bemisia tabaci* in GB and to compare the current policy with other options for potential future legislation in GB, noting that NI has Protected Zone arrangements in place via the EU plant health regime. Stakeholders are asked to assess the evidence within this document and combine this with their own experiences to give an opinion on favoured options for future policy.

Introduction

A review of the statutory measures relating to tobacco whitefly *Bemisia tabaci* (Hemiptera: Aleyrodidae) has been conducted. It has been prompted by ongoing interceptions of the pest on imported plants, outbreaks in ornamental crops in GB and new information about of the pest and the associated plant pathogenic viruses from other parts of the world.

Bemisia tabaci (Hemiptera: Aleyrodidae), commonly known as tobacco whitefly, is a glasshouse and open-field pest with a worldwide distribution (Parola-Contreras *et al.*, 2021). It is highly polyphagous with field observations indicating that it has hosts in 102 families (EFSA, 2013). It can cause damage in its own right but also vector a large number of potentially damaging viruses, which do not occur in GB and there are not known to be alternative vectors in GB. The potential for *B. tabaci* to introduce and spread viruses of fruiting vegetable crops (e.g. tomatoes) is the most significant threat it poses to GB. *B. tabaci* is not able to establish outdoors in the GB because the climate is unsuitable and so the risk is to crops grown in protected environments, such as glasshouses, rather than field grown crops.

B. tabaci is a quarantine pest for Great Britain, and Northern Ireland has a Protected Zone status for this pest as part of the EU plant health regime. There are specific requirements for the importation of some plants that are more likely to be infested with *B. tabaci* or some of the viruses that it can vector.

B. tabaci is regularly intercepted on imported poinsettia (*Euphorbia pulcherrima*) and other ornamental plants, particularly *Ajuga, Begonia, Crossandra, Dipladenia, Ficus, Hibiscus, Mandevilla* and *Nerium oleander*. Outbreaks occur annually in ornamental production nurseries. When outbreaks are detected, statutory action is taken to eradicate them and this action can be lengthy and costly to both industry and government. There have four outbreaks of *B. tabaci* in protected fruiting vegetable crops in GB since the pest was first recorded and all were eradicated.

Policy reviews for this pest took place in 2011 and 2015. In 2011, a consultation was carried out to seek views on whether *B. tabaci* should continue to be treated as a quarantine organism. Maintaining *B. tabci* a quarantine pest was the preferred outcome of the consultation. An additional consultation took place in 2015 when strengthening of requirements regarding the importation of high-risk plants was proposed and agreed. There were also updates to EU legislation in response to UK proposals in 2017 and 2019. These updates have been retained in GB law and in EU requirements for import and movements of the relevant hosts into the EU PZs for *B. tabaci*.

Quarantine status of *Bemisia tabaci* in GB and the EU

Current GB legislation

Bemisia tabaci is a GB quarantine pest and listed as a quarantine pest (Statutory Instrument (SI) 2020/1527 that is not known to occur in GB. In addition, some viruses which are vectored by *B. tabaci* are listed as quarantine pests for GB. Tomato leaf curl New Delhi virus (TLCNDv) and Begomoviruses are listed as pests not known to occur in GB. Other *B. tabaci* vectored viruses are listed in as provisional GB quarantine pests including tomato yellow leaf curl Sardinia virus (TYLCSv) and tomato yellow leaf curl virus (TYLCV). Import requirements relating to *B. tabaci* are summarised in Table 1 below.

Table 1: Import requirements relating to *Bemisia tabaci* – summarised Statutory Instrument 2020 No. 1527

Plants covered	Locations covered	Measures
All Plants for Planting (PfP) other than dormant plants, plants in tissue culture, seeds, bulbs, tubers, corms and rhizomes [Annex 7 part A point 8]	Countries where Begomovirus and 10 named viruses including tomato yellow leaf curl New Delhi virus (ToLCNDV) are present	No symptoms of viruses seen and for *B.tabaci* a i) Pest Free area (PFA), ii) Pest Free Production Site (PFPS) or iii) treatment
Cucurbitacae and Solanacae PfP [Annex 7part A point 9]	Any third country	PFA for ToLCNDV or no symptoms of ToLCNDV and for *B. tabaci* i) PFPS or ii) effective treatment programme
Unrooted cuttings of poinsettia [Annex 7 part A point 10]	Any third country	For Bt: i) PFA, ii) cuttings come from *B.tabaci* free plants AND PFPS verified by 3 weekly inspections, iii) cuttings come from Bt free plants AND treatment programme and weekly inspections for 3 weeks to show pest freedom
Poinsettia PfP excluding seeds and unrooted cuttings [Annex 7part A point 11]	Any third country	PFA and 3 weekly inspection for 9 weeks or weekly for 3 weeks, and produced from cuttings which have been subjected to the same requirements OR are packaged for retail and the consignment has been inspected to demonstrate pest freedom
PfP of *Begonia* other than seeds, tubers and corms, PfP other than seeds of *Ajuga, Crossandra, Dipladenia, Ficus, Hibiscus, Mandevilla* and *Nerium oleander* [Annex 7 part A point 12]	Any third country	PFA, site freedom demonstrated by insp. every 3 weeks for 9 weeks, or treatment plus weekly insp. for 3 weeks to demonstrate pest freedom OR are packaged for retail and the consignment has been inspected to demonstrate pest freedom

EU legislation

In EU legislation there is a distinction between 'non-EU populations' of *B. tabaci* and any populations of *B. tabaci* found in EU countries. The 'non-EU populations' of *B. tabaci* are treated as quarantine organisms which means that statutory action is taken whenever *B. tabaci* is detected on plants or plant products arriving in the EU from non-EU countries. Populations of *B. tabaci* that are established within the EU are treated as a quarantine organism only in countries which have a PZ for this pest. Two EU countries have a PZ for *B. tabaci*: Ireland and Sweden. Northern Ireland applies the EU plant health regime and also has a PZ for *B. tabaci.* The whole of the UK had a PZ for *B. tabaci* when the UK was an EU member state.

Biology of *B. tabaci*

Life cycle

In common with all whiteflies, *B. tabaci* has six developmental stages: egg, four larval instars, and the adult. Each female lays up to 160 eggs on the undersides of host leaves. The rate of development is closely linked to temperature. The first instar or 'crawler' is flat, oval and scale-like, and is the only mobile larval stage. It moves to a suitable feeding location where it moults and becomes sessile throughout the remaining larval stages. The first three larval stages last 2-4 days each whereas the fourth larval stage also known as a puparium lasts for about six days, depending on the temperature. The adult emerges through a 'T'-shaped rupture in the pupal case and expands its wings before powdering itself with wax from glands on the abdomen. Mating begins 12-20 hours after emergence and takes place several times throughout the life of the adult. A female may live for 60 days, the life of the male is generally much shorter, being between 9 and 17 days. The rate of development of *B. tabaci* is mainly determined by temperature, but also varies between hosts. On poinsettia plants kept at a constant temperature of 16, 19, 22, 25 and 27°C the development time (time from egg being laid to adult emerging) has been calculated to be 168, 86, 50, 41 and 36 days respectively and on tomato plants the equivalent times are 170, 88, 52, 43 and 27 days respectively. This would imply a potential 7 generations of *B. tabaci* a year for populations kept on poinsettias or tomatoes in a glasshouse maintained at 22°C year round. Between 11-15 generations per year will be completed in areas with the most suitable climates in the tropics, sub-tropics and warm temperate environments (Brown *et al.*, 1995).

Population development and dispersal ability

The development of *Bemisia tabaci* populations can be linked very closely with temperature (Parola-Contreras *et al.*, 2021). Infestation can build up rapidly in glasshouse crops. Four weeks after the introduction of *B. tabaci* into a glasshouse crop of chrysanthemums, there were an average of 2.9 eggs, 7.6 adults and 8 larvae per plant on the most susceptible variety (Hutapea *et al.*, 2018).

Adult *B. tabaci* do not fly very efficiently but, once airborne, can be transported quite long distances by the wind. Mass migration can occur when host plant quality declines, for example when cotton crops are no longer irrigated. The dispersal abilities of *B. tabaci* have been studied by releasing and then trapping adults that had been marked with a fluorescent dye in Arizona. Byrne *et al.* (1996) consistently trapped marked individuals 2.7 km away from release sites, demonstrating the maximum distance over which *B. tabaci* can migrate is likely to be longer than this. The migration was predominantly wind-directed and dispersal was patchy showing that migration is not just a passive process. In a UK context, for an infestation on ornamental plants to become a threat to a glasshouse crop of fruiting vegetables there would need to be a significant numbers of *B. tabaci* in the ornamental crop for there to be a significant risk of the pest moving to the crop of fruiting vegetables. Some of the factors that would reduce the risk of this happening even if *B. tabaci* were not regulated are:

- Ornamental nurseries and garden centres are likely to employ some control measures before a large population of *B. tabaci* built up to preserve the economic value of their plants
- Only a small proportion of any population of *B. tabaci* that built up on an ornamental crop would be likely to leave the glasshouse via vents or doorways
- To reach a tomato crop, the wind would need to be in the right direction to carry the *B. tabaci* there
- During much of the year, *B. tabaci* would be unlikely to survive outdoors and so would need to be carried quickly to the protected fruiting vegetable crop
- Only a small proportion of the *B. tabaci* that reach the outside of a glasshouse of fruiting vegetables would be likely to enter the glasshouse through a vent
- Large distances between ornamental and glasshouse edible crops

Biotypes

The existence of significant variation within *Bemisia tabaci* has been known about for many years. The concept of host races or biotypes of *B. tabaci* was proposed in the 1950s (Brown *et al.*, 1995). De Barro *et al.* (2011) reviewed the evidence on the diversity of *B. tabaci* and concluded that *B. tabaci* is a complex of 11 high-level groups with at least 24 morphologically indistinguishable species. The Middle East-Asia Minor 1 species; MEAM1, (B biotype) and Mediterranean species, MED (Q biotype) are considered to be the most important as pests internationally (Perier *et al.*, 2022). MEAM1 was formerly described as *Bemisia argentifolii (*Brown et al., 1995) and was first documented in the Americas in the mid-1980s. Glasshouse crops in North America, Europe and Japan were rapidly colonised by MEAM1 as a result of the movement of infested ornamental plants (Brown *et al.*, 1995). Of 60 samples of *B. tabaci* intercepted in the UK by inspectors in 2002-2003, 68% were MED, compared with 67% of 42 samples from 2010-2011. MEAM1 accounted for 30% of samples in 2002-2003 and 7% in 2010-2011 (Powell *et al.*, 2012). In late 2022, scientists from Fera Science Ltd. carried out biotyping assays on nine samples of *B. tabaci*. All samples were from consignments of *Solanum pseudocapsicum* and eight were from the Netherlands. The samples consisted of two or three *B. tabaci* specimens. In all cases, the species detected was MED. Although this testing of *B. tabaci* species or biotypes has been sporadic over time and has not covered all crops, it indicates that MED is likely to be the most commonly imported species.

B. tabaci MED was shown to be established outdoors in the USA when it was found in 10 residential landscape environments and two open field locations in Florida in 2016 (McKenzie & Osborne, 2017), having previously been thought to be restricted to glasshouses (Dickey *et al.*, 2013). MED more readily develops resistance to commonly used insecticides in vegetable crops (McKenzie & Osborne, 2017). MED has begun displacing MEAM1 as the predominant biotype in China, Japan and South Korea and this is thought to be related to higher levels of inset cticide resistance (Pan *et al.*, 2015) and it has also been linked to outbreaks of TYLCV throughout China.

Distribution

The *Bemisia tabaci* complex has a worldwide distribution (see Figure 1). The record of *B. tabaci* being present in England is based on the outbreaks that are recorded each year.

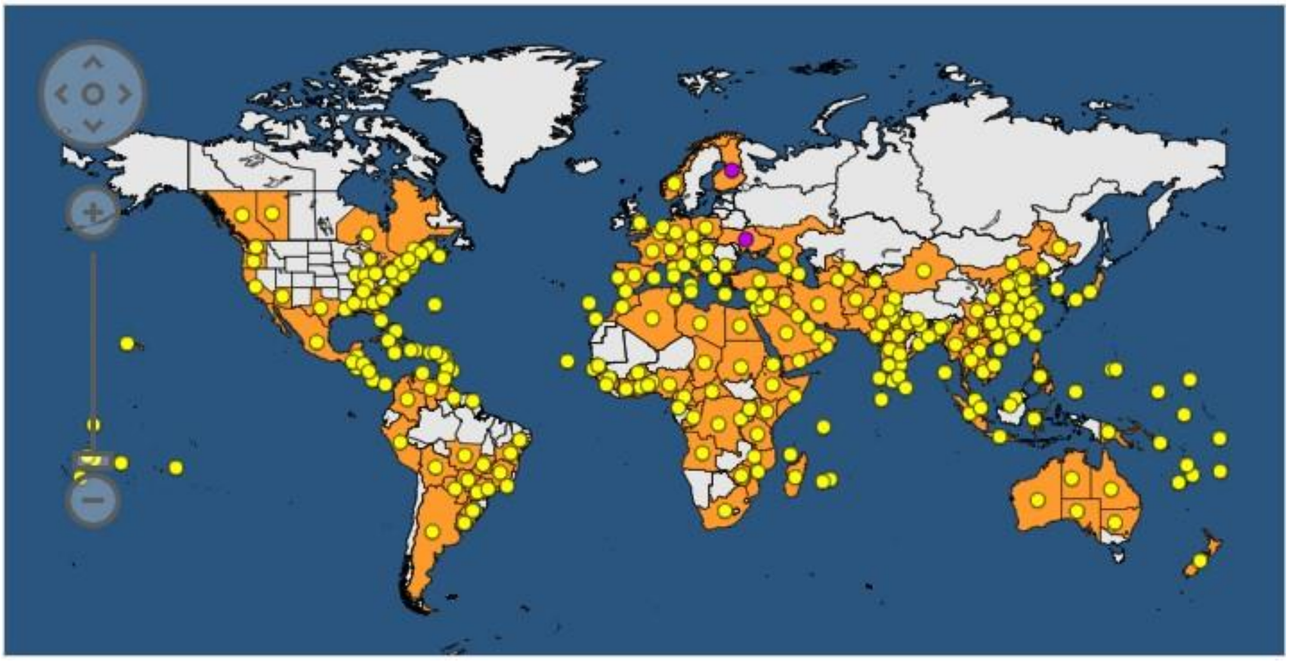

Figure 1: Worldwide distribution of *Bemisia tabaci* including records from protected environments (EPPO Global Database, last updated 10 November 2022)

B. tabaci is present in protected conditions across continental Europe, but its outdoor distribution is restricted to coastal areas of Mediterranean countries (Figure 2) and some areas with similar climates (EFSA, 2013, Gilioli *et al.*, 2014).

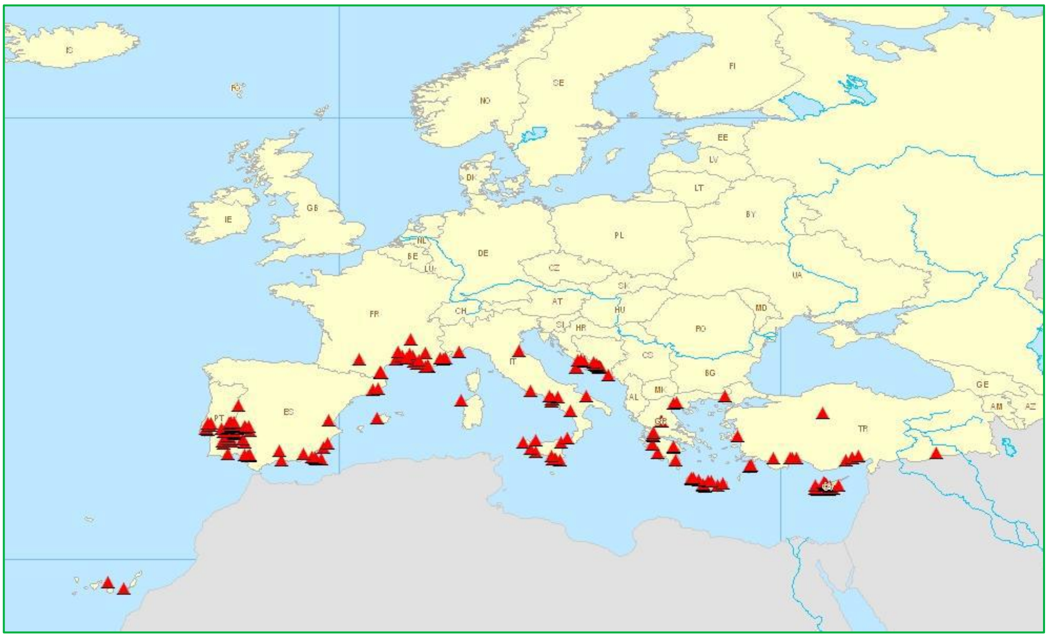

Figure 2: Distribution map of *Bemisia tabaci* in open fields in the Canary Islands, Europe and Türkiye (EFSA, 2013)

Hosts

Bemisia tabaci is extremely polyphagous with over 1000 recorded host plants (EFSA, 2013). Many of the host records are for the *B. tabaci* species complex rather than individual species, but

MEAM1 and MED are known to be particularly polyphagous with other species having a much narrower host range (Cuthbertson, 2015a, b). Field observations are not considered to be a reliable method of determining whether a particular plant is a host of *B. tabaci* because whiteflies can explore plants without feeding on it or laying eggs, and if they do lay eggs, the eggs may not develop. From field observations, *B. tabaci* has been reported from 509 species from 102 plant families, whereas studies in which the full life cycle has been demonstrated under experimental conditions have demonstrated that it has at least 49 host species from 11 plant families (EFSA, 2013). It predominantly colonises annual herbaceous plants (Brown *et al.*, 1995). Some of the most important host plants listed on the EPPO Global database are poinsettias (*Euphorbia pulcherrima*), gerbera (*Gerbera jamesonii*), cotton (*Gossypium hirsutum*), sweet potato (*Ipomoea batatas*), tobacco (*Nicotiana tabacum*) and tomatoes (*Solanum lycopersicon*). Other important hosts include cassava, aubergines, okra, lettuce and beans. Agricultural practices, in particular the use of irrigated monoculture are thought to have facilitated the expansion of hosts colonised by *B. tabaci* (Brown *et al.*, 1995).

Climatic Requirements

Bemisia tabaci is better suited to higher temperatures than glasshouse whitefly, *Trialeurodes vaporariorum,* a pest that is widely established in the UK and which is not a quarantine pest (Cui *et al.*, 2008, Krause-Sakate *et al.*, 2020, Xie *et al.*, 2011). Xie *et al.* (2011) found that *T. vaporariorum* populations built up faster than those of MEAM1 in the range 15 to 21°C, whereas MEAM1 develops faster than *T. vaporariorum* at temperatures greater than 24°C. In Chile, MEAM1 is limited to the warmer area of Arica y Parinacota, whereas *T. vaporariorum* is more critical in the central colder regions which demonstrate the difference in climatic tolerances (Krause-Sakate *et al.*, 2020). A distinction is also seen in Colombia and Ecuador where *B. tabaci* is found at altitudes of 0 to 400 m and *T. vaporariorum* from 1000 to 3000 m (Krause-Sakate *et al.*, 2020). These differences in environmental tolerances are reflected in the outdoor distribution of these two pests in Europe. *B. tabaci* is only able to survive outdoors in southern Europe whereas *T. vaporariourum* is able to survive outdoors in parts of southern England.

The potential outdoor distribution of MEAM1 was modelled by Kriticos *et al.* (2020) and the northern limits were found to be in southern France. Bradshaw *et al.* (2019) found that the limited amount of time when conditions are optimal for *B. tabaci* and the number of cold nights and cold days during the summer are likely to be factors preventing the establishment of *B. tabaci* outdoors in the UK. However, they found that in a future climate where the temperature reached 2°C above pre-industrial temperatures, *B. tabaci* could potentially develop temporary populations outdoors across the summer or possibly establish in East Anglia and southern England year-round. Whereas, EFSA (2013) concluded that under a climate change scenario in which there is an average temperature increase of +2°C, the northern limit of the distribution of *B. tabaci* would shift to Nantes and Paris, but it would not establish in northern European countries such as the Netherlands, Belgium and UK (EFSA, 2013).

Impacts of *Bemisia tabaci*

Impacts of *Bemisia tabaci* in Europe

Bemisia tabaci is one of the most economically important agricultural and horticultural pests in the world. It damages plants directly by feeding and indirectly by honeydew egestion and virus transmission. Feeding by adults and larvae causes chlorotic spotting (see Figure 3), growth distortion, and premature leaf drop. The honeydew egested by the feeding larvae covers the surface of the foliage and fruit and serves as a medium for the growth of sooty moulds. This reduces the photosynthetic potential of the infested plant. Honeydew and moulds also disfigure and lower the market value of fruit and flowers. However, it is the viruses vectored by *B. tabaci* that have the greatest economic impact. *B. tabaci* vectors plant viruses in the genera Geminivirus, Begomovirus, Closterovirus, Nepovirus, Carlavirus, and Potyvirus. These can cause total failure of susceptible crops.

Figure 3: Poinsettia showing chlorosis of new foliage that developed during heavy feeding by immature *Bemisia*. Photograph by James Castner, University of Florida (McAuslane, 2009)

First reports of *B. tabaci* in northern European countries (including the UK, the Netherlands, France and Germany) occurred in 1987 (Hoop *et al.*, 2015). These early interceptions of this highly polyphagous pest were on imported ornamentals, mainly poinsettias (*Euphorbia pulcherrima*). In the first years after *B. tabaci* was introduced into the Netherlands, between 70 and 100% of poinsettia crops were infected. The other commonly infected plants were *Begonia, Bouvardia, Gerbera, Hibiscus* and tomato. There was then a decline in the number of growing sites infested with *B. tabaci* in the Netherlands.

Some countries (Denmark, Finland, Ireland, Portugal (part), Sweden & the UK) opted for PZ status in 1992 (Commission Directive 92/76/EEC) although Denmark subsequently abandoned their PZ (in 2000). Finland carried out a cost:benefit analysis of the merits of their PZ policy in 2008. This analysis indicated that the cost benefit ratios could range from 0.52-2.63 with 0.52 meaning that the benefits would be only around half the costs, however in five out of the six scenarios they looked at, maintaining the PZ was the cheapest option (Heikkilä, 2008). However, in 2018 Finland abandoned their PZ 'due to an insufficient degree of continued economic and plant health benefit' (Commission Implementing Regulation (EU) 2018/791).

There is evidence that *B. tabaci* is becoming an increasing problem in the Netherlands. BASF's Dutch website says 'In recent years, tobacco whitefly has become increasingly common in greenhouse horticulture. Poinsettia, *Bouvardia*, *Hibiscus*, lisianthus (*Eustoma*) and *Gerbera* are good host plants and tobacco whitefly is also common in the fruiting vegetables peppers, tomatoes, eggplant and cucumber' (BASF, 2018). *B. tabaci* is permanently established in most all-year round lisianthus crops in the Netherlands and, despite several sprays a week, the population is difficult to control (Binnendijk, 2022). In poinsettia crops, *B. tabaci* can cause cosmetic damage which can interfere with marketability and export even at low densities (Pijnakker *et al.*, 2008). The Dutch Department of Agriculture, Nature and Food Quality granted an emergency authorisation for the use of Verimark (cyantraniliprole) to control *B. tabaci* in tomato crops, indicating its potential to cause significant damage (Ministerie van Landbouw Natuur en Voedselkwaliteit, 2022). The distribution of *B. tabaci* in Belgium is uncertain, but it is being studied in a current research project (ILVO, 2022).

In Germany, whiteflies are a major pest in poinsettia production and propagation. *B. tabaci* has spread through crops and is more difficult to control than *T. vaporariorum* (Richter, 2009). In North Rhine Westphalia, *B. tabaci* has been difficult to control with conventional insecticides in poinsettia crops, with biocontrol agents, biopesticides and botanical insecticides proving most effective (Landwirtschaftskammer Nordrhein-Westfalen, 2018).

The first major impacts of *B. tabaci* in Spain were reported on Tenerife from 1988. The pest was damaging crops including poinsettias, courgette, tomato, melon, and peppers. *B. tabaci* showed a high degree of resistance to chemicals. There was an increase in population levels of *B. tabaci* on the Mediterranean coast of Spain, the Canary Islands and the Balearic Islands in the 1990s. At this time it became one of the most important pests of horticultural crops in these regions and the impact was enhanced by the viruses that it vectored (Fernández García, 2013).

Interceptions in England and Wales

In England and Wales, *Bemisia tabaci* is one of the most frequently intercepted pests on imported plants and plant products. Records of diagnoses of *B. tabaci* from the five-year period from 1 Jan 2018 until 31 Dec 2022 have been downloaded from Fera's diagnosis database. The number of interceptions for all genera or species of plants for which there at least five diagnoses in total over this period have been listed in Annex 1. The genera or species has been classified as being either for edible use, cut flowers, plants for planting or mixed. This division is not straightforward because some of the species and genera can be used for multiple purposes. It is not possible to make a direct comparison of the risk relating to different hosts because: i) they include diagnoses of samples from ports, garden centres and growing sites; ii) the proportion of crops and consignments that have been inspected will vary; iii) plants for planting present a greater inherent risk than produce. The number of diagnoses will be higher than the number of records of noncompliance (https://planthealthportal.defra.gov.uk/imports/non-compliance/2022-non-compliance-data/) because multiple diagnoses may relate to one original imported consignment. Looking at the 35 species and genera on which more than five diagnoses were made during this period the number of diagnoses on edible consignments and crops (733) was very similar to the number of diagnoses from plants for planting (806). Of the diagnoses from plants for planting (806), 85% (685) were on plants that have import requirements, although this does not include plants for planting with less than 5 diagnoses. Diagnoses on poinsettias accounted for 41% (328) of all the diagnoses on plants for planting in this table (excluding those with less than 5 diagnoses). Of the plants for planting that do not have particular import requirements, the highest number of diagnoses were on *Eustoma* (18), *Syngonium* (14), *Persicaria* (12), *Lantana* (13) and *Limnophila aromatica* (11) and *Echinodorus* (10).

In September 2022 there was a particularly high number of interceptions (39) of *B. tabaci* on Christmas cherries (*Solanum pseudocapsicum*) imported from the Netherlands compared to recent years (e.g. two interceptions in September 2021). The pest was in very high numbers on the infested plants and was easy to detect. These interceptions indicated that one of the import conditions had not been met, i.e. that plants of Cucurbitaceae and Solanaceae from areas where *B. tabaci* is known to occur should 'have been subjected to an effective treatment ensuring the eradication of *Bemisia tabaci*'. This demonstrated that some of the interceptions of *B. tabaci* in the UK may not relate to weakness in the current import requirements, but instead a lack of compliance with these requirements. The interceptions were communicated to the Dutch NPPO and the Dutch authorities announced an intensification of the inspections of *S. pseuodocapsicum* and poinsettias destined for GB starting from 19th October 2022. There were fewer interceptions of *B. tabaci* on consignments of *S. pseudocapsicum* from the Netherlands in November and December 2022 (12) than in the same period in 2021 (23) indicating that the intensified inspections may have had some but not a very effective impact.

Outbreaks in England and Wales

The annual number of outbreaks of *Bemisia tabaci* in England and Wales is shown in Figure 4. For the purposes of this figure, an outbreak has been considered to be a situation where there is evidence to indicate that there is a population of *B. tabaci* that is spreading within a crop or between crops of plants. The number of inspectors in England and Wales and hence sampling effort has varied over the period covered by this graph and it can be difficult to distinguish interceptions from outbreaks in some situations and so this data should be considered as an indication of trends rather than a definitive record. The vast majority of the recorded outbreaks have been at ornamental plant producers, and the majority of the recorded outbreaks have been in poinsettia crops.

There have been seven recorded outbreaks of *B. tabaci* in interior landscapes such as botanic gardens, butterfly houses and visitor attractions and they can be very difficult to eradicate. These outbreaks have not led to significant damage to the plants held at the sites, but eradication campaigns have had an economic impact. Treseder *et al.* (2011) described the eradication of an outbreak of *B. tabaci* in the Rain Forest Biome at the Eden project in Cornwall. Eradication required a two-year intensive spray programme that the Eden Project conservatively estimated to have cost them £250,000.

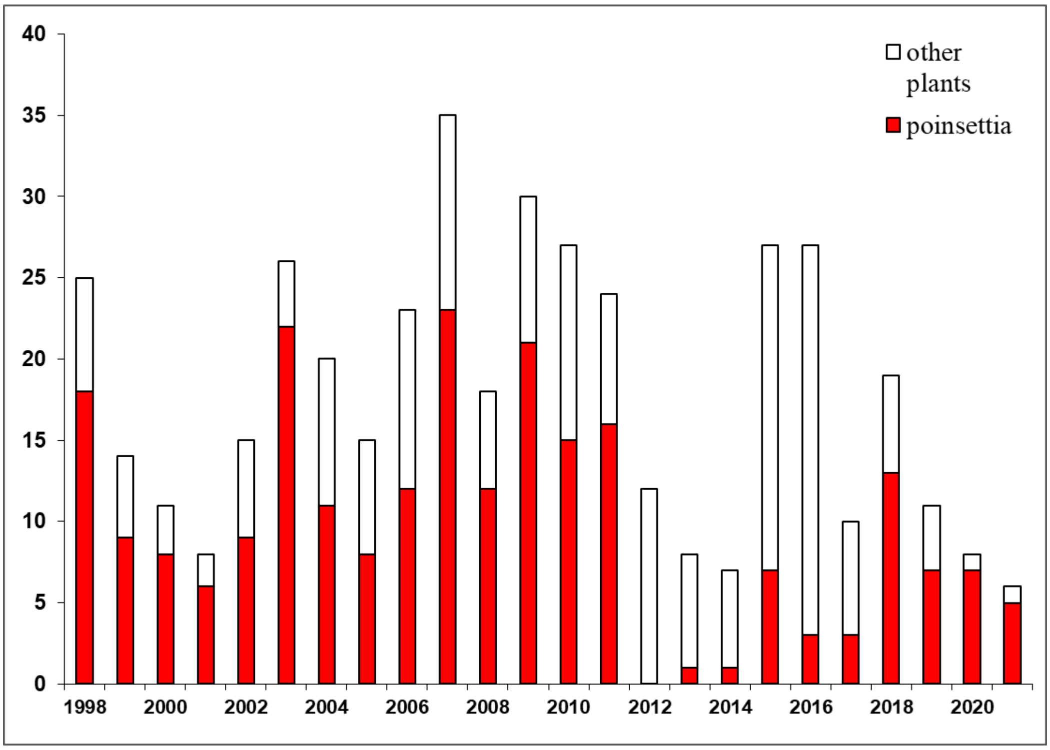

Figure 4: Number of recorded outbreaks of *Bemisia tabaci* by year in the England and Wales from 1998-2021

Outbreaks of *B. tabaci* in edible crops only represent a small proportion of the outbreaks that have been recorded in England and Wales. There have been four recorded outbreaks in fruiting vegetable crops – in this case meaning cucumbers, tomatoes and peppers. The first recorded outbreak in an edible crop was in a cucumber crop in the Lea Valley in 1998. This outbreak was quickly eradicated. In 2013, there were two linked *B. tabaci* outbreaks in England. Both growers had received cucumber plants supplied by the same company in the Netherlands indicating that the young plants were likely to have been the source the outbreak. One was in the north of England and was first found on recently received cucumber plants and is then thought to have spread to tomatoes on the same site. It was first detected in July and kept under control using biological control agents and biopesticides. Eradication was achieved during the annual crop break which took place between mid-November – late February. The second outbreak was in a pepper crop in the south of England in 2013. In 2018 there was an outbreak of *B. tabaci* in a pepper crop in the north of England which was brought under control relatively quickly. In addition to outbreaks in 'fruiting vegetable crops', there have been numerous outbreaks linked to herbs. There have been seven outbreaks at specialist producers of herbs including mint, parsley, thyme, tarragon and sage and at least 17 at nurseries growing a mixture of ornamentals and herbs. Israel has been the most frequent source of the herbs infested with *B. tabaci.*

Impacts in other continents

In sub-Saharan Africa, cassava viruses are a persistent and emergent threat to food security, causing losses of over one billion USD annually. The incidence of cassava viruses is more commonly attributed to propagation of virus-infected cuttings, but vector transmission can cause significant infections. *B. tabaci* is thought to be the primary vector in sub-Saharan Africa (Jacobson *et al.*, 2018).

In the USA, the MEAM1 *B. tabaci* biotype has caused billions (USD) worth of damage to crops due to direct feeding pressure and the deposition of massive quantities of honeydew (Perring *et al.*, 1993). Feeding by five to ten larvae per plant can induce phytotoxic disorders such as the silverleaf symptom seen in squash plants (Costa *et al.*, 1993). MEAM1 is the predominant vector of begomoviruses in open-field vegetable crops in the south-eastern USA. MEAM1 displaced the native biotype of *B. tabaci* in this region, and its introduction led to epidemics of previously unreported whitefly-transmitted viruses in Curcurbitaceae and Solanaceae crops (Gautam *et al.*, 2022).

In South America, MEAM1 and MED, along with *T. vaporariorum* are a continuous concern in glasshouse and field grown crops and the emergence of outbreaks of viral diseases is increasing (Krause-Sakate *et al.*, 2020).

B. tabaci was first recorded in China in 1949, but no significant damage was recorded until the mid 1990s. MEAM1 was discovered in China in 2000 and started to supplant the indigenous whitefly species causing serious losses. MED was first discovered in 2003 in Kunming, Yunnan Province. MEAM1 and MED have now colonised most of the country (Yao *et al.*, 2017). In Pakistan, *B. tabaci* vectors cotton leaf curl disease, the most economically important disease of cotton (Masood *et al.*, 2017).

Transmission of plant viruses

The *B. tabaci* complex has been reported as a super vector of viruses worldwide, transmitting numerous species to solanaceous, fabaceous, cassava and cotton crops as well as to several weeds (Krause-Sakate *et al.*, 2020). There is evidence to suggest that it has co-evolved with the viruses it transmits and that the species of the *B. tabaci* complex are more proficient at transmitting the viruses from the area of their geographic origin (Fiallo-Olive *et al.*, 2020).

The genus Begomovirus (family Geminiviridae) comprises viruses with either monopartite or bipartite single-stranded DNA genomes. Tomato Yellow Leaf Curl Virus (TYLCV) and Tomato yellow leaf curl Sardinia virus (TYLCSV) are present in most European Mediterranean countries and cause tomato yellow leaf curl disease, which is a serious threat to tomato production having a severe impact on crop production and yield. TYLCV is often a cause of major crop damage in the Mediterranean basin (Fernández García, 2013). TYLCV causes heavy economic losses wherever it occurs. Although TYLCV has a broad host range, it is primarily known as one of the most damaging viruses to infect tomatoes. The virus affects yields by greatly reducing the number of fruit produced (Czosnek, 2012). Plant virologists have judged TYLCV to be the third most important plant virus worldwide. In the 1960s it spread quickly from the Eastern Mediterranean Basin to large parts of Europe, Africa, North America and Japan. In affected regions, crops may be totally lost. *B. tabaci* populations of 5-15 individuals per tomato plant are required to achieve 100% transmission efficiency (Czosnek *et al.*, 2001, Yan *et al.*, 2021). In Mediterranean coastal regions of Europe, production of tomatoes is only possible under a complex disease management regime to reduce *B. tabaci* populations and virus incidence (EFSA, 2014).

In 2007 there were outbreaks of tomato yellow leaf curl virus at several tomato growing sites in the western part of the Netherlands. After the first detection, there was a survey of tomato growers within an area of around 40 km^2. TYLCV was found in 19 of 27 sites. Genetic sequence analyses indicated that the outbreak resulted from a single introduction of the virus, but it had been spread between glasshouses by *B. tabaci.* To tackle the outbreaks, infected tomato plants were removed, *B. tabaci* populations were controlled and no TYLCV infections were found in 2008 (Botermans *et* *al.*, 2009). TYLCV has not become established in other northern European countries such as Belgium, Denmark, Germany, the Netherlands and Poland even though they do not regulate European populations of *B. tabaci* and with the exception of the Netherlands, no outbreaks of TYLCV have been reported in these countries.

In 2013, the first detection of a bipartite begomovirus in Europe occurred in Spain. The virus detected was Tomato leaf curl New Delhi virus (ToLCNDV). ToLCNDV infects solanaceous and cucurbitaceous crops, but is especially aggressive in courgette crops. Since its introduction in 2013 it has caused considerable economic losses in Spain (Dirk Janssen & Ruiz, 2016). ToLCNDV was detected on peppers in Italy in 2018, this was the first detection of the virus on peppers in Europe (Luigi *et al.*, 2019).

Cucurbit yellow stunting disorder virus (CYSDV) and tomato chlorosis virus (ToCV) are examples of *B. tabaci* vectored criniviruses that are present in Europe. They induce symptoms in their corresponding hosts that are often mistaken for nutritional deficiencies: these symptoms consist of interveinal yellowing of leaves from the middle to the lower parts of plants. The genus Ipomovirus (family Potyviridae) contains one species which is present in Europe and infects cucurbitaceous crop species: cucumber vein yellowing virus (CVYV). Infected plants show yellowing and clearing vein on leaves and stunting of the entire plant and sudden plant death as a result of early infections (Dirk Janssen & Ruiz, 2016).

In addition to the threat posed by known species of *B. tabaci* spread viruses, there are also many “emerging viruses” that have been spread in Mediterranean horticulture. Many of these viruses are spread by *B. tabaci* and their introduction into EU countries is thought to be the result of global trade in plant material (Dirk Janssen & Ruiz, 2016).

Potential impacts of *Bemisia tabaci* if it was no longer regulated in GB

In the absence of regulation, the incidence of *Bemisia tabaci* in GB would be expected to increase as has been noted in the Netherlands. *B. tabaci* is unable to establish year-round outdoors in our current climate and so any economically important impacts are likely to be in protected environments. *T. vaporariorum* breeds outdoors in summer in southern England, it is better adapted to cooler conditions than *B. tabaci* and so it would be likely to continue to be more widely distributed in unheated protected environments. The environments and crops in which *B. tabaci* has the most potential to establish large populations and cause impacts are those which are maintained at higher temperatures year-round and have hosts present year-round. The area of the three crops for which there are horticultural statistics are shown in Table 3. In the Netherlands, the crops that are most impacted by *B. tabaci* are the ornamentals poinsettia, *Bouvardia*, *Hibiscus*, lisianthus and *Gerbera* along with edible crops of peppers, tomatoes, eggplant and cucumber. This list provides an indication of the crops likely to be at risk if *B. tabaci* became widely established in GB, along with other hosts that are not frost tolerant and grown in heated environments.

Table 2: Area of fruiting vegetable crops in UK in hectares, figures selected at four-year intervals from 2000-2020 (Defra horticultural statistics)

Year	2004	2006	2008	2010	2012	2014	2016	2018	2020	2022
Tomatoes (round, vine, plum and cherry)	189	201	213	213	204	232	232	184	189	192
Cucumbers	130	113	103	114	115	105	99	102	110	90
Sweet Peppers	55	62	65	72	85	92	90	86	85	83

The potential impact of *B. tabaci* on edible crops is greater than *T. vaporariorum* because of its greater importance as a virus vector (Jones, 2003). If *B. tabaci* vectored viruses such as TYLCV were introduced into a tomato crop in GB it could be very damaging at the site where it has been introduced. At the national scale however, the impacts would not be expected to be large. This is because it should be possible to eradicate the viruses from individual sites and the scope for *B. tabaci* and the viruses it carries to spread between production sites would be relatively low when compared to countries where *B. tabaci* can survive outdoors and countries where the glasshouse production is more densely concentrated than it is in GB. In an assessment of the threat posed by TYLCV and related viruses causing tomato yellow leaf curl disease to the EU, EFSA concluded that in glasshouse production in northern Europe, although temporary populations of *B. tabaci* and outbreaks of TYLCV can occur, their infrequent nature and limited scale mean that their overall impact can be considered limited (EFSA, 2014). EFSA carried out a similar assessment for risks relating to ToLCNDV published in 2020 (EFSA, 2020). This assessment does not include a similar statement about risks to northern Europe, but does say that 'establishment and spread are limited to regions with ecoclimatic conditions suitable for the establishment of vector populations (southern regions of Europe) or can occur as outbreaks wherever crops are grown under protected cultivation'.

Management of *Bemisia tabaci*

The use of resistant varieties can reduce the impact of *Bemisia tabaci* in some crops. For example, Sabia cultivars of chrysanthemums have been shown to be more susceptible to whiteflies than other cultivars (Hutapea *et al.*, 2018). Varietal selection can also reduce the impact of the virus spread by *B. tabaci*, such as the use of TYLCV resistant varieties of tomatoes in Spain (Stansly *et al.*, 2004). Netting over vents can reduce the risk of *B. tabaci* reaching glasshouse tomato crops (Kim, 2013). However, the use of insect screens across vents is likely to have a significant impact on the microclimate within the crop (Kittas *et al.*, 2006). Screens with holes of 0.19 mm or less are considered to be effective for excluding *B. tabaci* (Bethke *et al.*, 1994). Cultural control is one of the means of managing whiteflies in South America. One method of cultural control is by altering the irrigation regime; water stressed crops of cantaloupe melons have been shown to be more susceptible to whiteflies than those with increased irrigation. Secondly, crop free periods for specific crops can disrupt whitefly populations and in some areas of Brazil there is a legal prohibition on the cultivation of certain crops that are reservoirs for viruses (Krause-Sakate *et al.*, 2020).

Biological control agents have been used for many years to control populations of *B. tabaci*, especially in protected environments. The number of biological control agents available for control has expanded over recent decades and there are a range of predators and parasitoids marketed for use against glasshouse whitefly, *T. vaporariorum*, a pest that has been established in the UK for many years, and *B. tabaci.* Biological control agents are most effective against *B. tabaci* when employed as a preventative measure or when populations are very low. Two of the parasitoids used to control *B. tabaci* are *Encarsia formosa* and *Eretmocerus eremicus.* These can be accompanied by predators such as the predatory mite *Amblyseius swirskii,* the predatory beetle, *Delphastus catalinae* and the predatory bug *Macrolophus pygmaeus.* Environmental conditions are very important for the efficacy of biological control agents. They are unlikely to be effective in unheated environments during the winter in the UK. Biological control is thought to have a significant impact on whiteflies in South America, especially when used in tandem with other control techniques (Krause-Sakate *et al.*, 2020).

Another option for *B. tabaci* control is biopesticides. These are biologically based products that can be sprayed on to plants like pesticides. As these contain a living organism, they are best applied in particular environmental conditions to be effective. They fall into two categories: nematodes, such as *Steinernema feltiae*, and entomopathogenic fungi, such as *Beauveria bassiana.*

There are a range of physically acting products that can be used against *B. tabaci,* such as products containing maltodextrin*.* These products need to come into direct contact with *B. tabaci* to be effective and so the method of application is particularly important.

There are chemically acting products available for controlling *B. tabaci.* Active ingredients that are available in the UK and have some activity against *B. tabaci* include products containing: acetamiprid (pesticide group 4A); sulfoxaflor (4C); spinosad (5); abamectin (6); buprofezin (16); spirotetramat (23) and flonicamid (29). Some of these products are authorised for use on all of the most relevant host plants (ornamentals, tomatoes, cucumbers and herbs) whereas others can only be used on some of these hosts. Pesticide approvals change regularly and should be checked before using any product. The active ingredients vary in how toxic they are to beneficial insects and how long the impacts will persist for, but it is possible to combine some chemical treatments with the use of biological control agents.

Pathways for the spread of *Bemisia tabaci*

Movement on fresh produce and cut flowers

EFSA (2013) evaluated the risk of different trade pathways for the entry of *Bemisia tabaci* into the EU, entry meant the pest entering the area and establishing a breeding population. The probability of entry of *B. tabaci* into the EU on **fruits and vegetables including leafy herbs for consumption was considered to be unlikely** because of the pathway characteristics (cold chain) and the low probability of transfer to a suitable host. The probability of entry on **cut flowers and branches with foliage was considered to be moderately** likely because eggs and larval stages can survive transport, but the limited life of these products would reduce the risk. Although, they considered that there was a 'medium level of uncertainty' about the assessments due to the limited efficacy of import inspections. The survival of adult *B. tabaci* on cut flowers and branches with foliage was considered to be unlikely and this would make the probability that circulatively transmitted viruses could enter via this pathway unlikely. The probability that non-circulatively transmitted viruses associated with *B. tabaci* entering the EU was rated as very unlikely as the plants are non-host plants for these viruses. The EFSA risk assessments covered the whole EU. For the UK, the risk of entry would be lower for all pathways because it is only protected environments that are at risk from this pest.

Movement on plants for planting

In the EFSA (2013) study, the probability of entry on **plants for planting** was considered to be 'likely' because of the worldwide distribution of the pest and the high volume of trade. For example, the trade in ornamental plants is thought to have been responsible for the introduction of MEAM1 into Brazil, Argentina and Chile (Krause-Sakate *et al.*, 2020). The plants for planting that *Bemisia tabaci* is found on in the UK tend to be houseplants or plants which require frost free conditions year-round such as poinsettias and *Hibiscus.*

Natural spread

Bemisia tabaci can be moved long distances from crops if it gets caught in air currents, but intentional migration can also occur when crop conditions deteriorate or the whitefly density is very high (van Lenteren & Noldus, 1990). However, when whitefly populations are very low, dispersal will be very limited (EFSA, 2013). In the summer, populations are thought to move from glasshouse to glasshouse in the Netherlands (Hoop *et al.*, 2015) and Belgium (Nufarm, 2022), although the density of glasshouse production is much greater in the Netherlands than in GB making inter glasshouse movement more likely. Another possibility for spread in northern Europe is the seasonal establishment o *B. tabaci* on outdoor weeds and then onward spread to other glasshouses.

Impacts of current GB policy

To importers of fresh produce, cut flowers and finished plants

To comply with GB import requirements, importers need to ensure that the goods are free of *Bemisia tabaci.* This requirement may place extra costs on growers in the country of origin because additional pest management measures may be required. The requirement may limit the potential suppliers for certain produce. If *B. tabaci* is detected during import checks then the whole consignment will be destroyed, although only a fraction of produce, generally 3-5% is inspected on arrival in the UK.

As seen in Table 1, there are particular *B. tabaci* requirements that apply to the import of certain plants such as *Ajuga* and *Crossandra*. These requirements could further limit the potential suppliers of plants and increase costs.

To ornamental growers in UK

As a quarantine pest, statutory action is taken whenever *B. tabaci* is found on any imported plants or produce and also whenever it is found on any growing plants in the UK. The current policy can have an impact on UK ornamental growers by influencing:

- The supply of propagation material: growers need to source *B. tabaci* free propagation material. This may limit the supply of plants and increase the costs, but also have a positive impact if they can reduce the introduction of pests.

- The management of their growing crops. If *B. tabaci* is detected in a growing crop in the UK, statutory action such as the destruction of infested plants and treatments may be required to reduce the risk of an ongoing outbreak. Any destruction of crops will have costs, but have the benefit of reducing the risk of an ongoing outbreak or spread to other ornamental growers.
- The costs to UK growers of implementing the policy are partly balanced up by the fact that finished plants grown in other countries and imported into the UK need to be grown to the same standards.

To interior landscapes

When plants are introduced into botanic gardens and other interior landscapes there is a risk of quarantine pests such as *B. tabaci* being introduced. When such environments are heated year-round there is an increased risk of an ongoing population of *B. tabaci.* The quarantine status of *B. tabaci* means that there is a statutory requirement to eradicate such outbreaks.

To producers of edible crops such as tomatoes and cucumbers

The current policy reduces the risk of outbreaks of *B. tabaci* and associated crops in edible glasshouse-grown crops. For most pests of glasshouse crops, the most significant threat of introducing new pests comes from planting material (Bessin *et al.*, 1997), therefore measures to ensure propagation material is clean are likely to be the most effective at reducing the risk of outbreaks of *B. tabaci.* There are particular import requirements for imported Curcubitaceae and Solanaceae. These requirements help to protect growers from the threat of *B. tabaci* and associated viruses being introduced to aubergine, cucumber, pepper and tomato crops. The requirements could limit the potential suppliers of these plants. In the event of an outbreak of *B. tabaci,* the growers are placed under statutory notice to control and eradicate the pest.

The quarantine status of *B. tabaci* also limits the opportunity for outbreaks of *B. tabaci* at garden centres and sites where ornamental plants are produced. This means that the risk of *B. tabaci* entering production sites for edible crops via vents or doorways is reduced. This risk of *B. tabaci* entering edible crops via this pathway is lower in northern Europe than it is in Mediterranean countries because the pest is not able to establish outdoors and the most likely source of infection is other glasshouses. The risk of this pathway to edible glasshouse crops in the UK is lower than it is in countries such as the Netherlands where the density of glasshouse production in areas such as Westland is much higher than it is in the UK with numerous glasshouse facilities surrounding or adjacent to others. The risk of *B. tabaci* entering a glasshouse edible crop is partly determined by how close any potential source of *B. tabaci* is to the facility. In spring 2022, the Tomato Growers Association asked their members how close their sites were to the nearest garden centre or production site. The results of this survey are shown in Figure 5. This data shows that sites comprising approximately 40 ha of tomato production are grown within 0.1 mile (0-160m) of a garden centre / ornamental grower and 55 ha are within 0.25 mile (0-400m). Growing sites at a distance of greater than 400m from a garden centre or ornamental nursery are likely to be at a low risk of cross contamination. It is not possible to produce a numerical assessment of *B. tabaci* spreading from ornamental crops to edible crops in the UK, but the risk is considered to be relatively low because outbreaks of *B. tabaci* have not been reported from edible crops in Denmark and Finland where *B. tabaci* is not a quarantine organism. In contrast, *B. tabaci* has been able to become widely established in Dutch glasshouse crops. A second factor determining risk of spread from ornamental crops to edible crops is the size of the *B. tabaci* population in the ornamental crop. The quarantine status of *B. tabaci* helps to ensure that the number of outbreaks are minimised and that outbreaks are controlled.

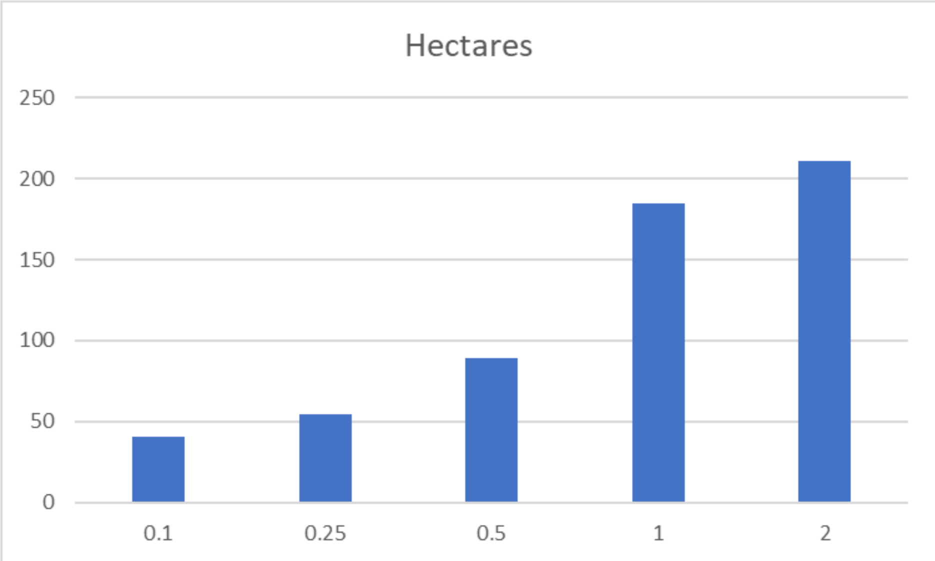

Figure 5: Area of tomato crop grown I the UK within increasing distances (in miles) of the nearest garden centre or ornamental plant nursery. The values are cumulative (explanation in main text).

Options for the future management of *B. tabaci*

The costs of the four different options described below have been compared in an economic analysis which is shown in Annex 2. This analysis represents a first attempt at quantifying economic consequences of the proposed options. The 2A option has not been included in the analysis. A number of assumptions have been made and the overall methodologies used are simple. A full cost benefit analysis will be carried out following the identification of the preferred option, where assumptions will be reviewed, and better data and information will be sought.

Option 1: Maintain the current requirements

This option would require no legislative changes. The current legislative requirements are set out in Table 1. The ongoing risk management measures would remain the same as they are now. The risk of outbreaks of *B. tabaci* could potentially go up or down as a result of changes to trade, the horticultural industry in the UK, the status of the pest in exporting countries, the available means of managing the pest in the UK and the climate.

The very low number of outbreaks of *B. tabaci* in glasshouse grown edible crops in the UK over the last 20 years suggests that the risk of outbreaks in such crops is relatively low with current legislation, but it is difficult to judge what the increase in risk would be in the absence of statutory measures.

Advantages of the current measures:

- Under the current policy, the risks relating to *B. tabaci* have remained low

- The policy has enabled the UK to maintain its pest free status and thus avoiding some of the impacts seen in other European countries

Some of the disadvantages of the current measures are that:

- The current requirements are not preventing a very high number of interceptions and outbreaks in ornamental crops in the UK so are not proving effective as quarantine requirements
- Statutory action is required when the pest is detected on imported plant products which present a relatively low risk to UK horticulture unless it is packed at a growing site
- Statutory action is necessary when the pest is detected within interior landscapes such as botanic gardens even though the pest does not present a threat to those sites
- Statutory action is required when *B. tabaci* is detected at growing sites on ornamental plants even though the threat to these sites may not be sufficient to justify statutory action.

Option 2: Strengthening of current requirements

This option would limit the alternatives for importing the high-risk plants as listed in column one of Table 3 by removing the options for allowing movement from sites where there has been only three weeks of pest freedom, the options for treatments followed by crop freedom and the option of consignment freedom for *B. tabaci*. These changes would provide an increased level of security against introducing *B. tabaci* into GB and the associated risk to protected edible crops. This policy would be likely to lead to fewer interceptions and hence outbreaks and therefore a reduced need for statutory action.

The disadvantages listed for Option 1 would also in general to Option 2. In addition, the restriction would be likely to limit available sources of certain species of plants for planting and hence lead to increases in prices. It could potentially mean that some plants cannot be obtained.

An additional variation of this **option (2A)** would be to add to the list of host plants such as *Begonia* in the final row of the table below that have specific requirements relating to *Bemisia tabaci.* The following proposed additional hosts have been selected from the Table in Annex 1, using the criteria that they are generally imported as Plants for Planting, there have been at least 10 diagnoses between 2018-2022 and there were at least two diagnoses in 2022: *Eustoma, Lantana, Limnophila aromatica* and *Echinodorus.*

Table 3: Possible changes to import requirements to reduce the risk relating to *B. tabaci* in line with Option 2

Plants covered	Locations covered	Measures
All Plants for Planting (PfP) other than dormant plants, plants in tissue culture, seeds, bulbs, tubers, corms and rhizomes [Annex 7 part A point 8]	Countries where Begomovirus and 10 named viruses including tomato leaf curl New Delhi virus (ToLCNDV) are present	No symptoms of viruses seen and for Bt a i) Pest Free area (PFA), ii) Pest Free Production Site (PFPS) ~~or iii) treatment and inspection to demonstrate crop freedom~~
Cucurbitaceae and Solanacae PfP [Annex 7 part A point 9]	Any third country	PFA for ToLCNDV or no symptoms of ToLCNDV and for Bt i) PFPS ~~or ii) effective treatment programme~~
Unrooted cuttings of poinsettia [Annex 7 part A point 10]	Any third country	For Bt: i) PFA, ii) cuttings come from Bt free plants AND PFPS verified by 3 weekly inspections, iii) ~~cuttings come from Bt free plants AND treatment programme and weekly inspections for 3 weeks to show pest freedom~~
Poinsettia PfP excluding seeds and unrooted cuttings [Annex 7 part A point 11]	Any third country	PFA and 3 weekly inspection for 9 weeks or weekly for 3 weeks, and produced from cuttings which have subjected to the same requirements OR are packaged for retail and the consignment has been inspected to demonstrate pest freedom
PfP of *Begonia* other than seeds, tubers and corms, PfP other than seeds of *Ajuga, Crossandra, Dipladenia, Ficus, Hibiscus, Mandevilla* and *Nerium oleander* [Annex 7 part A point 12]	Any third country	PFA, site freedom demonstrated by insp. every 3 weeks for 9 weeks, ~~or treatment plus weekly insp. for 3 weeks to demonstrate pest freedom OR are packaged for retail and the consignment has been inspected to demonstrate pest freedom~~

Option 3: Re-designate *B. tabaci* as a Regulated Non-Quarantine Pest

Under this policy option, *B. tabaci* would become a Regulated Non-Quarantine Pest with a zero tolerance on the following plants for planting: Curcubitaceae, Solanaceae, *Ajuga, Crossandra, Dipladenia, Ficus, Hibiscus, Mandevilla* and *Nerium oleander* and a 0.5% tolerance on the following plants for planting: *Euphorbia pulcherrima* (poinsettias).

The measures aimed at reducing the risk of introducing *B. tabaci* spread viruses on the following plants (rows 1 and 2 of Table 1) would also remain in place:

- All plants for planting other than dormant plants, plants in tissue culture, seeds, bulbs, tubers, corms and rhizomes from countries where Begomovirus and 10 named viruses including ToLCNDV are present

- Curcurbitaceae and Solanaceae from any third country

The advantages of this option are that:

- All action would be focused on the highest risk commodities
- No action would be taken if *B. tabaci* were detected on lower risk commodities such as imported vegetables
- No action would be taken if *B. tabaci* were detected in interior landscapes
- There would be a tolerance for very low levels of *B. tabaci* on poinsettia plants to reflect the fact that once they leave growing sites, they tend to be relatively short-lived houseplants which are sold during the winter when there is no risk of *B. tabaci* surviving outdoors.

The disadvantages of this option are that:

- RNQPs are not as straightforward to implement for inspectors as quarantine pests, although there are parallels with the pests listed in Annex II of the Plant Health Directive (2000/29) that applied to the UK until late 2019
- In most cases, any measures would be restricted to hosts listed in Table 1 of this document (and Annex 7 of 'The Plant Health (Phytosanitary Conditions) (Amendment) (EU Exit) Regulations 2020'), however, it would be possible to add additional hosts if this could be technically justified.
- There would be an increase in the number of sites infested with *B. tabaci* in GB and hence a greater consequential risk to protected edibles growing sites. With this option, the risk would be higher than the risk for options 1 and 2.
- It would be difficult to turn back from this policy once introduced, as it would mean accepting the *B. tabaci* is present in GB.
- Having a difference in policy relating to *B. tabaci* between GB and Northern Ireland, the Republic of Ireland and Sweden would mean there would be additional requirements for the export of plants to these locations. There could also be impacts on trade to countries outside the EU, although, the list of countries which list *B. tabaci* as a quarantine pest is relatively short (Azerbaijan, Bahrain, Belarus, Chile, Georgia, Kazakhstan, Moldova, New Zealand, Norway, Russia, Switzerland, Türkiye and Ukraine)

Option 4: Stop taking action against *B. tabaci* but maintain measures relating to the viruses vectored by *B. tabaci*

With this policy option, the measures that apply to *B. tabaci* spread viruses would remain in place, but other controls on *B. tabaci* would be removed. These controls are listed in the first two rows of Table 1 and apply to:

- All plants for planting other than dormant plants, plants in tissue culture, seeds, bulbs, tubers, corms and rhizomes from countries where Begomovirus and 10 named viruses including ToLCNDV are present
- Curcurbitaceae and Solanaceae from any third country

The aim of this policy option would be to reduce the risk of importing *B. tabaci* spread viruses into GB, but other than the cases listed above, no action would be taken if *B. tabaci* were found on a commodity. All the advantages that are listed for option 3 above would also apply to this option.

Some of the disadvantages of this option would be that:

- There would be an increase in the number of sites infested with *B. tabaci* in GB and hence a greater consequential risk to protected edibles growing sites. With this option the risk would be higher than the risk for option 3.
- Having a difference in policy relating to *B. tabaci* between GB and Northern Ireland, the Republic of Ireland and Sweden would mean there would be additional requirements for the export of plants these locations. There could also be impacts on trade to countries outside the EU.
- It would be difficult to turn back from this policy once introduced, as it would mean accepting the *B. tabaci* is present in GB.

Conclusion

The four different policy options for comment have been compared in Table 4 below. Stakeholders are requested to consider the evidence provided in this consultation document alongside any other evidence they may be aware of and then indicate which is your favoured option and why. The simple economic analysis that has been carried out as part of this review projects that:

- Option 2 (and 2A) would be expected to lead to lower outbreak costs
- Option 3 and 4 would be expected to lead to lower costs with complying with biosecurity measures
- Overall Options 3 and 4 would lead to lower costs overall

Table 4: Comparison of the implications of different options to 5 types of stakeholders

Option:	1	2 and 2A	3	4
Type of stakeholder	Maintain current requirements	Strengthened requirements	RNQP	Measures only on viruses
1. Importers of produce, cut flowers and plants	No change	No change for produce and cut flowers. Some more restrictions for plants for planting.	Measures removed for produce and cut flowers	All measures removed
2. Ornamental growers	No change	Some propagating material harder to import. Some plants difficult to move if *B. tabaci* detected.	Some host plants would be out of the scope of legislation, more flexibility for poinsettia growers.	No eradication requirement.
3. Interior landscapes	No change	No change	No requirement to eradicate	No requirement to eradicate
4. Growers of protected edible crops	No change	Increased protection from *B. tabaci*	Increased risk of *B. tabaci* spreading from ornamental crops to edible crops	Increased risk of *B. tabaci* reaching crops
5. Government	No change	Minor changes from current intervention	Reduced intervention needed but basis for action less clear, harder to implement policy.	Reduced costs of inspection

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Annex 1: *B. tabaci* diagnoses 2018-2022

Table of diagnoses of *Bemisia tabaci* by Fera Science Ltd covering diagnoses in England and Wales from January 2018 – Dec 2022. The table includes diagnoses on imports at outbreak sites.

	2018	2019	2020	2021	2022	Host Total	Type	Imp. Req
Euphorbia pulcherrima	80	102	60	56	30	328	PfP	1
Ocimum spp.	23	37	6	41	65	172	edible	
Corchorus spp.	34	34	13	26	38	145	edible	
Solanum pseudocapsicum	3	2	5	34	94	138	PfP	1
Capsicum spp.	24	31	11	40	25	131	edible	
Mandevilla (incl. Dipladenia)	23	30	7	9	31	100	PfP	1
Hibiscus spp.	17	36	4	4	15	76	PfP	1
Eryngium spp. (exl E. maritum and E. planum)	5	5	1	25	14	50	edible	
Telfairia occidentalis	8	24	4	3	1	40	edible	
Vernonia spp.	18	3	0	5	10	36	edible	
Piper spp.	6	1	0	10	15	32	edible	
Nerium oleander	8	13	4	1	1	27	PfP	1
Colocasia spp.	2	6	6	11	0	25	edible	
Manihot spp.	7	0	0	8	8	23	edible	
Solanum	4	3	1	3	7	18	mixed	1 (PfP)
Eustoma (incl. Lisianthus)	6	3	1	3	5	18	PfP	
Persicaria	3	0	2	8	4	17	edible	
Ipomoea batatas	4	6	0	4	2	16	edible	
Solanum melongena	4	3	6	3	0	16	edible	
Syngonium	0	0	1	12	1	14	PfP	
Lantana spp.	0	7	2	1	3	13	PfP	
Salvia spp.	9	1	2	0	1	13	mixed	
Crossandra spp.	6	2	1	2	0	11	PfP	1
Limnophila aromatica	0	0	0	9	2	11	PfP	
Echinodorus spp.	0	1	1	3	5	10	PfP	
Anubias spp.	2	1	2	1	2	8	PfP	
Perilla spp.	0	4	1	3	0	8	edible	
Alternnanthera spp.	1	3	0	2	1	7	PfP	
Aster spp.	0	0	0	1	6	7	mixed	
Gerbera spp.	2	0	1	2	2	7	PfP	
Abelmoschus esculentus	2	4	0	1	0	7	edible	
Cryptocorne spp.	0	1	2	0	3	6	PfP	
Lavandula spp.	5	0	0	1	0	6	PfP	
Ipomoea aquatica	0	0	6	0	0	6	PfP	
Rosa	4	2	0	0	0	6	cf	
Ajuga spp.	1	0	2	0	2	5	PfP	1
Amaranthus spp.	3	1	0	1	0	5	edible	

Brassica spp.	1	2	0	1	1	5	edible	
Celosia spp.	1	1	0	1	2	5	PfP	
Polygonum spp.	4	1	0	0	0	5	PfP	
Acalypha indica	2	2	0	0	1	5	edible	
Chrysanthemum	2	2	0	0	1	5	cf	
Euphorbia	3	0	1	1	0	5	PfP	
Solanum macrocarpon (= macrocarpum)	3	2	0	0	0	5	edible	
others (<5 diagnoses)	24	41	13	27	36	141	mixed	
Year Total	354	417	166	363	434	1734		

*1: PfP = plants for planting; cf = cut flower; *2: 1 = specific import conditions apply to this host

Annex 2: Economic analysis of the policy options

To support the *Bemisia tabaci* consultation, an analysis has been carried out to indicatively estimate the impacts of the proposed options outlined in the consultation. A full cost benefit analysis will be conducted following the identification of the preferred option, including a review of the assumptions used and as such, this analysis should be considered for illustrative purposes only. Lastly, it is recommended to view the analysis in conjunction with the qualitative description of the options in the consultation document. The analysis does not take into account any impacts on market access and increased routine pest management costs that could arise from the establishment of *B. tabaci* in the UK.

a) Cost to UK businesses:

The main impact to UK businesses that has been considered at this stage, is the assumed additional cost passed on by exporters to UK businesses from the change in biosecurity measures proposed[1].The analysis has considered different pass-through rates of 25%, 50% and 100% to give us a range of potential costs to UK businesses. Pass-through occurs when a business changes the prices of the products or services it supplies following a change in its costs.

Under Option 2, complying with biosecurity requirements for *B. tabaci* will become more expensive, suggesting that more costs will be borne by UK businesses. In contrast, under options 3 and 4, the current requirements for plant products such as vegetable and cut flowers will be removed. This is reflected as savings in the final estimates (Table 1), as it is assumed that exporters will no longer pass on the costs associated with following biosecurity measures for these commodities. In reality, however, the behaviour of exporters could differ and depends on a number of factors such as the ability of exporters and UK business to absorb any change in costs. This has not been explored here and therefore Table 1 presents an indicative estimate of the costs and savings that could arise[2].

Table 1: Annual estimated costs to UK businesses, £millions (*-ve figures denote savings)*

	Option 2	Option 3	Option 4
Lower bound estimates	£1.0	-£0.5	-£0.7
Central estimates	£1.9	-£0.9	-£1.4
Upper bound estimates	£3.8	-£1.8	-£2.8

[1] In the absence of robust data, the cost of complying with biosecurity measures is conservatively assumed to be 5% of the respective commodities trade value. Different approaches were used to obtain the trade values of the commodities in our analysis including research on the domestic production of poinsettias as well as the HMRC trade dataset. The commodity codes of HMRC trade data do not dis-aggregate to the species level and instead the CN code deemed the most representative was used, and an estimate of the proportion of the aggregate value that represents the plants of interest was made (5%). This approach will be reviewed after the consultation stage.

[2] The analysis assumes that all exporters will comply with the 'treatment' method as this is the cheapest of the biosecurity measures. Different scenarios of biosecurity measures adoption will be explored in a full CBA analysis.

a) *Bemisia tabaci* Outbreak Costs

The risk of *B. tabaci* outbreaks under the proposed options has also been explored. A simple risk analysis using information on the number of past *B. tabaci* outbreaks and the management cost of *B. tabaci* were used in the absence of conducting a full pest outbreak analysis[3]. This enabled us to indicatively estimate a per hectare cost of a *B. tabaci* outbreak and extrapolate it to the average number of *B. tabaci* outbreaks in the last 10 years. Assuming 1 – 5 hectares were affected in each of the previous Bt outbreaks, provides low to high ranges in our final estimates.

For each of the proposed options, a percentage risk rating was assigned, representing the probability of an outbreak of *B. tabaci*. The probability of *B. tabaci* outbreak is considered 'high' or 'very high' for Options 3 and 4, therefore a 100% and 300% risk rating was assigned. Under option 2, the risk of a *B. tabaci* outbreak is considered 'low,' so a -50% risk rating was used. Applying these risk ratings to the outbreak costs, provides an estimate of the additional cost or savings from potential *B. tabaci* outbreaks under the proposed options (Table 2).

Table 2: Estimated Impact from Bemisia Outbreak £million ***(-ve figures denote savings)***

	Low Risk	High Risk	Very High Risk
	Option 2	Option 3	Option 4
Lower bound estimates	-£0.1	£0.2	£0.5
Central estimates	-£0.1	£0.5	£1.0
Upper bound estimates	-£0.3	£1.2	£2.5

b) Final Outputs

Combining the two outputs together, Table 3 presents the estimated impact of the proposed options for *B. tabaci,* consisting of the impact of complying with the new biosecurity measures and the risk of *B. tabaci* outbreaks. The two costs should be considered together as while Option 3 and 4 show savings to UK businesses, there is a much higher risk of an outbreak, which would bring further costs. Due to the preliminary nature of the outbreak analysis (that it is based on simple calculations that do not take into account the several direct and indirect costs associated with pest outbreaks) the actual costs of outbreaks are likely to be higher, and therefore options 3 and 4 are likely to have an overall net cost rather than saving.

[3]Management costs are based on estimating the labour cost, pesticide cost, bio control and water cost for poinsettias, cucumbers, and peppers using previous analysis conducted by Defra for Bt. The management cost as a % of total sales was applied in the analysis.

Table 3: Combined estimated annual business costs and outbreak costs. (-ve figures represent savings), £million									
	Option 2			**Option 3**			**Option 4**		
	Lower	Central	Upper	Lower	Central	Upper	Lower	Central	Upper
Biosecurity Cost	£1.0	£1.9	£3.8	-£0.5	-£0.9	-£1.8	-£0.7	-£1.4	-£2.8
Outbreak Costs	-£0.1	-£0.1	-£0.3	£0.2	£0.5	£1.2	£0.5	£1.0	£2.5
Total	**£0.9**	**£1.8**	**£3.5**	**-£0.2**	**-£0.4**	**-£0.6**	**-£0.2**	**-£0.4**	**-£0.4**

Overall, the analysis in this document represents a first attempt at quantifying economic consequences of the proposed options for *Bemisia tabaci*. A number of assumptions have been made and the overall methodologies used are simple. A full cost benefit analysis will be carried out following the identification of the preferred option, where assumptions will be reviewed, and better data and information will be sought. Until then, this analysis should be considered as an indication of the potential impacts to the UK and should be viewed in conjunction with the description of the options in the consultation document.