BMSB – kiwifruit impacts and on-orchard management

March 2017

Purpose

This Brown Marmorated Stink Bug (BMSB) discussion paper summarises current knowledge of impacts to kiwifruit and strategies for on-orchard management. It has been produced to provide a platform for development of an industry on-orchard management strategy for this pest.

Background

BMSB is rapidly emerging as one of the most significant biosecurity threats to the New Zealand kiwifruit industry, as pressures at our borders increase and the severity of potential impacts to our industry become more apparent.

KVH, MPI and other GIA partners are putting significant efforts into keeping BMSB out of New Zealand and ensuring we have the best possible shot at eradication if it were to arrive, including;

- Readiness and response arrangements under GIA
- Research efforts to mitigate risk and impact
- Working with importers
- Communications to increase the likelihood of detection.

While keeping New Zealand BMSB free is our primary focus, these topics have been covered previously and will not be addressed in this paper. Rather this paper will seek to build a picture of what on-orchard management might look like, should BMSB establish here.

In all invaded countries BMSB has first established in urban areas and moved into agricultural areas several years later. Therefore, we don't expect on-orchard management to immediately follow an incursion, like it did for Psa, however by planning our approach now we can implement R&D projects to overcome knowledge gaps in advance.

We have a limited understanding of the impacts to kiwifruit, as only a year ago, there was no available evidence to suggest that kiwifruit was even a host despite BMSB being present in numerous kiwifruit growing regions. This picture is rapidly changing;

- In the USA, kiwifruit is primarily grown in California and although BMSB has been present and widespread in this state since 2005, impacts to agriculture have been limited and there have been no reported impacts to kiwifruit. The reasons for this are unclear, although it may be climate related as pest populations are significantly less than further east where agricultural impacts are most severe.
- In China, Korea and Japan, BMSB is a native and lack of reported impacts to kiwifruit were initially believed to be a result of population suppression by natural predators. A recent B3 (Better Border Biosecurity) project using literature searching in Chinese has subsequently revealed that BMSB is a serious kiwifruit pest in China and reports of impacts do exist that our searches in English were not picking up. Shane Max has also reported impacts from Korea that are now believed to be BMSB but previously may have been attributed to other causes. As far as we know, BMSB is not a significant pest of kiwifruit in Japan.
- In Europe, BMSB has been present for 10 years but wasn't reported in Italy until 2013. It took a further three years for large numbers to build and enter kiwifruit orchards, with impacts only being reported for the first-time in 2016.
- KVH / Zespri have funded research in California to better understand BMSB feeding preferences on Hayward and G3. This research indicates that in a lab setting BMSB will feed on either cultivar

with equal preference, however the research was conducted on fruit softer than the desired “vine condition” which may be an import factor influencing impacts on-orchard.

What we have learnt about BMSB impacts to kiwifruit and on-orchard management is summarised below.

Impacts to kiwifruit

Reports from Italy, Korea and China, and observations from other horticultural sectors in the USA suggest that if BMSB were to arrive in New Zealand, we could expect the following;

- Up to 30% fruit loss from fruit drop and storage rot. However, this figure is based on anecdotal reports of symptoms that are difficult to attribute to BMSB and therefore may contain a significant margin of error. Conducting on-orchard trials would provide more reliable insight.
- Not considered a market access pest so direct market access implications considered unlikely for all markets except possibly Australia who may take a conservative position.
- Insecticide use may create challenges to operate within current MRL limits for some markets. The size of that challenge will depend on the rates/timing of the applications (and therefore residues). Some customers may not accept fruit that have had certain insecticides used even if it meets MRLs. These impacts are outlined under “Chemical controls”
- Insecticide use may disrupt current IPM programmes and cause secondary pest outbreaks.
- Increased packing and QA costs to prevent storage rot.
- Increased operational costs from insecticide use, netting, and labour.

Description / symptoms[1]

BMSB adults and nymphs affect fruit quality by sucking sap from leaders, young leaves, shoots and fruits. The affected leaves often have yellow-green spots and may cause flowers or buds drop at the early stage. The injured young fruits generally have symptoms including: black spots or blue scars on the skin; flower or fruit drop and deformed fruits. BMSB also turned the injured parts of ripe fruits to white ‘spongy’ and eventually injured fruit rot (Figure 1). When ripe fruit was affected by these two pests, the injured part of fruits became hard and bitter, with limited storage life.

Figure 1. (left) Small rot surrounds feeding wound on G3 fruit in Korea suspected to be caused by BMSB (Shane Max, Zespri); (right) Internal damage to “Mighties” kiwifruit exposed to BMSB in California, arrows point to the white “spongy areas that typically develop post-feeding (Jesus Lara, UCR).

[1] NB. The following two sections are sourced primarily from translated Chinese publications, therefore some translational errors may exist.

When do these impacts occur?

(dates in brackets are Southern Hemisphere estimates based on Northern Hemisphere observations)

BMSB over winter in inanimate objects or in the seams of locust, elm, poplar and willow trees (i.e. shelter belts). In Spring, as the temperature increases they start to move to the top of these trees or to other fruit trees and begin inflicting damage (Figure 1). Eggs are deposited shortly after in early summer (late Nov / early Dec). Nymphs begin emerging about a week after egg deposition and gradually move further from the eggs as they develop into adults which is typically late summer (~Feb). Impacts are typically observed from summer to early autumn (Dec to March). In China and USA it is typical for BMSB to have one generation per year although two or more generations may occur in warmer, tropical climates.

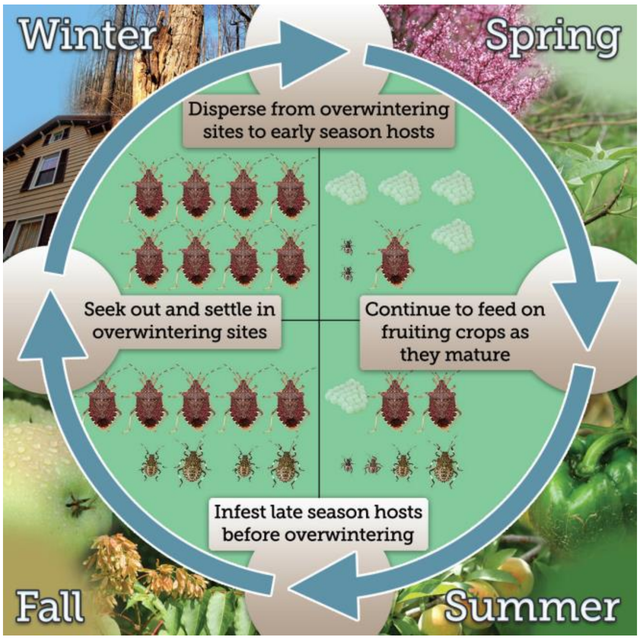

Figure 2. Typical seasonal biology of BMSB (stopbmsb.org)

Will BMSB establish in New Zealand?

Climate modelling indicates that New Zealand is highly suitable for BMSB establishment, especially the Bay of Plenty that is considered suitable under even the most conservative models (Figure 3). Given our suitable climate, the number of border and post-border interceptions this summer and that aggregations of 10 or more BMSB arriving together have a 50% likelihood of establishing here, it is considered prudent to begin planning for on-orchard management, without losing focus that early detection and eradication remain our primary goals.

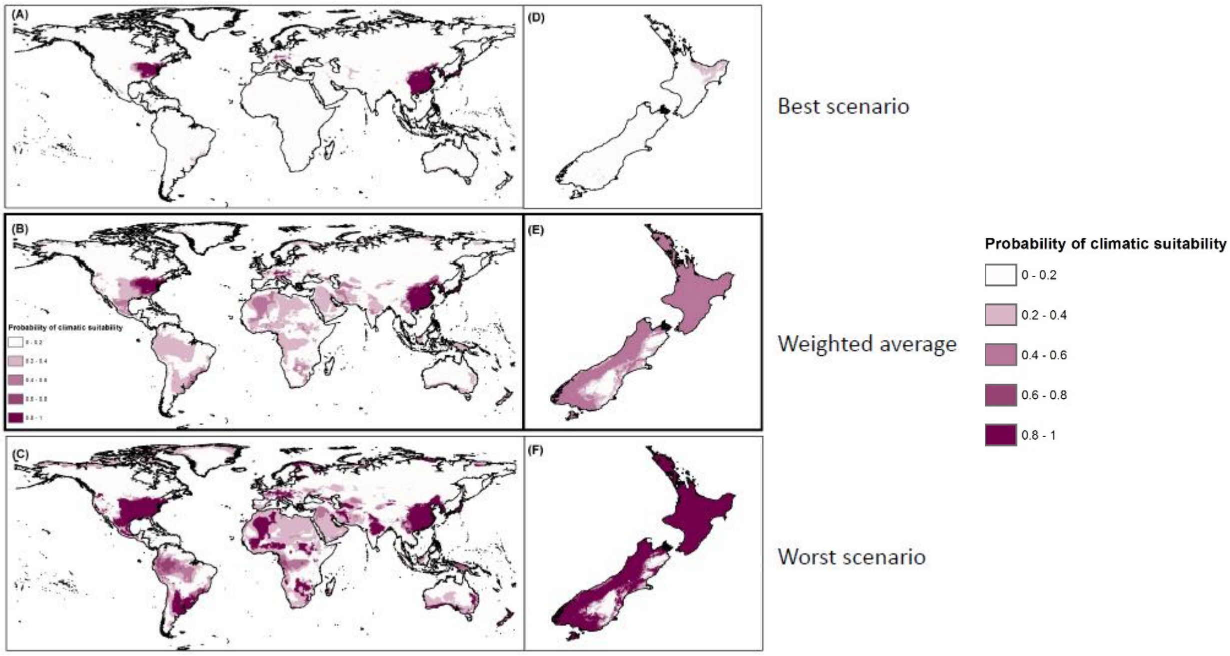

Figure 3. BMSB potential distribution projections based on presence – absence models (Seney et al. 2016). *Key is reproduced on right to be more readable.*

On-orchard management

As one of the main impacts from BMSB comes from use of insecticides themselves, in the form of MRL restrictions and disruption to IPM programmes resulting in outbreaks of secondary pests; consideration has to be given to an overall management strategy of which chemical control is a single component. Other components may include the following (described in more detail below);

- Monitoring to optimise effectiveness of interventions
- Management strategies
- Application of less toxic options such as biopesticides
- Biocontrol agents to suppress populations.

On-orchard monitoring and management strategies

Since 2010, the USDA has been running a national project against BMSB involving 50 researchers from 18 institutions, called StopBMSB (www.stopbmsb.org). The following is a summary of their on-orchard monitoring and management advice for orchards but also includes information from other sources:

- Korean kiwifruit growers use netting to keep BMSB out. If this was utilised in New Zealand in conjunction with release of a biocontrol agent, it could also serve to keep the biocontrol inside the netting, suppressing populations already inside.
- Monitoring can be done using pyramid traps baited with a commercial lure (Figure 4). These traps can be an excellent monitoring tool and are effective at capturing BMSB adults and nymphs as an indication of population levels so that interventions can be timed accordingly (rather than capturing all individuals like a fruit fly trap). Kiwifruit growers in Italy and Korea have also been using these traps. MPI do have some of these traps in New Zealand, some are currently deployed in Whitianga to ensure that no further individuals exist from February's investigation.
- StopBMSB is currently working on designing a cheaper, smaller and more user-friendly version for growers. We should consider the merits of sourcing our own industry supply once available.
- Monitoring can be used to trigger when further intervention is required (biocontrol, biopesticides or chemical sprays). For example, in the USA traps are deployed within the orchard or at the border, and if any trap reaches a threshold of 10 adult BMSB, two doses of an effective insecticide were applied, at alternate-rows with a seven day interval between sprays. This strategy has been demonstrated to reduce the number of BMSB-targeted sprays by 40% compared to weekly sprays, while maintaining an equivalent level of protection.
- BMSB does not reside permanently in any crop. It is considered a border driven pest, meaning it invades from the outside and pressure is often highest along orchard edges, especially edges bordering woodlands. Therefore, it is recommended that monitoring focuses on these areas and includes periodically inspecting sampled fruit for internal injury, since it may not be associated with injury on the fruit surface.

Figure 4. Commercial BMSB pheromone trap

- “Attract and kill” strategies capitalise on border pressure, by sacrificing a tree or row on the border and using traps or lures to attract large numbers of the insects to that specific area, and then treating that area only. Improving this approach is a current research focus of StopBMSB.
- Individuals that are preparing to overwinter tend to be the most susceptible. Therefore, products with the best effectiveness against this pest should be used later in the season (Jan – March).
- Insecticides should be rotated among products in different classes with different modes of action.
- Many of the effective insecticides for BMSB have relatively short residual activity against it; thus, alternate-row applications at about seven-day intervals may improve control. Alternatively, weekly border sprays are also effective (insecticide treatment to orchard perimeter plus the first full row). Limiting sprays to border row trees can also help protect important natural enemies in the rest of the orchard.
- In Japan, boxes filled with paper, or straw mats are used as traps outside to attract overwintering bugs. They also use special “slit” traps of layered pieces of plywood. Bugs crawl into the slits cut between boards and are trapped. A single trap can catch more than 2000 bugs!

More detail on tools used in these management strategies

1. Biological control

“At the end of the day, this is a landscape scale pest that utilises so many hosts and habitats that there is no possible way that you can hope to manage those populations with insecticides, or traps, or other human tactic. Biological control, especially by the egg parasites, represents the ultimate solution for bringing this pest to economically acceptable levels”.

Chris Berg, Professor Entomology, Virginia Tech

One of the most promising control strategies is the development of a biological control, a natural enemy that can provide ongoing population suppression. A project funded by Better Border Biosecurity (B3) and undertaken by Plant and Food Research (PFR), is seeking EPA pre-approval to release the parasitoid wasp *Trissolcus japonicas* should BMSB establish here. This wasp is thought to be effective in suppressing BMSB egg populations by up to 80%. The next consideration would be the model to release the parasitoid, and whether growers would be able to purchase live organisms and release these in the own orchards.

2. Biopesticides – are there more friendly alternatives?

Some biopesticides may be just as effective as more toxic insecticides providing mortality and valuable sublethal effects.

The combination of neem and pyrethrins (Azera™) is reported to be effective and can be used in organic agriculture in the US. Neem acts as an antifeedant and pyrethrins are repellent and can also be lethal. There are several Neem products registered for use in New Zealand but not for kiwifruit specifically. There doesn’t appear to be residue decay information for kiwifruit and many markets have either chosen default MRLs of 0.01 or have this listed as exempt (including some of the larger markets). Conducting residue trials to provide this data may enable higher MRLs to be imposed for these markets.

Another alternative showing promise are microbial biopesticides such as the Japanese fungus *Ophiocordyceps nutans* (specifically attacks stink bugs), *Beauveria bassiana* (available as Botanigard™) and *Metarhizium anisopliae* (available as MET52™). New Zealand has expertise in some of these microbial pesticides having used them successfully in other crops. Action to follow up and determine if a feasible option, what work is currently underway, and if other work should be funded.

Repellents are another potential control strategy, which repel without killing. Essential oils, clove, lemongrass, spearmint and ylang-ylang oils are among those found to be highly effective although further research is required to provide a slow release formulation that provides on-going protection.

Biopesticides may be a valuable tool to both conventional and organic growers. Further work is required to better understand their effectiveness and if warranted conduct residue trials to higher than default MRLs accepted by those markets where not listed as exempt.

3. Chemical control – what options do we have?

In the US, chemical control has been the most widely used strategy for managing BMSB damage to crops, however it should be considered a last resort given the market access challenges that may result from MRLs. Tree fruit growers in the mid-Atlantic have increased the number of insecticide applications, in some cases nearly fourfold from 2010 to 2011 and have reduced the interval between sprays. Most pyrethroids have limited effectiveness with many bugs recovering within seven days, therefore growers have turned to more effective but also more toxic options such as endosulfan, methomyl and neonicotinoids. Active ingredients that have been most effective include; pyrethroids (bifenthrin, permethrin, fenpropathrin, and beta-cyfluthrin), neonicotinoids (dinotefuran, clothianidin, and thiamethoxam,), carbamates (methomyl and oxamyl), the organophosphate acephate, and the organochlorine endosulfan.

<u>What can we use in New Zealand?</u>
MPI have commissioned a review of BMSB chemical control options that can be registered for use in New Zealand in a response situation (including small scale spraying and area wide spraying). This review identified permethrin, bifenthrin and dinotefuran as the most suitable candidates for use in New Zealand. These are now going through the registration process (including any health or environmental analyses) which is due for completion in February 2018.

<u>Can we use permethrin, bifenthrin and dinotefuran on kiwifruit in New Zealand?</u>
None of these three options are currently available for use post-flower in the Crop Protection Standard (CPS). However, in cases where data is not available markets take a conservative approach. For these products, obtaining residue data by conducting decay curve trials may support higher Maximum Residue Limits (MRLs). Gordon Skippage at Zespri provided the following information;

- Proposed rates and timing of spray application are important in determining whether a chemical can be used as this is what MRLs are based on.
- An application of any of these sprays at a rate higher or applied later than the registered use will exceed NZ MRL.
- If the MRL is exceeded, then legally the fruit cannot be sold at all.

Permethrin

- Listed as prohibited in the CPS
- On restricted or banned list by a number of Zespri's EU customers
- However – has the highest MRLs 2mg/kg for NZ and most of our trading partners (except EU and Korea). These are based on a "fruit" listing (not kiwifruit) – and may not be achievable based on the timing/rate etc.

Bifenthrin (Talstar)

- In NZ CPS for scale control (pre-flowering) - not useful as BMSB not likely to be in vines at this point.
- On restricted list by a number of Zespri's EU customers
- NZ MRL 0.01mg/kg (effectively zero)

Dinotefuran

- Doesn't appear to be registered for use on any crop with ACVM (in NZ)
- On restricted or banned list by a number of Zespri's EU customers
- NZ MRL is 0.1mg/kg – all export countries are effectively the same or zero (most are zero) except Korea

Proposed approach / Knowledge gaps

- Identify other options - KVH has requested the complete report from MPI to determine what other chemicals may be suitable and if data exists that may answer some of the questions above.
- Ensure we have legal access to apply products in NZ - the registration process should include industry considerations. Engage with consultant who is completing this work and identify what is required to achieve this.
- Reduce market access risk - residue trials of application to mature fruit could provide data to support more accurate MRLs. These trials could be conducted next summer.