Milestone Report

Project Code: VG13075

Project Title: An investigation of low cost protective cropping

Milestone Number: 104

Milestone Due Date: 30 September 2015

Research Provider: Applied Horticultural Research

Project Leader: Gordon Rogers

Report Author: Jenny Ekman

Milestone Description: Winter field trials complete

Milestone Achievement Criteria: Results from winter field trials analysed. Summer field trials planned

This project has been funded by Horticulture Innovation Australia Limited using the vegetable levy and funds from the Australian Government.

Summary

Trials have been conducted using a number of different types of frost protection materials over winter 2015. These have demonstrated major increases in yield and quality of lettuces grown under frost protection materials in Camden and Werribee. All of the materials tested increased air and soil temperatures and raised RH around the crop. The lightest materials tested gave just as good a result as heavier, more expensive fleeces, so could represent a highly cost effective solution to cool winter temperatures and frost.

A capsicum trial in Bundaberg using the same materials is still underway, with harvest expected within the next 3 weeks.

Next steps involve extension of the results gathered so far, as well as a number of trials over summer. These will repeat and validate results obtained last summer, as well as test some new materials and technologies which have recently become available.

The hot, dry conditions forecast for this summer will enable a thorough test of the effectiveness of low cost protected cropping solutions at mitigating the effects of extreme weather events.

Milestone Achievements

Criteria 1 – Results from winter field trials analysed.

Winter trials have been conducted testing frost protection materials at three sites and with three different crops:

1. Werribee, Victoria – cos lettuce
2. Camden, NSW – babyleaf lettuce
3. Bundaberg, Qld – capsicums

Sites were selected to provide a range of different environmental conditions. A total of 6 different types of material have been tested:

1. Agryl (Crop Solutions UK)
    a. 18gsm
    b. 22gsm
    c. 30gsm
2. Groshield (NetPro)
    a. 18gsm
    b. 30gsm
3. Elders / JAG Trading
    a. 50gsm

In addition, plots were constructed with the Groshield 50gsm held off the crop. This was done to determine whether the weight of the material itself was negatively affecting plant growth.

Harvests have been conducted at Werribee and Camden: capsicums at Bundaberg are scheduled for harvest in approximately 3 weeks time from the date of this report.

All of the materials tested increased air temperatures, soil temperatures, and ambient RH around the crop. As a result, all significantly increased yield. The results for the different materials tested were similar regardless of fleece manufacturer and weight, with the exception of the Elders / Jag Trading 50gsm fleece which gave less positive results.

It is concluded that the results (collected so far) support use of frost protection fleeces for growing crops over winter. It is interesting to note that the lightest materials – which are also the cheapest – gave results just as good as the heavier grade fabrics.

A full report on the results outlining the effect of fleece materials on air and soil temperatures as well as RH, yield and crop quality is included in Appendix 1 of this report.

Criteria 2 – Summer field trials planned

Plans are underway for summer work repeating some of the trials conducted last year as well as evaluating a number of new products / technologies.

1. The effect of several different netting materials will be evaluated at Silverdale, west of Sydney. A mixed crop of chillies and capsicums will be used for this trial, and is scheduled for planting during the week of 12 October. Measurements will include determination of yield, insect damage and fruit quality.
2. A trial repeating the previous work on netting of capsicum will be set up at the end of October in Bundaberg.
3. A trial on Cravo retractable roof 'greenhouses' will also be conducted in Bundaberg. A crop of capsicums will be grown inside and outside the structure.
4. Trials on semi-permanent netting will be repeated at East Gippsland on babyleaf crops
5. Further trials on windbreaks and floating row covers will be conducted at Robinvale

Extension activities

Initial results on capsicums grown under floating net covers were presented to an agronomists meeting in Bundaberg (20 May).

A Fact Sheet has been produced on "Managing insect contaminant in processed leafy vegetables in processed leafy vegetables". This includes results from the floating row cover trials conducted last summer. A copy of this Fact Sheet is included in Appendix 2 of this report.

A series of presentations have been given nationally on managing insect contamination using floating row covers. Groups have attended these meetings in Gatton (26 August, 32 attendees), Cranbourne (11 September) and Lindenow (9 September, 15 attendees), with another scheduled for WA on 2 October (est. 15 attendees).

Outputs

- Results on capsicums have been presented in Bundaberg
- Results on floating row covers have been/will be presented at workshops in Gatton, Cranbourne, Lindenow and Wanneroo.

- A Fact Sheet has been produced on “Managing insect contaminant in processed leafy vegetables in processed leafy vegetables”. (Appendix 2)

The next steps will be to summarise and extend results of the winter trials to growers. This will be achieved through presentation at field days, production of a Fact Sheet on use of frost protection materials and online information on the trial results.

A project variation request to allow this to occur was recently approved.

Refereed Scientific Publications

Not applicable

Outcomes

Growers have been informed about the application of netting materials to prevent insect contamination of leafy vegetables. This is a big issue for growers producing packaged products, especially babyleaf crops.

The latest research supports the use of fleece materials to grow crops during winter in cooler areas. There is potential to significantly increase production using this methodology. The results of these trials will be communicated to growers, including a cost benefit analysis of use of these materials.

The Bundaberg based grower who is involved with these trials is actively investigating adoption of this method on a commercial scale. This includes either purchasing the mechanisation equipment from overseas or having a similar device constructed locally. This equipment would allow nets to be easily spread and retrieved over a large production area with minimal labour.

Intellectual Property, Commercialisation and Confidentiality

No IP, commercialisation or confidentiality issues or development to report

Issues and Risks

None to report

Other Information

No additional information to report

Appendix 1 – Winter frost protection trials

Introduction

The floating row cover trials conducted during summer 2014-2015 gave some promising results in terms of yield, protection from insects and crop quality. The insect netting materials tested had only small effects on temperature and humidity but protected the crop from sunburn and wind damage.

In winter, the main issues are not insects, but rather cold temperatures and, at times, damaging wind and rain. Frost protection materials are used widely in Europe to grow vegetables under cold conditions. The materials not only protect from frost, but also raise overall temperatures underneath the material by several degrees. They may also provide some moderate protection from adverse climatic conditions.

The aim of this trial was therefore to test a number of frost protection materials under a range of environmental conditions and different crop types. Sites were selected to provide a range of different environmental conditions. In each case the reasons for using frost protection materials were slightly different.

Werribee

While frosts can occur in Werribee during winter, the close proximity of growing areas to the sea means that temperatures rarely fall below zero. However, daytime maximums are often less than 15°C, which significantly reduces growth rates of vegetable crops. Increasing daytime temperatures and soil temperatures on average, could significantly increase growth rates over the July – September period.

Camden

Although Camden, west of Sydney in NSW, is approximately 450km further north than Werribee, minimum daily temperatures can be much lower. Unlike Werribee, the Camden site is nearly 50km from the ocean, close to the foothills of the Blue Mountains. Frosts occur regularly during winter months, occasionally falling as low as -4°C between June and September. Daytime temperatures are generally mild however, often reaching 15 − 20°C.

Bundaberg

Bundaberg is mild to warm during winter months, with conditions still suitable for growing a wide range of crops. The area is frost free, with nightly minimums rarely falling below 4°C and daytime maximum temperatures averaging around 25°C. However, for temperate/tropical vegetables such as capsicums, these conditions are marginal for production.

In Bundaberg, harvesting of the autumn capsicum crop usually finishes by mid July. While the spring crop is planted at about this time, there is a break in production between August and November. While capsicum production in Bowen covers much of this period, there is a period of several weeks when supply is short in the market. Increasing the temperature around capsicum plants could bring harvest forward. Earlier maturation, particularly if it increased the number of red fruit, could be a major benefit of using frost protection materials.

Another potential benefit is the protection afforded by frost protection materials to wind. Bundaberg is prone to strong winds and storms. Previous trials with insect netting demonstrated that protecting the plants from wind resulted in healthier looking plants with improved fruit quality.

Method

Materials

The main materials used in the trial were 18gsm and 30gsm Daltex Groshield frost protection fleece, 2.1m width, supplied by NetPro. The trial also tested a 50gsm material supplied by Elders, manufacturer unknown. This material was narrower than the Groshield, so only just covered a standard bed with little scope for securing the edges. These materials were used at all three sites.

The trial at Camden additionally tested some Agryl frost protection materials supplied by Crop Solutions UK. Only small samples of this material were available, which limited replication of these treatments. Three weights of Agryl were provided for testing; 18gsm, 22gsm and 30gsm. They therefore provided a good comparison with the Groshield materials.

Air temperature in all three trials was monitored using Hobo UX100 outdoor loggers. These were fixed to short posts placed into the centres of each treatment area. Soil temperature was also monitored, using i-buttons inserted into tubes backfilled with perlite. The tubes were buried in the ground to a depth of approximately 6cm, this being the main zone of root development.

Figure 1 - Installation of temperature loggers: A Hobo UX100 was used to monitor air temperature and RH, while an i-button buried inside a small tube monitored soil temperature (only lid visible at left, i-button at base of tube at right).

Trial layout - Werribee

In Werribee, 3 x 10m sections of each material were laid out on two seedbeds, using the plan shown in Figure 2. Beds had been newly sown with cos lettuce seedlings (Figure 3). The treatments were secured with soil around the edges of the fleece material.

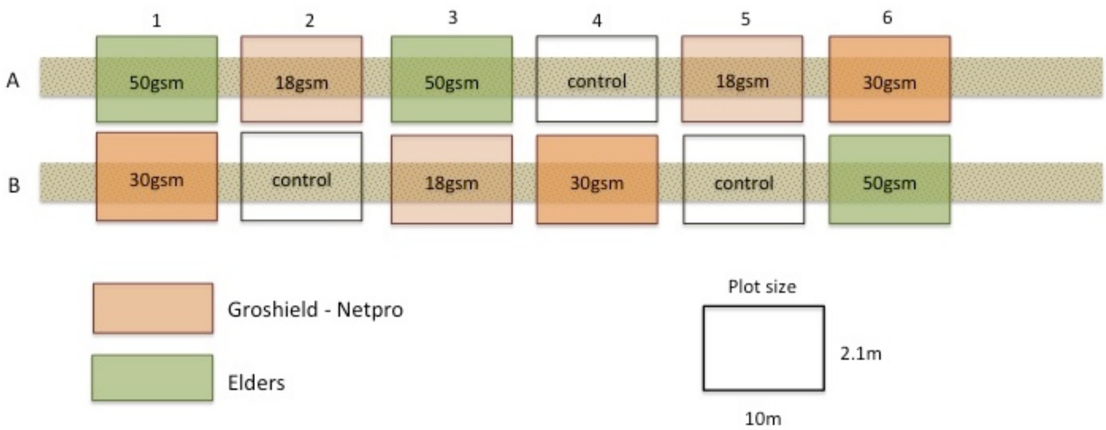

Figure 2 - Trial plan in Werribee

Figure 3 - Initial trial setup in Werribee

Bundaberg

Larger, 20m long sections of each material were tested in Bundaberg. In this case, four separate rows of capsicum were used, with uncovered buffer rows in-between those used for the trial. The fleece materials were laid out over capsicum seedlings planted approximately one week previously. As this was a winter crop, capsicums were planted in a single row, rather than a double row as is usual during warmer months. The edges were secured with soil.

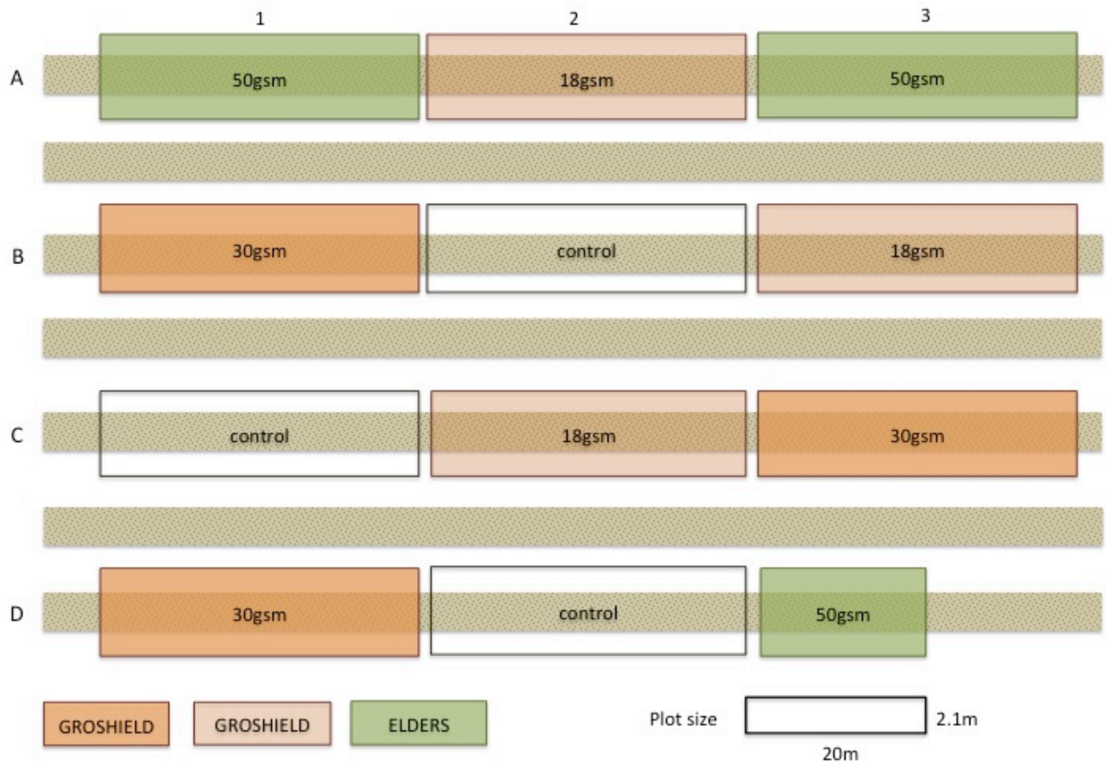

Figure 4 - Trial plan in Bundaberg

Figure 5 - Initial trial setup in Bundaberg

Camden

A total of 8 treatments were tested in Camden. One that was added to the original plan was a treatment where the fleece was lifted off the crop. This was trialed because of the previous observation that growth appeared to be improved where the material was raised the crop. In summary the treatments were:

- Uncovered control
- Agryl from Crop Solutions UK, all pieces 2.4m x 25m
    - 19gsm
    - 22gsm
    - 30gsm

- Daltex Groshield from NetPro, rolls 2.1m x 250m
    - 18gsm
    - 30gsm
    - 30gsm lifted off the crop using inverted plant pots
- Frost protection from Elders Rural Supplies Windsor
    - 50gsm

Because of the number of treatments, only two replicate plots 10m long were tested for each treatment. The fleece was laid out over beds freshly seeded with oakleaf lettuce at a density suitable for babyleaf production. The edges were secured with a combination of sandbags, soil, and metal pins.

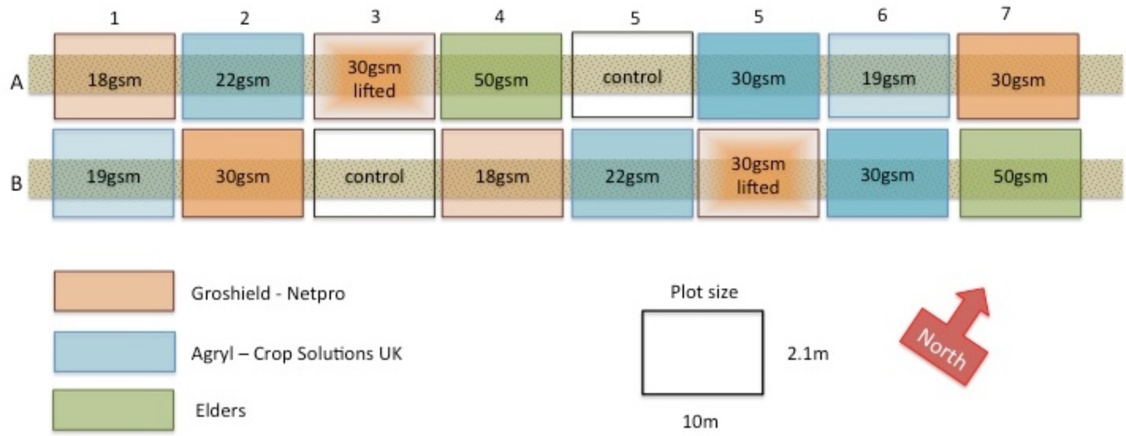

Figure 6 - Trial plan in Camden

Figure 7 - Initial trial setup in Camden

Analysis

Yield data was analysed using CoStat statistical software. The means were separated using the Student-Newman-Keuls test for statistically significant differences at a confidence level of p=0.05.

Results

NOTE : The results from these trials are not yet complete. The capsicum trial is due for harvest on around 22 October. The Werribee trial was harvested 24 September. Initial data on yield and insect numbers is presented, however shelf life and temperature analysis is not yet available. The Camden trial data is complete.

Ambient temperatures

Ambient temperatures, as measured at the nearest Bureau of Meteorology weather station, show large and significant differences between the three trial sites.

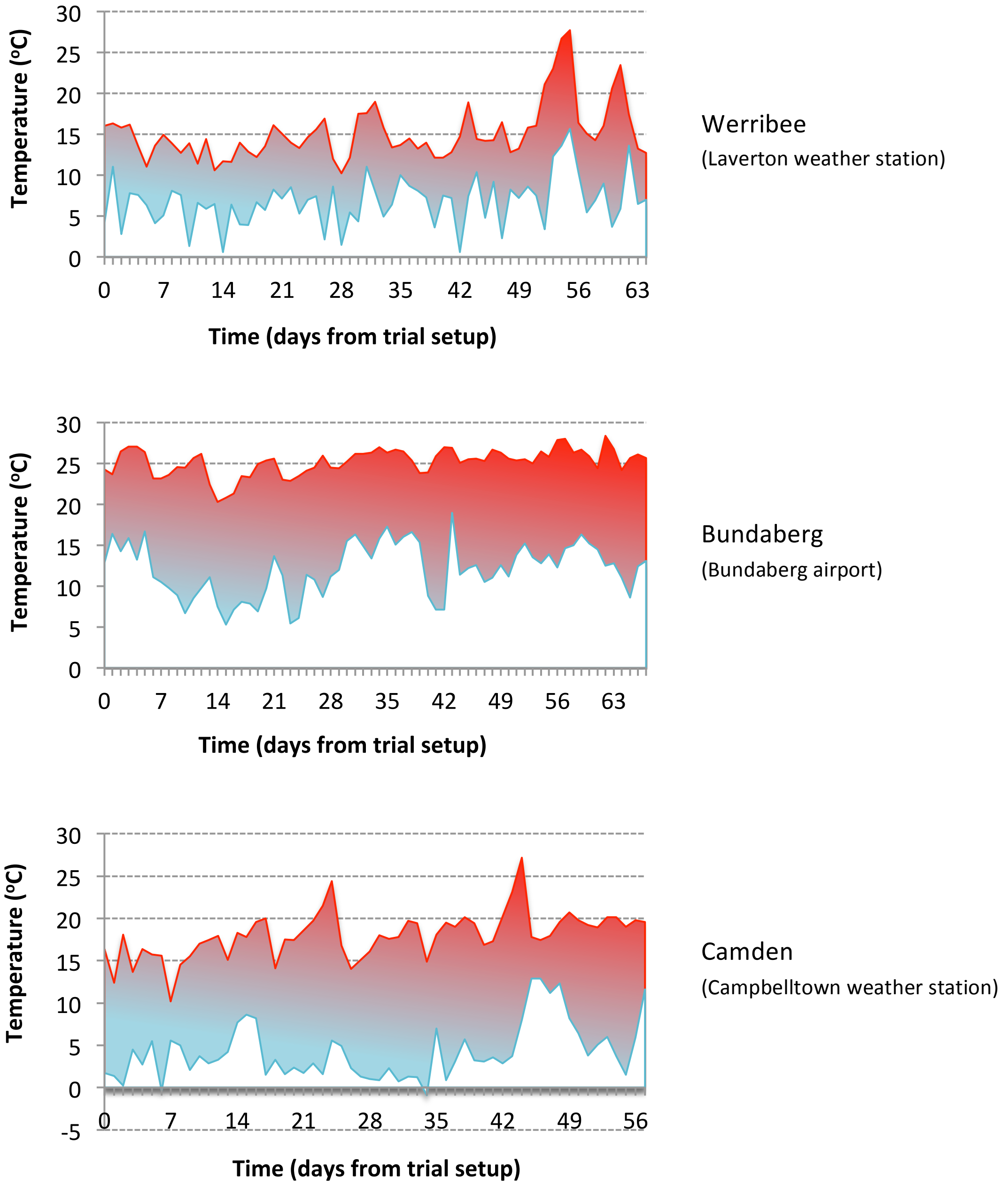

Figure 8 – Daily maximum and minimum temperatures during the trial period for each of the three sites, as recorded by the local Bureau of Meteorology weather station

During the trial period a number of frosts were experienced at the Camden site, two light frosts at Werribee and none in Bundaberg. As expected, daily maximum temperatures were higher in Camden than in Werribee, even though night time minimums were lower. Bundaberg temperatures were significantly higher than either, although temperatures approaching 5°C were experienced twice.

Yield - Werribee

Well before harvest, there were clear differences between the lettuce grown under the fleece and those left unprotected. Yield of lettuce was significantly increased for the lettuces protected by either 18gsm or 30gsm Groshield compared to those left unprotected (Figure 10, Table 1). The lettuces grown under the 50gsm material were intermediate. It was noted that some of the lettuces grown under this material appeared to have been damaged by the material. Some of the 50gsm material came loose during the trial, due to being fractionally too narrow for the beds. This fleece had to be removed two weeks prior to harvest, as it could no longer be secured without crushing the lettuces underneath.

Figure 9 - Size differences in cos lettuce grown without and with fleece protection materials in Werribee during winter months.

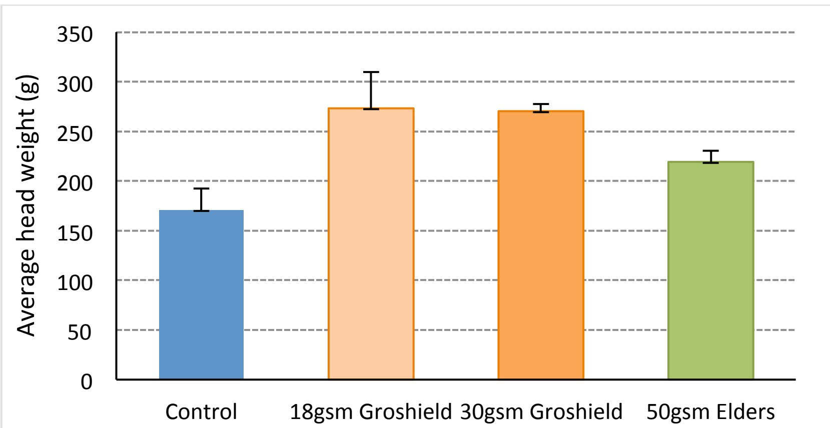

Figure 10 - Average weight of lettuces grown in Werribee during winter 2015 and left uncovered, covered with 18 or 30gsm Groshield or covered with 50gsm frost protection material. Bars indicate the standard deviation of each mean value (n=3).

Table 1 - Average weights of lettuces grown in Werribee under different frost protection materials. Letters indicate means that are statistically different (p<0.01)

Treatment	Weight (g)	
Control	171.6	a
18gsm Groshield	273.3	c
30gsm Groshield	270.7	c
50gsm Elders	215.4	b

One issue experienced during the trial was loss of lettuces due to 'bottom rot' (*Rhizoctonia solani*). This appeared to increase under the 50gsm covers; one of the three replicate plots was not assessed due to extensive collapse of the lettuces underneath. Incidence was similar in the uncovered controls and the plots with Groshield.

The lettuces appeared paler under the fleece materials, particularly the 50gsm material. There was also some damage noted under all of the fleece materials where the covers had restricted crop growth. Loosening the covers more than once during crop growth may have avoided this damage, although over-loosening may also increase wind rub from flapping material.

Yield - Camden

Even a week after seeding, differences started to appear between the covered and uncovered plots.

Figure 11 - Growth of lettuces in the open compared to under fleece, one week after seeding (left) and at initial harvest (right). Poor germination and stunted growth can be seen in the lettuces left uncovered at the front of the picture, compared to the lush growth of those under the fleece (right)

Two harvests were conducted at Camden, at eight and ten weeks after seeding. The first was when the larger plants were just reaching commercial maturity. The covers were removed at this time. A second harvest was conducted two weeks later. This allowed further rapid growth in all treatments, particularly the controls, which were clearly undersize at harvest 1. Some plants were slightly overmature at this stage.

Harvests were conducted using four 30x30cm quadrats within each plot. As growth varied between the north and south sides of each bed, and was sometimes reduced at the centre, the four samples were taken in a diagonal pattern across the bed. The samples from harvest 1 were assessed for total weight, and shelf life was monitored over two weeks at 5°C. At harvest 2 only yield was recorded.


Figure 12 - Harvesting lettuce from the Camden site

The uncovered lettuce were extremely small at harvest 1. Germination in these plots was uneven, and the lettuces themselves appeared stunted. After a further two weeks (harvest 2), they were approximately the same size as the lettuces in treated plots at harvest 1, indicating that the fleece treatments brought harvest forward by approximately 2 weeks.

However, during this two week period, lettuces in the plots covered with fleece approximately tripled in size. Sunny conditions, regularly reaching 20°C during the day, undoubtedly assisted this rapid growth.

The fleece treatments were all approximately similar, with the exception of the 50gsm material. As noted in Werribee, this material had some negative impacts on growth, likely due to being too heavy for the plants underneath. Even after the material was removed, these plants failed to fully recover and catch up with those protected using lighter materials.

Lifting the fleece off the plants appeared to have some benefits, although these plots were very patchy according to the high and low points of the material. Results from the Agryl and Groshield were statistically similar, although a trend to increased growth under the Agryl may be observed. There appeared to be no benefits in using heavier weight materials: the lightest (and cheapest) of the materials tested gave the best results overall.

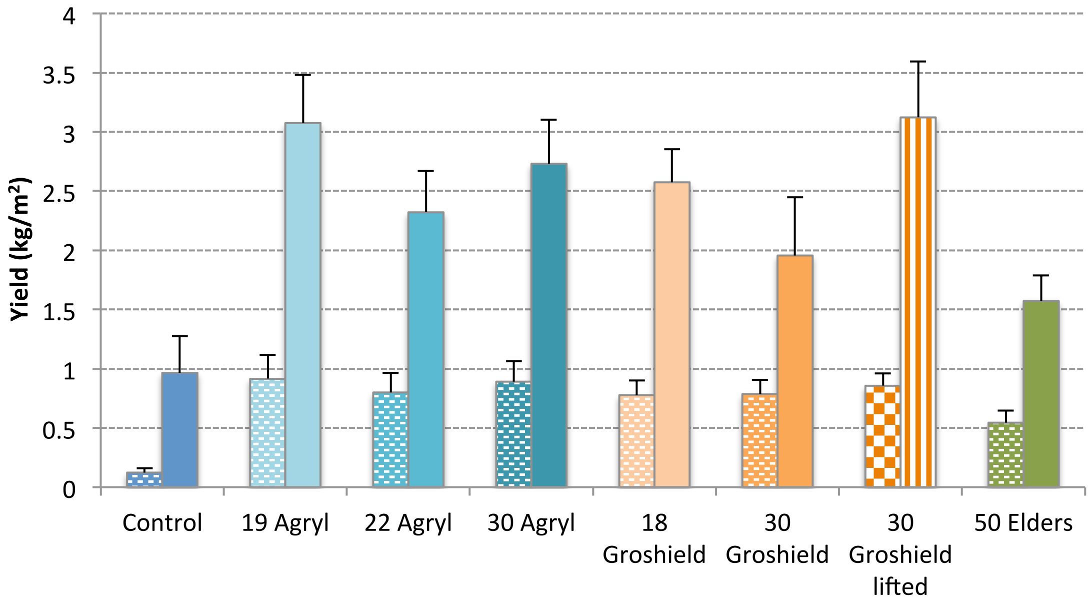

Figure 13 - Yields from an initial and second harvest at Camden, harvests conducted two weeks apart using different sections of the bed. Bars indicate the standard error of each mean value (n=8)

Yield from the control plots was significantly lower than that from all the other treatments at harvest 1, and significantly lower than all except the 50gsm treatment at harvest 2 ($p<0.01$) (Table 2). Stored samples were assessed subjectively after 1 and 2 weeks at 5°C. After 1 week the control was significantly lower quality than the other samples ($p=0.01$), however after 2 weeks all samples were considered unacceptable quality.

Table 2 - Yields from an initial (harvest 1) and second (harvest 2) harvest at Camden, harvests conducted two weeks apart. Letters indicate means which are statistically different ($p<0.01$)

Treatment	Harvest 1 yield		Harvest 2 yield	
Control	11.1	a	87.0	a
19gsm Agryl	82.4	b	277.0	c
22gsm Agryl	72.0	b	209.1	bc
30gsm Agryl	80.3	b	246.0	bc
18gsm Groshield	64.6	b	232.0	bc
30gsm Groshield	70.9	b	230.8	bc
30gsm Groshield lifted	77.2	b	281.3	c
50gsm Elders	49.1	b	141.6	ab

Insects - Werribee

Insect populations were assessed by vacuuming 24 lettuces per plot.

Insect numbers were generally low, as could be expected during winter. Significant vegetable weevil larvae damage was noted in two plots (30gsm and 50gsm frost protection), although no actual larvae were found. It is possible that reduced penetration of insecticides and/or warmer conditions under the fleece might favour insects emerging from soil underneath the covers.

In total, 41 pest insects were recovered from the control plots, compared to 3, 16 and 0 insects from the 18gsm, 30gsm and 50gsm treatments respectively. Most of these were aphids, as well as small numbers of Rutherglen bug and leafhoppers.

Insects - Camden

Insect populations were assessed by vacuuming a strip in the centre of each plot.

Insect numbers were very low, averaging less than 6 insects/plot for all of the lettuces covered by the frost protection fleeces. Higher numbers were found in the control, which averaged 25 insects/plot. Green leaf hoppers were the dominant pest, particularly in the controls. Brown sowthistle aphids and thrips were found in all treatments, although in lower numbers under the frost protection materials.

Temperature and humidity data - Camden

All of the fleeces increased temperature and humidity compared to the uncovered control plots. This increase was 2-3°C overall. However, the amount that the fleece materials raised the temperature was not equal across the temperature range, being greatest at low temperatures and once ambient temperature increased to 20°C or more.

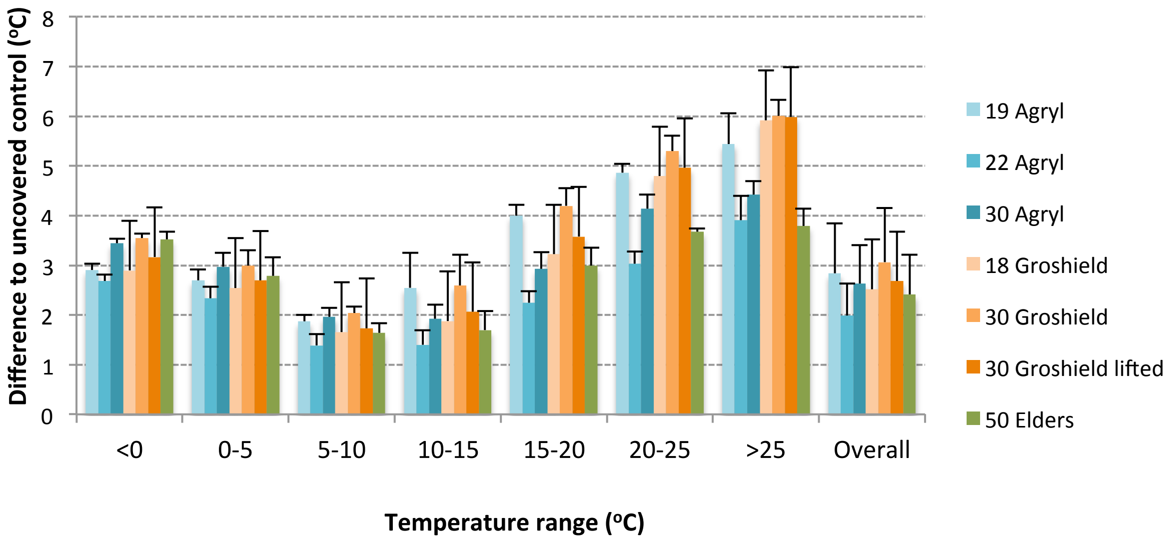

Figure 14 - Difference in air temperature between the uncovered control and different types of fleeces, for temperatures recorded in 5°C bands. Bars indicate the standard deviation of each mean value.

Perhaps surprisingly, the weight of material made little difference to the resulting increase in temperature.

As with temperature, all of the fleece materials tested increased RH around the plants. This increase was greatest (although highly variable) when ambient RH was low (<70%). Overall, all of the fleece materials increased RH by around 5-15%.

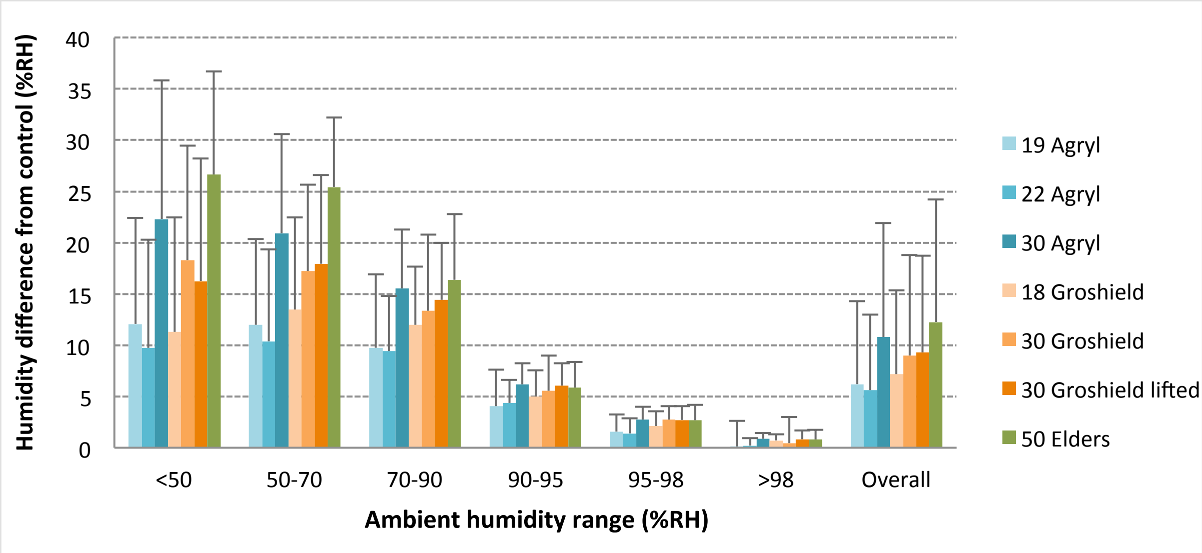

Figure 15 - Difference in relative humidity (RH) between the uncovered control and different types of fleeces, for Rh values recorded in different bands. Bars indicate the standard deviation of each mean value.

Soil temperatures were also elevated by all of the fleece covers. Soil temperatures generally increased by 2°C on average, regardless of fleece type or weight. The greatest increases occurred when soils were cold, being below 8°C. The exception occurred once ambient soil temperatures increased to 20° or more. Under these conditions, the soil remained slightly cooler under the fleece, although this difference is unlikely to be statistically significant.

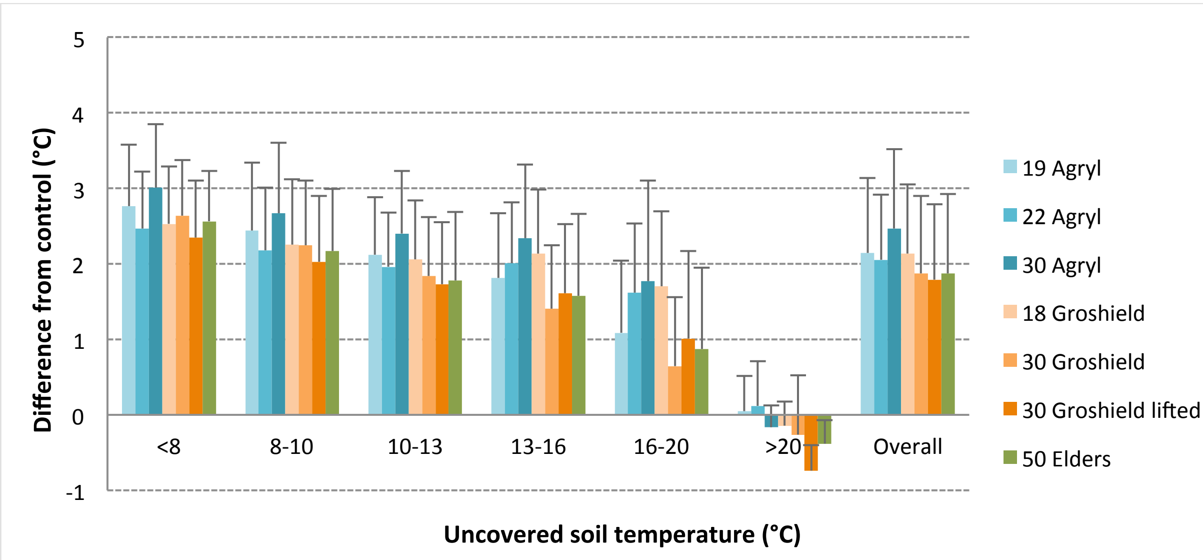

Figure 16 - Difference in soil temperature between the uncovered control and different types of fleeces, for temperatures recorded in 2-4°C bands. Bars indicate the standard deviation of each mean value.

Conclusions **(as at September 30, 2015)**

The fleece materials tested all increased yield of lettuces grown over winter. The fleeces significantly increased both air temperature and soil temperature, and slightly raised humidity around the crop. They also reduced the number of insects within the crop, which could affect both crop damage and contamination of packed product.

There were few differences noted between the materials, with the exception of the 50gsm fleece, which gave less positive results. It is notable that the lightest materials – which are also the cheapest – gave just as good a result (if not better) as heavier fabrics.

As not all of the results are in it is not possible to make firm recommendations as to the use of fleeces. However, it appears that the best strategy may be to use these materials over winter until air temperatures increase to a regular daytime maximum of approximately 20°C. After this time they may be removed to allow the crop to 'harden up' and possibly develop a richer colour.