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Potatoes NEW ZEALAND

Technical Bulletin

Mesh crop covers for the control of tomato potato psyllid and blight

1. Key points

- Tomato potato psyllid (TPP) has caused major alteration to integrated pest management (IPM) programs and a return to high levels of insecticide use.
- 'Mesh crop covers' are a farm proven, non-chemical, pest control technology from Europe that can control a wide range of pests, both insects and vertebrates, across many field crops. Just like fly screen on a house, they are a physical barrier so stop the pest even reaching the crop. They also improve the crop microclimate.
- Research by the Future Farming Centre (FFC) has shown that mesh is highly effective at blocking TPP, and therefore also *Candidatus* Liberibacter solanacearum (CLso). Mesh also significantly increased yields in food crops, which depending on grade are up to 60% higher than agrichemicals. Field gate gross margins also increased between $4,531 to $21,110 (27% to 75%).
- Mesh has also reduced blight, sometimes dramatically, in field trials. This is currently believed to be due to mesh reducing the amount of UV light reaching the crop. However, it is unknown if the effect applies to both *Phytophthora infestans* and *Alternaria solani*. More research is required to confirm this.
- While highly effective at TPP control, aphids are able to penetrate mesh as new-born juveniles. This is believed to be the first example of a crop where aphids regularly penetrate mesh. Once inside, the mesh protects the aphids from their natural biocontrol agents, so their populations can explode. Research is required to develop a biological control solution before widespread adoption in commercial crops.
- Mesh has considerable potential for seed potato production, and is already being used by some growers. The aphid issue means that insecticides need to be used with the mesh, but, the combined effect of mesh and chemicals means the highest possible protection from insect pests and their associated diseases. The impact on other potato diseases (including contact transmitted viruses) needs further investigation. Ideally a biocontrol solution, as for food crops, would allow a reduction in chemical use which would reduce the risk of resistance developing. Further investigation is required into how seed potato certification can integrate with the use of mesh crop covers.

2. Introduction

The dominant management solution for control of tomato potato psyllid (*Bactericera cockerelli*, TPP) in potatoes has been insecticides. However, this has negatively impacted integrated pest management (IPM) programs, brings the risk of resistance, and is contrary to the industries and the consumers desire to reduce pesticide use. Since 2011, the Future Farming Centre (FFC) has been researching the use of 'mesh crop covers' for TPP control, and made the serendipitous discovery that mesh is also reducing potato blight, though it is not yet known if this is early blight (*Alternaria solani*) and/or main blight (*Phytophthora infestans*).

3. Mesh crop covers

Mesh crop covers are a crop protection technology that originated in Europe in the early 1990s. Mesh is made from woven plastic threads, similar to fishing line, made from either high density polyethylene (HDPE) or polypropylene. They are therefore exceptionally strong and durable, unlike frost cloths, especially the non-woven / spun bonded types. Growers in Europe have achieved a 15+ years lifespan.

Mesh works in the same way as fly-screen on a house, it is a physical barrier that stops the pest reaching the crop. This means that mesh can achieve exceptionally high levels of pest control in field situations. Importantly, as it does not kill pests, rather it forces them to find another food source. It does not create the same pressure for evolved resistance as with the use of agrichemicals.

Mesh crop covers have been effectively used on many field crops, the main limitation being crop height (e.g., sweetcorn). Mesh has however not previously been used in commercial potato production. Mesh works against any pest that comes into the crop from outside, i.e., is not present in the soil or on the crop at establishment. It therefore can protect against other potato pests, e.g., tuber moth.

At a whole-farm level, mesh can therefore control a very wide range of pests across many crops, thereby spreading the cost over a larger area of the farm, and allowing a reduction, even elimination, of insecticides from multiple crops, thereby better meeting customer demands, and potentially gaining premium prices for being 'spray free'.

For more information on use of mesh crop covers in commercial horticulture see http://www.bhu.org.nz/future-farming-centre/ffc/information/crop-management/production/mesh-potatoes/mesh-crop-covers-for-pest-control-in-commercial-crop-production-2017-ffc-merfield.pdf

4. Maximum mesh hole size

Field mesh covers come in a range of hole sizes for different pests, from 0.3 mm for thrips through 0.6 mm, 0.8 mm to 1.3 mm for larger insects such as root flies. Initial laboratory work tested a wide range of mesh hole sizes from 0.15 mm to 1.4 mm against adult TPP to determine the maximum hole size that would keep 100% of TPP out, which was found to be 0.64 mm, so, the standard 0.6 mm hole size mesh is completely TPP proof.

5. Field trials

Three field trials have been conducted in Canterbury, with increasing levels of sophistication. The first year was primarily to test the effect of mesh on blight, and involved simply placing pieces of mesh over a crop of potatoes (see below for the effect on blight), even so a small reduction in TPP was achieved.

The second year used two contrasting types of mesh, one with high light transmission and the other with low light transmission, against an uncovered and untreated control, with individual plots, with mesh pegged down, and managed to organic standards. A 23% increase in total yield (all tubers >1 cm dia.) of 43 t/ha and a 125% in tubers >125 g with a yield of 30 t/ha was achieved by the two mesh treatments. There was also a clear impact on tuber size with a 63% increase in mean tuber weight and a 58% increase in maximum tuber weight. The results for the two meshes were very similar, despite the large difference in light transmission, indicating light levels are not a yield limiting factor in Canterbury.

The third years trials were run under mainstream growing conditions, using three mesh sizes 0.3, 0.4 & 0.7 mm, with large plots (9 × 9) meters, with the mesh dug in as per commercial use, compared with a weekly agrichemical regime and a null control. Mesh practically eliminated TPP, a total of 12 individuals across all three mesh treatments, compared with chemicals, a total of 1,614, and the control a total of 1,250 TPP. Yield was significantly increased by mesh, with a bulk yield of 95 t/ha for the best mesh compared with 84 t/ha for agrichemicals and 75 t/ha for the control, a 12% increase over chemicals and 26% increase over the control. This also exceeded the theoretic maximum yield of potatoes in Canterbury of 90 t/ha. Mesh marketable yield for tubers >60g was 87 t/ha, and 68 t/ha for >125g tubers, a 24% and 60% increase over agrichemicals. Average tuber weight and maximum tuber weight from mesh both increased 67% over agrichemicals. Performance increased with decreasing mesh size. As mesh was cheaper on an annualised basis than sprays, and yield was higher, field gate gross margins increased between, $4,531 to $21,110 (27% to 75%) from a lower input - lower return to a higher input - higher return scenarios.

In the second and third trials temperature and humidity were recorded. Mesh caused a small increase in temperature, which equated to a significant increase in growing degree days which is taken to be part of the cause of increased yields, along with wind protection. Counter intuitively mesh caused a decrease in relative humidity (RH) above 15°C, due to the higher temperature air being able to absorb more water.

5.1. Field trial conclusions for TPP control

The results of all the field trials have shown that mesh crop covers offer close to 100% control of TPP, especially when they are dug in as per commercial use. This is also inline with the use of mesh for the control of other insect pests on other crops.

That covers prevent TPP from reaching the crop in the first place, unlike insecticides which can only kill a psyllid when it has landed and/or fed on the crop, is of particular importance, because it is not TPP that causes the main damage to potatoes, rather it is *Candidatus* Liberibacter solanacearum (CLso) that TPP transmits to the plant, that causes the damage, including zebra chip in the tubers. Insecticides therefore cannot prevent CLso infection, only reduce it, mesh in comparison can completely prevent CLso infection.

Mesh therefore is by far the most effective means of controlling TPP and CLso on potatoes, in that the level of control is as close to 100% as is practically possible, and, the potential for CLso transmission is as close to zero as possible.

As mesh also increases yield and while costing less, the potential to increase profit and crop sustainability is considerable.

For all the research reports on mesh crop covers on potatoes see http://www.bhu.org.nz/future-farming-centre/information/crop-management/crop-production/mesh-crop-covers-for-potato-blight-and-pest-control/

6. Mesh and blight control

The primary purpose of the first years trial was to assess the effect of mesh crop covers on potato blight, as it was believed that the RH would be higher under the mesh and therefore exacerbate potato blight. The result was completely contrary to expectations with a very large Reduction in blight under the mesh (Figure 1)

Figure 1. First years field trial, with complete haulm death from potato blight on the uncovered plot at the back and low levels of blight on the mesh covered plot in the foreground.

This blight reduction effect has been consistently observed in all subsequent trials (Figure 2).

Figure 2. Blight and psyllid yellows on uncovered potato haulm (top) and mesh covered haulm (bottom).

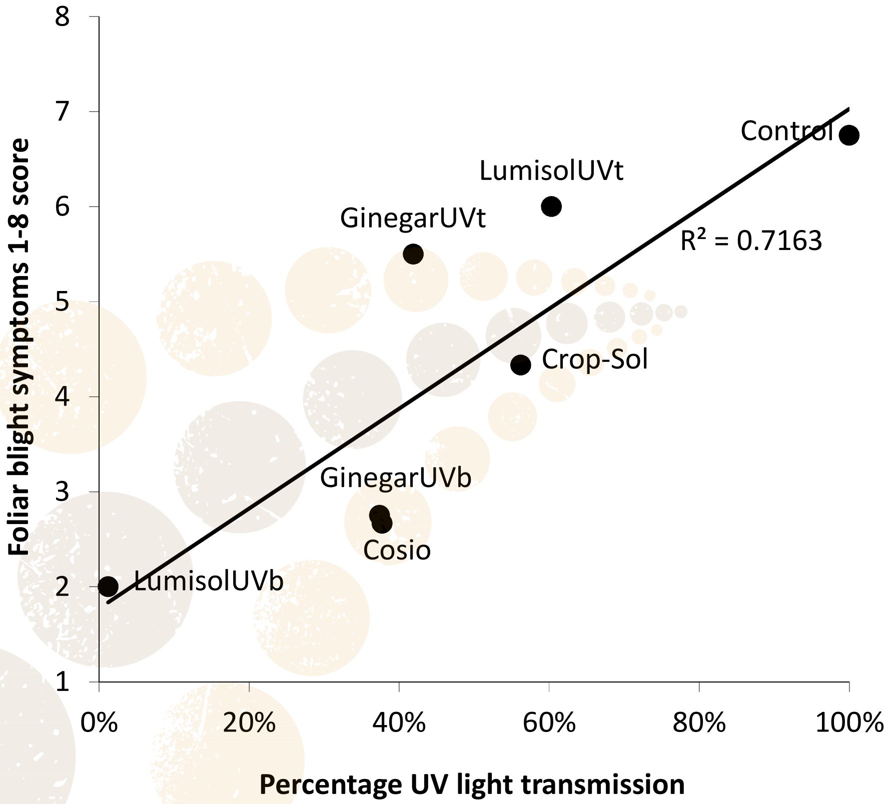

Figure 3. Relationships between UV light transmission, relative to an uncovered control with median blight severity score 1= no blight, 8 = complete haulm death.

A number of causes for the effect have been hypothesized including temperature, RH and mesh blocking spores. These have mostly been ruled out, and, it is believed that the cause is mesh reducing the amount of UV light getting to the crop. Further experiments using a range of UV blocking materials has found a clear linkage between UV light and blight (Figure 3).

However, the study only measured foliar blight, and, due to resource limitations it was not possible to determine if the blight was caused by *Phytophthora infestans* or *Alternaria solani* or both pathogens. Further research is required to confirm if the effect holds true for both species.

The report on this experiment can be downloaded from www.bhu.org.nz/future-farming-centre/information/crop-management/crop-production/mesh-crop-covers-for-potato-blight-and-pest-control/2015-16-third-year-of-mesh-trials

It was serendipitously discovered in the experiment that there was a very similar effect of reducing UV light on the occurrence of psyllid yellows. On the basis that there is a direct link between the level of psyllid yellows and psyllid populations, it appears that reduced UV light is inhibiting TPP. This has been taken as a possible explanation for why TPP does not prosper even when it gets under mesh. Other experiments have shown that eliminating UV light, causes TPP inoculated onto potato plants to leave the plant, and, that UV light traps, as used in food premises to catch flies, are exceptionally attractive to TPP in a glasshouse environment www.bhu.org.nz/future-farming-centre/ffc/information/crop-management/pests/the-use-of-uv-a-light-insect-traps-for-tpp-control-and-monitoring-in-glasshouses-final-report-2018-ffc-merfield.pdf.

7. Aphids penetrating mesh

Despite mesh being a highly effective way of controlling a wide range of insect pests on practically any field crop, aphids have infested mesh protected potato crops. This was initially put down to the mesh not being dug in and therefore 'hermetically' sealed, or, a green bridge effect in trials where haulm from the next door plot was resting on the outside of the mesh. However, in the final field trial, where mesh was dug in creating a hermetic seal, and residual herbicides were applied to the mesh edges eliminating any green bridge, aphids (mostly the green peach aphid, *Myzus persicae*) were found in all mesh plots. Further laboratory work with *M. persicae*, has shown that while adults cannot get through the mesh, if while on the mesh they produce nymphs, those are able to penetrate mesh hole sizes down to 0.15 × 0.35 mm. Once inside the mesh, the nymphs are protected from their natural enemies by the mesh, so, populations can build to high levels.

This effect has not been seen in the 25 plus years mesh has been used for crop production so it appears to be specific to potatoes, which prior to this research, mesh has never previously been used on. While 0.15 ×0.15 mm hole size mesh is aphid proof, this is well below the minimum field mesh hole size of 0.3 × 0.3 mm, as the smaller sizes are only used in glasshouse quarantine meshes, which are too expensive for field use. Further, as soon as mesh is used in the field, damage, e.g., holes, threads spreading, etc., will occur making them no longer aphid proof. Considering the huge potential of mesh for control of TPP and other potato pests, as well as its use on other crops, allowing a potentially dramatic reduction of insecticides on horticultural crops in New Zealand, it is considered vital a means of managing aphids is developed, ideally avoiding the use of insecticides. The key to this is that mesh is a form of protected cropping, such as cloches and glasshouses. There are many decades of experience in controlling aphids in glasshouses using commercially available biological control agents, such as *Aphidius colemani* and ladybirds, so it is believed that it is entirely feasible to develop a robust and economically viable biocontrol system for aphids under mesh. This would also be a valuable resource for other crops if aphids become problematic on them.

8. Mesh for seed potato production

Mesh crop covers are also considered to have considerable potential for seed potato production, and are already being used in early generation crops. The obvious problem is with aphids getting through the mesh and therefore transmitting viruses. However, as noted above, only newly born aphids can penetrate the mesh, and, as there is no maternal transmission of viruses, i.e., from mother to nymph, the juveniles that do penetrate the mesh don't carry any viruses. Laboratory experiments have also failed to find adult aphids feeding through the mesh, so this potential route for transmission looks unlikely. So, even though aphids are penetrating mesh, it appears that mesh can still prevent virus transmission, although this needs to be directly confirmed. While biological controls are being developed for under-mesh aphid management, insecticides can be sprayed through the mesh to control aphids should they get in so allowing the use of mesh for seed crops.

A key requirement for seed crops is for inspectors to be able to access the crop for inspections. It is considered quite feasible to use mesh in such a way that inspectors can still do their jobs. For smaller areas of mesh e.g., 100 - 1,000 m2 for early generation where the mesh is dug in, access zips can be sewn into mesh. For larger areas, the ends of sheets can be secured by pegs or purpose designed sand bags. These can be then lifted to permit access under the mesh. In Europe, small tractors, with slider bars for the mesh to run over, are used under larger size mesh sheets. Likewise workers can also work under mesh, wearing suitable head gear so the mesh slides over their heads as they move through the crop. There are therefore a number of options to make mesh compatible with seed potato certification, and, mesh has the potential to create much lower virus and CLso in the crops, creating even better quality seed, which will benefit the entire New Zealand potato industry.

9. Future Research

A range of additional research is required to ensure that all the issues around using mesh, both for food and seed potatoes, have been ironed out, to give growers the confidence to use mesh.

- Confirming if mesh is controlling both species of blight or only one.
- Developing an effective and economic biological control system for aphids penetrating mesh.
- Confirming compatibility with irrigation systems, particularly centre pivots which will have to track across the mesh.
- Compatibility with other crop production practises, e.g., hilling up, mechanical weed control, post emergence weed spraying, petiole analysis or soil nutrient testing, and for seed crops, roguing, test digging, purchaser company crop inspections.
- Efficacy of aphicides sprayed through mesh.
- Efficacy of post emergent herbicides sprayed through mesh.
- Impact of mesh on other potato diseases, e.g., sclerotinia, Fusarium, scab, black leg, etc.
- Ability of mesh to control other potato pests, e.g., mealy bugs, tuber moth, weevils.
- The ability of mesh to reduce virus transmission in seed crops, both aphid and mechanically vectored.
- Compatibility with seed certification practices.

Growing together