Developing a forecasting model and Decision Support System for *Pea seed-borne mosaic virus* epidemics in field pea crops

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Key messages

- *Pea seed-borne mosaic virus* (PSbMV) infection is widespread in Western Australian (WA) field pea seed stocks, and major seed yield and quality losses are common in the states' pea crops.
- Field pea validation blocks were set up annually between 2010 and 2014 to monitor aphid activity and PSbMV incidence under differing climatic scenarios.
- The data collected, and other historical data on PSbMV spread in WA, will be used in combination with climatic data to develop and validate a forecasting model that predicts PSbMV epidemics in pea crops.
- The forecasting model developed will be incorporated into a Decision Support System (DSS) made accessible to growers via the internet. It will provide advice in implementing an appropriate integrated disease management (IDM) regime tailored to suit their particular circumstances.

Aim

PSbMV causes a serious disease in field pea crops, and other important grain legumes, both in WA and around the world. Sowing infected pea seed produces infected plants that act as a primary inoculum source for secondary spread by aphid vectors throughout the growing season. In field experiments in WA involving sowing seed lots with different levels of infection, sowing 6% infected seed caused up to 25% yield losses. Losses and seed quality damage were accentuated when crops became infected at high levels prior to podding. In WA, the disease PSbMV causes is second in importance only to pea blackspot disease caused by *Mycosphaerella pinodes*. However, its importance is often underestimated due to difficulties in recognising its foliage symptoms. This study is to attain a better understanding of the epidemiology of PSbMV under WA conditions with the ultimate purpose of developing a forecasting model and DSS to provide a more effective IDM regime to growers that is tailored to suit their particular circumstances.

Methods

For model calibration and validation, large square 'validation blocks' of field pea were set up annually by DAFWA between 2010 and 2014 across 5 different sites in the Avon and Esperance regions of the WA grainbelt. There were 2-3 sites per year. The 'validation blocks' were located at Muresk (2010-2011), York (2012), Bolgart (2013-2014), Wittenoom Hills (2010- 2012) and Grass Patch (2010-2014). Two cultivars were used, Kaspa and Twilight. Data collected from the different years and sites represents a wide variety of climatic scenarios, including ones ranging from dry to very wet starts to the growing season. All sites were sown between 26 May and 22 June depending on rainfall. Sites were visited weekly to change aphid sticky traps and every 2 weeks (every 2-4 weeks from 2010-2012) to collect leaf samples. Yellow sticky traps were used in all years to monitor aphid build-up and flights. In 2014, pan traps were set-up to collect intact aphids which are easier to identify to species level. Leaf samples collected in the field were tested for PSbMV by ELISA in the laboratory. Levels of seed transmission in samples of sown or harvested seed were established by growing out representative seed samples and testing the seedlings for PSbMV by ELISA.

Results

Table 1 illustrates the range of diversity of results obtained within different validation blocks growing at five sites between 2011 and 2014. The extent of virus spread in the crop, and into harvested seed, depended on: i) the rainfall before planting (i.e. availability of green bridge) which drove aphid activity and numbers, ii) the level of virus infection in the seed sown, and iii) the field pea cultivar used. The highest crop and seed infection occurred in Kaspa when the input levels of infection were high and virus spread was extensive early on. There was no colonisation of pea plants by aphids so virus transmission was by transient winged migrants visiting the crop and then flying on.

Table 1. Summary of results from validation blocks at all sites over a 4 year period. [Data summarised are PSbMV incidences in sown seed stocks, in foliage at flowering time, foliage at final incidence and harvested seed]

Year (cultivar sown) Site location			PSbMV % incidences (Day/month)	
2010 (Kaspa)	**Seed sown**	**At flowering**	**Final incidence**	**Harvested seed**
Wittenoom Hills	7	9 (22/9)	24 (7/10)	3
Grass Patch	7	11 (22/)	90 (7/10)	6
Muresk	7	38 (7/9)	72 (29/9)	9
2011 (Kaspa)				
Wittenoom Hills	2	4	5 (5/10)	2
Grass Patch	2	8	9 (5/10)	4
Muresk	2	4 (7/9)	47 (26/10)	1
2012 (Kaspa)				
Wittenoom Hills	10	53 (19/9)	73 (3/10)	10
Grass Patch	10	90 (19/9)	90 (3/10)	27
York	10	80 (19/9)	77 (3/10)	11
2012 (Twilight)				
Wittenoom Hills	<1	0 (19/9)	3 (3/10)	1
Grass Patch	<1	11 (3/9)	24 (3/10)	8
York	<1	8 (19/9)	24 (3/10)	1
2013 (Kaspa)				
Bolgart	13	90 (4/9)	96 (24/9)	19
Grass Patch	13	98(15/8)	100 (24/9)	21
2013 (Twilight)				
Bolgart	2	24 (28/8)	37 (24/9)	8
Grass Patch	2	32 (15/8)	44 (24/9)	14
2014 (Kaspa)				
Bolgart	2	29(4/9)	94 (1/10)	N/A
Grass Patch	2	30 (11/9)	82 (10/10)	N/A
2014 (Twilight)				
Bolgart	4	20 (27/8)	55 (1/10)	N/A

N/A = Not available

Table 2. Field pea validation blocks at 2 sites illustrating growing seasons with dry (Wittenoom Hills 2011) and wet starts (Bolgart 2014)

Site	Rainfall Mar	Rainfall Apr	Rainfall May	Rainfall Jun	Rainfall Jul	Rainfall Aug
Wittenoom Hills 2011	3.3	13.8	34.4	17.6	49.6	38.6
Bolgart 2014	0	58.4	75.8	52	76.8	35

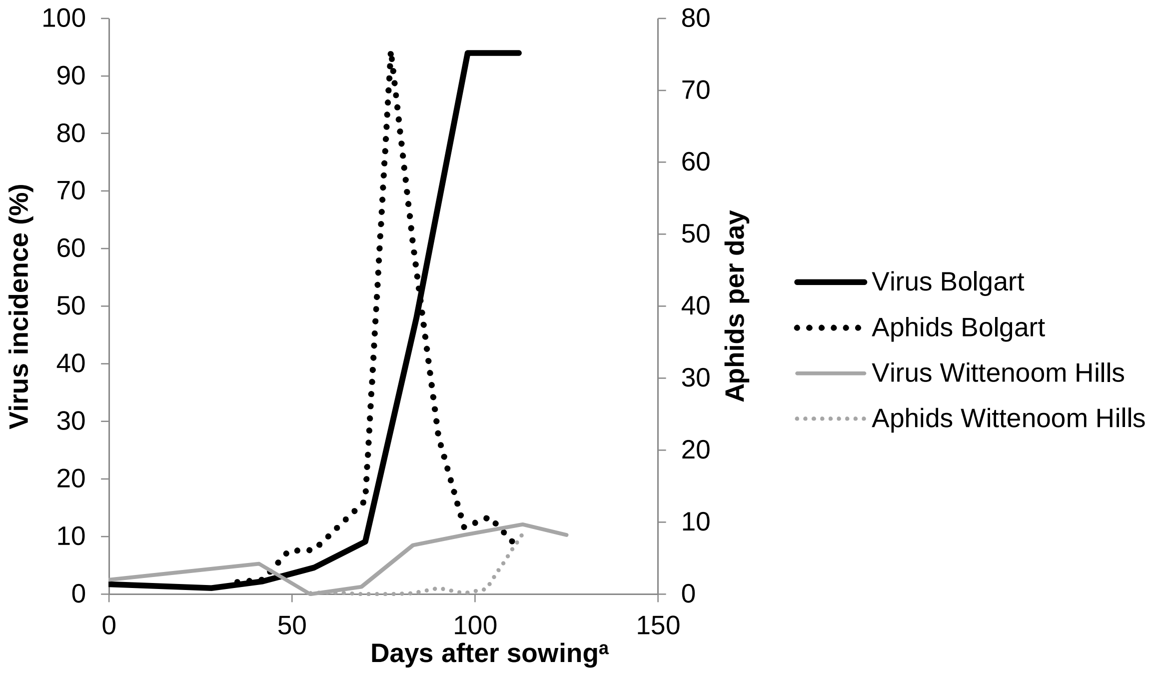

Figure 1. Comparison of virus incidence in cv. Kaspa and aphid numbers caught/day in the field pea validation blocks at Wittenoom Hills in 2011 and Bolgart in 2014.
[a] Sowing dates 30 May at Wittenoom Hills and 11 June at Bolgart

As an example, Table 2 provides rainfall data and Figure 1 compares virus spread and aphid count data from two sites each in different years. They exhibit contrasting scenarios following early growing season rainfall, Wittenoom Hills (70 km north east of Esperance) in 2011 and Bolgart (120 km north east of Perth) in 2014. In March to June in 2011, Bolgart received approximately 180 mm of rainfall while Wittenoom Hills received 68 mm. Aphid build-up in pastures, earlier sown crops and weeds was higher at Bolgart due to the earlier rains. This then led to green bridge development resulting in earlier aphid arrival in field pea blocks and high peak aphid flight numbers. In turn, this resulted in earlier of PSbMV spread and higher final incidence. The low pre growing season rainfall in Wittenoom Hills resulted in low levels of plant biomass and therefore delayed aphid arrival and lower aphid numbers earlier in the growing season. This resulted in minimal spread of PSbMV and low final incidence.

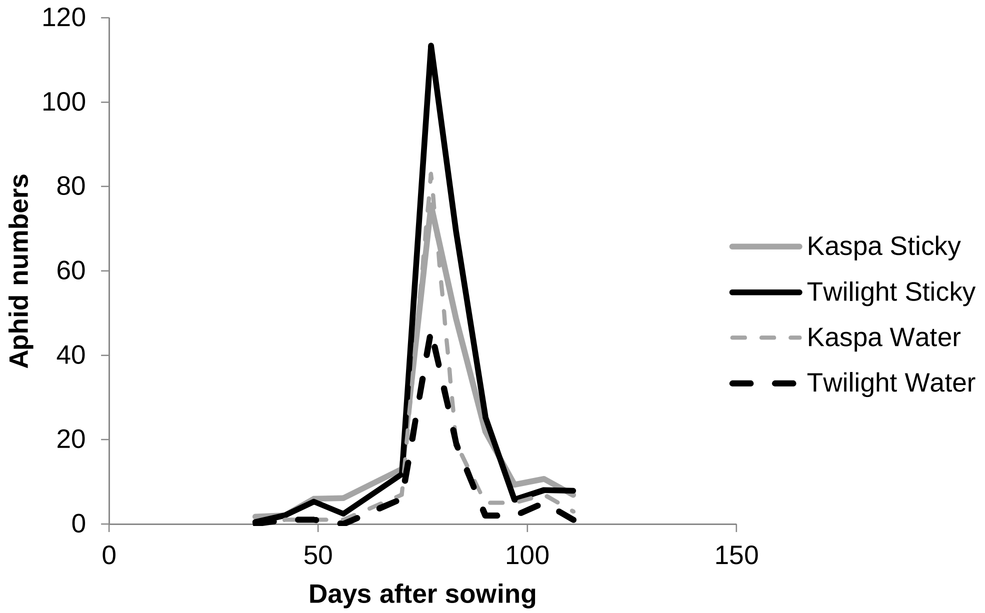

Figure 2. Comparison of water traps and yellow sticky traps in Kaspa and Twilight blocks in 2014.

Prior to the 2014 growing season only yellow sticky traps were used to count aphid numbers flying over the field pea blocks. The sticky traps monitor aphids flying through the airspace above the crop only and do not reflect actual aphid landing rates. To rectify this, in 2014 water pan traps were added to quantify and identify aphid species landing in the crop. In the Kaspa plot, the numbers of aphids caught in the water pan traps related well with the numbers on the yellow sticky traps as shown in Figure 2. This gives validity to the use of the water traps. Additionally, we managed to get good aphid species identification from the water traps. In contrast, in the Twilight plot there was a disparity between the peak aphid values between the water and sticky traps with far greater numbers caught by the sticky traps. This is most likely due to stubble cover reducing the amount of winged aphids actually landing in the Twilight block. In contrast, the absence of stubble in the Kaspa plot meant a good association between aphids flying over the block and aphids landing rates.

Conclusion

We obtained data on PSbMV spread and aphid numbers flying over field pea stands at five sites over a 5 year period. The time of aphid arrival, extent of virus spread in the crop and amount of infection in harvested seed varied widely depending on pre growing season rainfall, level of virus infection in the seed sown and field pea cultivar. Wet starts to the growing season favoured early aphid arrival and greater virus spread whereas a dry start spread favoured the opposite. Aphid and PSbMV data from these sites is currently being used to calibrate and validate a forecasting model and DSS for use by advisers and growers. Further validation blocks will be set up in the 2015 growing season.

Using reliable data to develop a user-friendly forecasting system should, wherever possible, be the cornerstone of any management approach seeking to provide advice on whether or not to deploy an IDM approach in a locality in a particular year. The model and DSS developed by this project will allow growers to not only avoid implementing control measures unnecessarily, thereby avoiding incurring expenses without obtaining benefits, but also ensure that control measures are deployed when needed.

Our economic analysis suggested that taking action based on having PSbMV forecasting model predictions could lead to field pea yield increases of 20% during epidemic conducive years with anticipated profit increases of $48/ha on average. Widespread optimal PSbMV management would generate increased grower confidence in growing field pea, thus leading to its increased adoption which could be by up to 60% in the Esperance and Great Southern Regions. This potential increase does not include rotational benefits to cereal production via improved nitrogen fixation, greater weed control options and more effective disease breaks. Moreover, the reduction in PSbMV-induced discoloured seed delivered to market could lead to a decrease in pea seed export downgrades and further increase profits by $12/ha.

Key words

Field pea, PSbMV, epidemiology, forecasting model, decision support system.

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