# The production of baby-leaf lettuce under floating crop covers

Robert Munton
Britton Produce

Project Number: VG09188

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This report is published by Horticulture Australia Ltd to pass on information concerning horticultural research and development undertaken for the vegetables industry.

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HAL
Horticulture Australia

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## The production of baby-leaf lettuce under floating crop covers

**Milestone No** 190

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**Details**

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**Report Purpose Statement**

The purpose of this report is to collate and examine all the information gathered over the life of this project and provide industry with insights into the validation under Australian growing conditions of a cost effective protected growing system for the commercial production of baby-leaf lettuce.

**Acknowledgments**

Britton Produce Pty Ltd

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Australia

cropsolutions ...quality crop covers

one harvest

HAL Know-how for Horticulture™

17 May 2013

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# Media Summary

## The key components of the project

- Systematic Trials of floating Crop Covers for the field production of baby-leaf salad crops
    - The project demonstrated a crop cover system designed to deliver benefits over open field salad crops and rigid frame protection systems.
    - Expected key benefits were expected to include:
        - Protection from insect infestation without chemical pesticides
        - Reduction of irrigation water requirements, through lower evaporative losses.
        - Lower costs compared to traditional frame mounted overhead nets, plastic or glass
- A Final Report supplied to HAL

## What is the industry significance of the project?

- The fresh-cut and ready-to-eat salad processing industry is the major vector for salad consumption growth in Australia
- The industry seasonally experiences unacceptable levels of foreign body customer complaints, the vast majority of which are categorised as insect contamination
- The objective of this project was to gather data around the benefits and limitations of using floating crop covers to determine whether they were an effective means of reducing insect populations in field grown crops
- The project would further explore other potential crop production benefits

## Key outcomes & conclusions

- Floating crop covers are highly effective at reducing insect infestation and insect damage in field grown baby-leaf salad crops and insect population reductions of 89% have been demonstrated
- Floating crop covers provide further benefits of excluding most wind-borne foreign body contamination, reduce ground moisture loss, provide a level of protection from weather induced damage, and reduce the length of growth cycles during cooler winter and shoulder seasons

## Recommendations for future R&D

- This project was confined to a single product group (baby-leaf salads) and a single horticultural region (south Queensland Granite Belt)
- It is recommended that the systematic trial of floating crop covers is extended to all leafy salad crops including head lettuce

- It is recommended that the systematic trial of floating crop covers is extended to other horticultural row crops

## *Recommendations for practical application to industry*

- It is recommended that the application of floating crop covers is extended to all significant baby-leaf salad growing regions

# Technical Summary

## *The nature of the problem*

- Field grown salad crops are exposed to environmental pressures that potentially cause stress, damage and insect infestation from time to time
- The modern consumer and retailer demand safe leafy salads that are free from contamination and blemish
- It was postulated that the physically protective environment provided by enclosing the crop in a fine weave lightweight crop cover may reduce some of these pressures in a cost effective manner

## *Brief description of the science undertaken*

### Science and Technology Evaluation

- A wide range of commercially available crop covers were sourced locally and internationally and small scale comparative trials were carried out in the same location
- The performance of the different covers were initially compared and measured against unprotected controls over a 12 month season to determine their relative ratings against typical assessment criteria determined by the processor and the grower
    - These criteria included leaf rub, bruising, number of insects present, physical damage, insect damage and harvest yield
- The two "best performing" crop covers were selected for larger scale commercial plantings

### Major research findings and industry outcomes

- The optimum crop covers can reduce harvested baby-leaf salad insect loads by 89%, or better
- Chemical spray applications are reduced by at least 50% during a typical crop cycle
- Wind-borne foreign body contamination is reduced to 0% for baby-leaf salads grown under floating crop covers
- The general quality, strength and shelf-life of baby-leaf salad grown under floating crop covers, as measured by a leading fresh-cut salad processor, are indistinguishable from unprotected leaf
- In the test region (Queensland's Granite Belt) crop growing times were show to be reduced by up to 20% during the cooler ambient periods
- Soil moisture levels are better retained during drier periods than unprotected crops and require less irrigation
- The same section of crop cover can be used repeatedly over and over so purchase costs can be amortised over multiple seasons

## *Recommendations to industry, research peers and HAL*

- Floating crop covers provide multiple advantages to foreign body reduction and their application over multiple geographic locations and salad crops should be validated

## *Contribution to new technology and any future work suggested*

- This project has added insights into how sensitive baby-leaf salad crops can be grown with enhanced protection against environmental impacts in a cost effective manner
- This technology should now be evaluated across multiple crop types and regional areas

## BACKGROUND

*[Image 1 – root crops under floating crop covers in East Anglia UK]*

Floating crop covers provide a physical barrier that protects leafy salad vegetables from insects and wind-blown contamination.

Floating crop covers do not require expensive and inflexible rigid support frames, are easy to apply and remove, and provide a very cost effective alternative to traditional protection methods.

The quality of commercially available crop covers is highly variable and is determined by the specification of the materials and the manufacturing process used. High quality covers are produced on modern weaving looms in a process similar to fabric manufacturing. High quality covers can be used again and again so the investment can be expensed over multiple seasons. Some of the covers first used in the UK over 10 years ago are still in use today.

- Pest Protection
    - An impenetrable physical barrier against:
        - Insects, frogs & snails
        - Birds & feral animals
        - Wind-blown contaminants (leaves, pine needles, etc.)

- Climate Protection (micro-climate)
  - Night soil temperatures increased by up to $3^0$C. (= improved growth rates)
  - Peak summer day temperatures are reduced by up to $3^0$C.
  - Protection from sunburn, wind, rain & hail
  - Improved moisture retention (water use reduced by 30-50%)

Modern floating crop covers were invented and developed during the late 1990's by vegetable farmer, Ian Campbell of Perth Scotland. Ian was a major grower of the root vegetable, Swede.

UK grown Swede is susceptible to attack by cabbage root fly, particularly in the late spring and early summer. The fly lays eggs on the leaves of the growing plant, and the emerging white headless larvae, up to 9mm long, move down the stem of the developing plant and into the edible root region, where their burrowing causes plant death or visible damage to the root sufficient to render it unmarketable. A broadening restriction of the use of effective pesticides encouraged Ian to experiment with a variety of net and cover products that were generally available in the market place. His experimentation led to the development of a highly specific woven net that closely resembles the products commercially available today.

Ian founded a business called Wondermesh to market floating crop covers to fellow growers. A few years later he separated from Wondermesh and founded the Perth Scotland based business Crop Solutions Ltd (CSL). CSL is now the market leader in Europe for the supply of floating crop covers. They further offer a wide range of products including thermal fleece, insect net, bird net, mulch, ground cover and equipment for the laying and retrieving of floating crop covers.

Floating crop covers fall into two primary categories, fleece and net.

- **FLEECE:**
  - Fleece is a hot blown product made from polypropylene. It exhibits a high absorbency and is designed principally for a single use, although some operators are now achieving 2 years use. Fleece raises trapped air and soil temperatures by $3^0$ to $4^0$C.
  - Whole head Cos and Iceberg lettuce grown under fleece in the UK is producing recovered head weights of 80g higher compared to unprotected crops which is attributed to increased growth rates and cleaner product at harvesting.
- **NET:**
  - Net is a woven high density polyethylene product (HDPE) and is designed for multiple uses over consecutive seasons. It is manufactured on fabric style looms. Whilst some woven nets can be sourced from Asia, these are generally of inferior quality. The best quality products are typically produced in Europe where modern technology looms are used.
  - Thermal net (very fine net) is a new developed hybrid product that raises trapped air and soil temperatures by $2^0$ to $3^0$C. It provides similar thermal insulation properties as fleece whilst the enhanced

durability properties of its structure enable multiple re-use in the same manner of a net

- Crop Solutions have developed proprietary specifications for materials and designs used in net production
- Inferior products stretch and deform across the weave, and seams are liable to deform. These unwelcome properties drastically reduce the effectiveness and longevity of the cover as target insects can readily enter where the mesh size has been distorted and enlarged by stretching. The inferior quality covers are also difficult to lay and retrieve as the long retrieved rolls become similarly distorted

# Early Work

Coin Britton, research provider to this project, began experimenting with crop covers around 7 years ago. He encountered the application of floating crop covers whilst travelling in Europe and upon return to Queensland commenced limited trials using locally sourced shade-cloth and hail net to investigate what benefits could be derived.

In 2009 Colin installed a supported and enclosed canopy of hail-net at his Thulimbah farm on Queensland Granite Belt. This 5 metre high structure allowed the access of heavy farm machinery and enclosed 1 ha of crop. However the cost of this structure was prohibitive (around $45,000 for 1ha of cover), and the structure also proved to be susceptible to damage when a large section of the structure was destroyed under the weight of a hailstorm in early 2010.

The early experimentation led Colin to believe that significant benefits could be derived from the proper application of crop protection. The relatively inexpensive crop covers seemed to offer a low capital cost solution. However when faced with a plethora of suppliers and different crop cover types it became clear that a methodical, analytical approach was required to study the benefits and limitations of the various types of cover available.

# Crop Covers in Europe

During the duration of this project the author visited the UK and Europe on multiple occasions, meeting with suppliers and users of floating crop covers.

Whilst this was not officially part of this project the information acquired is helpful to the reader in their understanding of the adoption of crop covers.

A note form summary of this information is attached as Appendix 6.

## *Introduction*

This Project was designed to investigate and report on the following aspects of floating crop covers:

1. To specify the optimum covers for spinach
2. To validate a mechanical method for the laying and retrieval of the covers
3. To provide an account of the benefits and constraints of adopting floating crop covers

   a. Demonstrate (or otherwise)
      i. Protection from insect infestation
      ii. Protection from windborne contamination (leaves, twigs, paper, etc.)
      iii. A reduction of irrigation water requirements
      iv. A lower installation cost than traditional frame mounted overhead netting
      v. Protection from the ingress of wild birds
      vi. Protection from the ingress of native and feral animals including frogs
      vii. Protection from seasonal hail
      viii. Creation of micro-climates
         1. enhanced quality and reduced variability of crop
         2. enhanced seed germination rates and time
         3. a shortening of growth cycle
         4. extension of the growing season (both early & late season)
         5. frost protection
      ix. reduction of pesticide use
4. Performance comparison of Chinese v. European sourced crop covers
5. Efficacy of overhead spraying through the crop covers
6. Growth cycles, yields and general quality assessments of the harvest product
7. Methods for securing the crop covers:
   a. Tri Pegs, Standard Pegs & Roundhead Peg
   b. Sand bag tubes
   c. Heaped soil mechanically positioned by rotary discs along the cover edges
8. Validate a sanitation process for retrieved crop cover
9. Shelf-life assessment by a fresh-cut Processor
10. Validate the technology for baby-leaf crops other than spinach
11. Demonstrate that the project can be scaled up to a commercial scale and that significant financial, quality, risk and food safety benefits can be demonstrated
12. Conduct an On-farm field day.

## *Materials & Methods*

Britton Produce partnered with the following business during this project to assist in the validation of the technology

1. Crop Solutions Limited (UK)

*[Image 2 & 3 – large areas under covers]*

## Phase 1 Trial Methodology

The initial trials comprised of four crop cover variants sourced from Crop Solutions Limited of Scotland and three variants sourced from Net-Pro of Stanthorpe. The variants trialled were identified by their suppliers as follows:

1. 0.8 Flea-beetle net
2. 0.6 Aphid net
3. 16 x 16
4. Agryl 19 Thermal Crop Cover
5. Frost Cover
6. Net-G
7. Net-R

This trial was designed to identify and short-list the two most promising crop covers that could later be assessed in larger scale commercial trials. Short lengths of 20m x 7m were manually placed over sections of a tat-soi baby-leaf crop that had all been sown on the same day in the same location.

The results of Preliminary Trial #1 are summarised below.

| | | | | | 1=minor; 5=severe | | | | | 1=wet; 5=dry |
|---|---|---|---|---|---|---|---|---|---|---|
| **Net Variant** | **Variety** | **Plant date** | **Harvest date** | **Yield/m in kg** | **Leaf Rub (1-5)** | **Bruising (1-5)** | **Insects Present** | **Physical damage (%)** | **Insect damage (%)** | **Visible Moisture Bed (1-5)** |
| **1. - 0.8 Flea-beetle net** | Tatsoi | 8-3-11 | 5-4-11 | 2.890 | 1 | 1 | 0 | 1 % | 1 % | 3 |
| **2. - 0.6 Aphid net** | Tatsoi | 8-3-11 | 5-4-11 | 4.244 | 1 | 1 | 0 | <1% | <1% | 3 |
| **3. - 16 x 16** | Tatsoi | 8-3-11 | 5-4-11 | 3.668 | 2 | 1 | 0 | 0% | 2% | 4 |
| **4. - Agryl 19 Thermal Crop Cover** | Tatsoi | 8-3-11 | 5-4-11 | 1.764 | 4 | 1 | 0 | 1% | <1% | 1 |
| **5. - Frost Cover** | Tatsoi | 8-3-11 | 5-4-11 | 1.005 | 3 | 1 | 0 | 1% | <1% | 1 |
| **6. - Net-G** | Tatsoi | 8-3-11 | 5-4-11 | 1.637 | 2 | 1 | 0 | 0% | 16.6% | 4 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **7. - Net-R** | Tatsoi | 8-3-11 | 5-4-11 | 2.670 | 3 | 1 | 0 | 3% | 27% | 1 |
| **Control** | Tatsoi | 8-3-11 | 5-4-11 | 4.418 | 1 | 1 | 0 | 3% | 57% | 5 |

These trials were all located in the same block and bed preparation and seeding was undertaken as a single operation with the covers being manually placed over the trial beds.

Whilst there was obvious variance in the results the relative degree of insect damage and moisture retention was considered to be the most significant for the project.

It was noted that temperatures were un-seasonally cool, and that cloud-cover was un-seasonally high. The rainfall during initial trials was noted as high with 150mm recorded on one single day.

Twelve months of trials were completed and the preliminary benefits and limitations of each type of nine different crop covers were determined. This information was used to select the crop cover types nominated for the next stage scaled-up trials using crop cover lengths of 200 metre x 7 metre.

The primary top-level objectives of the project were to:

1. Demonstrate the effectiveness of the crop covers to provide protection from insects

2. Demonstrate whether crop covers were effective in retaining moisture and reducing irrigation water requirements

Chart 1 below – "Insect Protection v. Cover Induced Damage" summarises the effectiveness of different crop covers at reducing insect populations in baby-leaf crops. These results are averaged over the duration of the trials and represent results from multiple trials. No insecticides were applied to the trial and control blocks.

The effective insect screening properties of the crop covers were determined by observing a secondary measure of insect damage on the leaf after harvesting. Insect populations were observed to vary through the growing cycle, and the unprotected control blocks provided no restriction to movement. The insects came and infested the crop and sometimes left again. It was therefore decided that the observed physical insect damage was a more relevant measure of the insect population over the growth cycle of the crop than the count of insect numbers taken at the single point of time of harvest. The visible insect damage was determined by taking a representative sample from each trial and comparing this with the control block.

A secondary observed effect was that some crop covers caused physical damage (leaf-rub) to delicate baby-leaf in windy conditions. It was therefore decided to use the combined indicators of insect damage and leaf-rub as a primary selector for determining the most suitable Covers for advancing to Phase 2 trials.

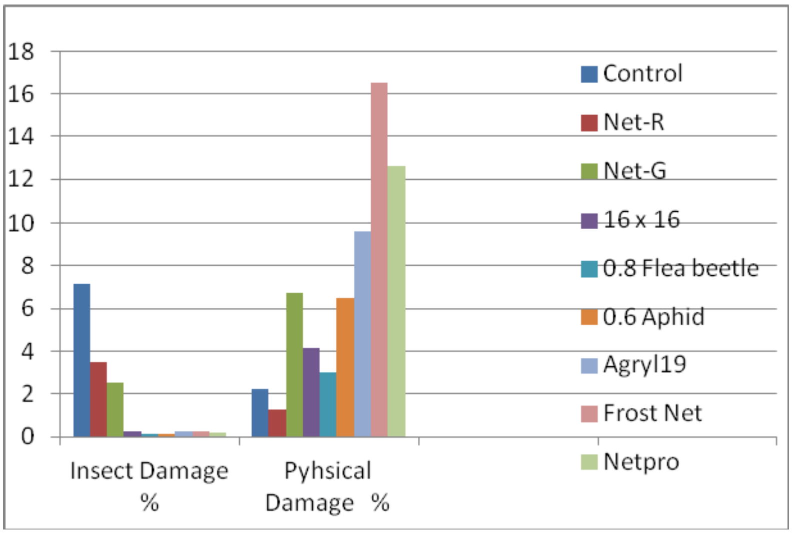



**Chart 1-Insect Protection v. Cover Induced Damage**

The averaged data recorded over the first stage of trials recorded insect damage under the Covers 0.8 Flea Beetle, 0.6 Aphid, 16x16, Agryl19, Frost Net and Netpro at about 0.25% compared to the unprotected control of 7%. However, most of this data was collected over the winter and cool spring period when there were very few insects present in the environment. Individual trials recorded insect damage on the Control as high as 57% compared to 0% under the Covers 0.8 Flea Beetle, 0.6 Aphid, 16x16, Agryl19, Frost Net and Netpro.

The Phase 1 trials were undertaken using relatively short 20 metre lengths of cover and the covers were retained using pegs supplied by the Crop Covers Ltd. Tearing of the covers, particularly around the securing peg, was observed in many trials. Conversations with the UK supplier have revealed that European growers are now using sands bags placed along the perimeter of the netting to overcome this problem. It is also reported from the UK that the sand bag retention of netting reduces leaf-rub as the net is held in place more firmly which in turn reduces flapping and friction with the leaf during windy conditions.

The Crop Solutions Ltd supplied covers identified as 16x16mm, 0.8 Flea Beetle, and 0.6 Aphid covers provided good protection from insects whilst causing relatively low levels of leaf rub. These nets were robust and were suitable for multiple re-use. In comparison, Agryl19, Frost Net and Netpro were easily torn by the securing pegs and were expected to have a relatively short life in Australian conditions. The ability to re-use the nets over multiple crops is critical to providing a cost effective solution.

Phase 1 was unable to demonstrate the water retention properties of the nets as excessive and regular rainfall prevented the soil from drying out. However, the unprotected control block soil was visibly observed to lose moisture more rapidly.

It was also observed that during wet conditions the very close weave nets restricted air movement under the Cover.

The initial Phase 1 trials provided the data for the later commercial scale phases of the project. Two crop covers were selected for the scaled up trials. These were 0.8 mm Flea-Beetle net and a 16 x 16 net, both sourced from Crop Solutions Limited UK. Extended trials were conducted over more than a full year with 200 metre lengths of protected baby-leaf (mainly baby spinach) planted at one month intervals. Each trial crop was monitored, assessed, harvested and inspected for performance. Field and ambient data from under the net was collected by an automatic weather station and compared to the unprotected control plantings throughout the trials.

The results of the project are summarised below.

## *Project Results*

1. **Specify the optimum covers for spinach**
    a. The 0.8mm Flea-Beetle Insect Net supplied by Crop Covers Ltd UK consistently delivered the most favourable results for the trials carried out Thulimbah, Granite Belt
        i. Harvested crop yields (kg/$m^2$) per cycle showed a slight increase from non netted crops
        ii. Crops grown under 0.8 mm net reached harvest point 20% quicker on average than unprotected crops (NB – in affect this is a yield increase as it allows extra crop cycles to reach maturity during a season)
        iii. The cover demonstrated an average increase of 30% moisture retention
        iv. Crop grown under 0.8 mm net did not compromise the packed shelf life after harvesting and packing
        v. Minimal insect damage was observed with no pesticide application
        vi. No visible damage to the nets was observed, even after multiple uses
        vii. Overall, 0.8 mm net demonstrated the best protection against insect infestation
            1. 89% of insects removed in independent processor trial compared to standard grown product in adjacent block (see Appendix 6)
        viii. 0.8 mm net demonstrated excellent performance in creating an elevated microclimate during low ambient temperatures
        ix. 0.8 mm net demonstrated good protection from frost

The following image shows the high quality and uniformity of plants grown under 0.8 mm net. No visible insects, signs of insect damage on the leaves, or sign of disease were detected. The leaves were of desired size for optimum yield and were of high product quality.

*[Image 4 – crop vigour under the net]*

*[Image 5 – crop vigour after net has been removed]*

**2. Validate a mechanical method for the laying and retrieval of the covers**

a. Australian Laying

i. We were unable to source commercially available laying and retrieving equipment for the trial work, as the European demand for this equipment was very high during the period we had planned to test it. Discussions with Crop Solutions Ltd also revealed that their machine was not suitable in its current format for use on the relatively narrow widths of film that we were trialling in Australia.

ii. Britton Farms therefore designed and constructed a tractor mounted prototype net laying device for the trials.

iii. The following photographs illustrate a simple but effective device that holds one roll of net. The machine uses a hydraulic motor to slowly lay or retrieve the net.

iv. This device worked in a satisfactorily manner for the relative narrow net widths used in the trials (up to 8 metres wide), but was unsuitable when applied to the retrieval of nets greater than 8 meters in width. The UK built commercial machine described in the following section would be more appropriate for the larger width nets. The local device worked efficiently with roles of net 200m in length and under 8 meters in width.

v. The project trialled different methods of cleaning the nets but found it extremely difficult to clean them as they were retrieved. However, it was observed the nets were very efficient at self cleaning as a good shower of rain does as much for cleaning them as any other method. Discussions with CCL and independent users in the UK revealed that the UK market does not consider that cleaning is unnecessary and that to date no machine has been designed for this purpose.


*[Images 6 & 7 – Crops covers being laid with the assistance of the tractor mounted device in Thulimbah]*

b. UK Developed Laying & Retrieving Device
   i. This device is commercially sold in the UK for approximately $30,000
   ii. It is supplied by CCL and widely used in Europe
   iii. It's first function is to lay crop covers with the assistance of a team of field workers who place and secure the covers around the edge of the seed beds
   iv. It's second function is to rewind and roll the crop cover onto a detachable spindle for storage prior to re-use on the next crop



*[Images 8, 9 & 10 – Tractor mounted commercial Crop Cover laying & retrieval device in UK]*

3. **Provide an account of the benefits and constraints of adopting floating crop covers**
    a. **Benefits**
        i. **<u>Protection from foreign materials - insects</u>**
            1. It was observed over multiple trials that a very significant reduction in pest numbers can be achieved by removing the nets immediately prior to harvest.
                a. Effectively, insects are physically excluded from entering the protected environment so insect induced damage, insect infestation and insect breeding is prevented.

*[Image 11 – Insects unable to reach crop below the net]*

                b. This is particularly important for fresh-cut processors as customer foreign body complaints are a major problem
                c. The major fresh-cut processors have invested $ millions in sophisticated washing, screening, optical sorting and inspection methods to remove unwanted insects from ready-to-eat products yet alarmingly high numbers of contaminations continue to occur.
                d. The most successful method of reducing insect foreign body contamination incidents is to exclude them at source in the field
                e. Floating Crop Covers present a clearly demonstrated method of drastically reducing insect populations in harvested baby-leaf crop formal factory trial results
                    i. The chart below shows an independent trial carried out by fresh-cuts processor Harvest FreshCuts Pty Ltd (HFC)
                    ii. This trial shows that both 0.8 mm and 16x16 net are equally effective at reducing insect population numbers

iii. Further independent trials undertaken by HFC demonstrated insect reductions of 89% between protected and unprotected crops

**Raw Material Trial Results - Brittons Net Trials April 13**

Detail below shows no significant difference in insect population under nets in the two types of nets used

| | Baby leaf Type | Date of Receipt | Sorting Mechanism | Wt of sample taken from sorter (g) | No of insects | % insects | Type of insect | Other Quality Observations | Shelf life Observations |
|---|---|---|---|---|---|---|---|---|---|
| Sample 1 0.8 (net specification) Trial 30-40kg | MIZUNA (Trial) | 5-Apr-13 | Griddle Plate&Sorter | 50 | 0 | 0% | | 2% yellow leaves | Achieved shelf life of standard product P+8 days |
| | MIZUNA (Trial) | 5-Apr-13 | Roller 1+2 | 40 | 2 | 5% | 1 Soldier beetle, 1 ladybug | | |
| Sample 2 1.6 Trial (net specification) 30-40kg | MIZUNA (Trial) | 5-Apr-13 | Griddle Plate & Sorter | 30 | 0 | 0% | | | Achieved shelf life of standard product P+8 days - marginally better appearance than sample 1 |
| | MIZUNA (Trial) | 5-Apr-13 | Roller 1+2 | 30 | 1 | 3% | 1 Soldier beetle | 1% yellow leaves | |

ii. **Protection from windborne foreign bodies (leaves, twigs, paper, etc.)**

i. All growing regions can be affected by windborne foreign bodies. These will include:
   1. Leaves, twigs, flowers, bark, pine needles, rubbish (especially near roads), and anything else that will blow in the wind.

ii. Crop covers cause a barrier between the product and these foreign bodies.

ii. When nets have accumulated large amount of these foreign bodies care has to be taken when removing nets to prevent these from spilling on to other product or back into the product to be harvested.

iii. It was found if nets were retrieved consistently from one end to the other these items would be collected at the end of the block.

iii. The photographs below illustrate wind-blown foreign bodies that have been excluded from entering the crop

*[Images 12, 13 & 14 – leafs, twigs, etc captured on the net]*

**iii. <u>A reduction of irrigation water requirements</u>**

a. It should be noted that over the trial period the Granite Belt experienced the wettest 3 years on record which prevented the project from definitively determining the water saving properties of crop covers.
b. The Idea for this project was born during drought conditions and it was proposed that water could be saved and crop quality improved during dry periods by applying crop covers.
c. Records indicate that irrigation requirements were reduced by 30% – 50% depending on the time of the year.
d. A reduction in evaporation rates was clearly observed in the surface soil protected by crop covers. There was a marked improvement in moisture retention in the soil versus the open and un-netted ground. The nets presented a physical barrier between the ambient air and the ground which created a microclimate, reducing evaporation and limiting the evaporative effects of wind. This reduction in water loss appeared to help the protected crops to grow more consistently and less variance in plant and leaf size was observed.

The dark vertical patch to the left of the wheel track illustrates where the net was removed, showing moist top soil to the left and dry to the right

*[Images 15 – moisture retention]*

**iv. <u>A lower installation cost than traditional frame mounted overhead netting</u>**

a. It is difficult to accurately determine the exact cost of floating crop covers in comparison to more tradition frame type protection as they are influenced by currency fluctuations, shippings costs, installation costs, volumes imported and operating costs. In addition the relative life of the different systems is very difficult to accurately quantify.
    i. 0.8 mm Flea Beetle net, as recommended by this project, will cost approximately $10,000 per ha to deliver to Australia (See Appendix 4)
        1. This represents an additional production on-cost of c.$0.20 per kg if amortised over just one year
        2. However this on-cost will rapidly decrease if the net is used over successive seasons (i.e. 10 years use = $0.02 / kg)
        3. There are some additional labour costs involved with the laying and retrieving of nets and these will vary with the location, crop, cover type, season and level of automation deployed
    ii. The hail-net supported structure that Britton farms installed in 2009 cost around $40,000 per hectare and was extensively damaged the following year
    iii. A commercial poly tunnel from leading UK supplier Haygrove will cost around $55,000 per hectare
    iv. An automated retractable poly greenhouse from USA supplier Cravo will cost in excess of $300,000 per hectare
    v. Therefore, simplistically floating crop covers are significantly cheaper to install that other types of crop protection
b. The various merits of these different systems was outside the scope of the project

**v. <u>Protection from the ingress of wild birds</u>**

a. From time to time throughout the year Britton Produce has experienced product damage from wild ducks and lesser damage from rabbits.
    i. This damage normally coincides with a full moon or very dry period
    ii. This damage at times has affected 100% of a block, but also can be limited to a few random leafs.
        1. The damage can be very light but still make product un-harvestable
        2. There also is the issue of bird faeces deposited unseen in the crop
b. During the trial period Britton Produce lost no protected product to ducks or other contamination
c. However during the same period Britton Produce recorded a loss of products valued at $43,500 to direct damage from ducks. This damage was recorded only on the trial farm so this figure would increase over the larger farm business operations

d. Every year is different but Britton Farms has experienced periods when duck attack was unmanageable and damage as high as $10,000 to $20,000 has been sustained in a single night.

Product attacked by wild ducks


*[Image 16 –bird damage - ducks]*

Product covered by nets same trial


*[Image 17 –no bird damage – under nets]*

**vi. <u>Protection from the ingress of native and feral animals including frogs</u>**

a. Throughout all of the trials that were carried out over 3 years, no frogs were found in the trial crops.
    i. The net perimeters were secured by pegs or sand-bags in most instances so were not 100% enclosed around the edges and despite this limited area of access no frogs were observed in the trial crops, and only very small numbers of small insects and moths were found in any of the netted product.
    ii. Most of those present were picked up during the harvesting process.
b. Through the same period of the trials one frog and one mouse was discovered in unprotected harvested product. These contaminants were found during fresh-cut salad processing and as such posed a significant food safety risk.
    i. It is very difficult to identify a green frog on the back of a green leaf.
    ii. These frogs can be as small as a 5 cent piece and appear to sometimes survive the commercial washing processes.
c. The majority of frogs and mice are unaffected by the pesticide sprays permitted during baby-leaf production and all chemical sprays lose their effectiveness as harvest time approaches
    i. Typically the number of insects present increase as harvest time approaches in unprotected crops
d. We could not definitively claim that the crop cover eliminated all frog contamination as their presence is typically sporadic. However we believe that the overall reduction in insect contamination levels is likely to discourage the presence of frogs and small rodents as their insect food source is restricted.
e. In addition a fully secured crop cover closed by a furrow of soil or closely spaced sand bags will almost eliminate the opportunity for infestation

    i. Results from independent processing trials by a major fresh-cut processor showed reductions of insect populations of 89% in crop cover protected products.
    ii. Appendix 2 shows independent fresh-cut processor trial results

f. The field presence of animal faeces in field crops and the associated food safety risk is also of major concern
    i. Over the duration of the project we observed the presence of faeces from many animals including foxes, birds, ducks, dogs, rabbits and others that were unidentifiable on top of the crop covers.
    ii. In the absence of a crop cover, this material would otherwise be deposited in the crop and would likely by undetected in the harvesting process

*[Image 18 –animal faeces on top of net]*

*[Image 19 – faeces on top of net]*

**vii. <u>Protection from seasonal hail</u>**

a. Virtually any conceivable protection system will be overwhelmed by a major weather event
b. We have demonstrated floating crop cover nets to be effective against hail damage of about pea size providing that the hail only covers about 50 % of the ground
c. However we believe the results will differ depending on the storm intensity and net type used
    i. Over the project period we experienced only one hail event where cover trials were planted
    ii. This was a light small hail event and no damage was observed in the protected crop
    iii. Hail of greater quantity and size is likely to cause varying degrees of damage to cover-protected crops depending upon the location, storm intensity, wind speed, temperature with melt rates and net specification
    iv. When hail accumulation increases to a weight that forces pressure back onto the product crop damage is likely to occur.
d. We have observed that the stronger / heavier net covers are more efficient at protecting the crop than the lighter fleece types
    i. A longer more detailed study would need to be done to assess the outcome from different types of storm damage to crops covered by nets

            1. Individual storms would have to be assessed over an extended seasons
    ii. We confidently predict, however, that any physical barrier between the crop and the elements will reduce damage induced by hail

e. Hail caused substantial losses especially over the summer season in Queensland
    i. During the 2012-13 Summer Britton Farms recorded 6 hail storms between October and March which resulted in lost product with a market value of over $200,000
    ii. We believe this loss would have been reduced by 80% with the application of netting covers on this single farm
    iii. Baby-leaf crops supplied to processors typically have acceptable defect levels of less than 5 %
    iv. Even a minor hail storm can render a crop unusable or at least require substantial manual sorting

f. Heavy rain

*[Image 20 –heavy rain accumulation on top of a supported hail net]*

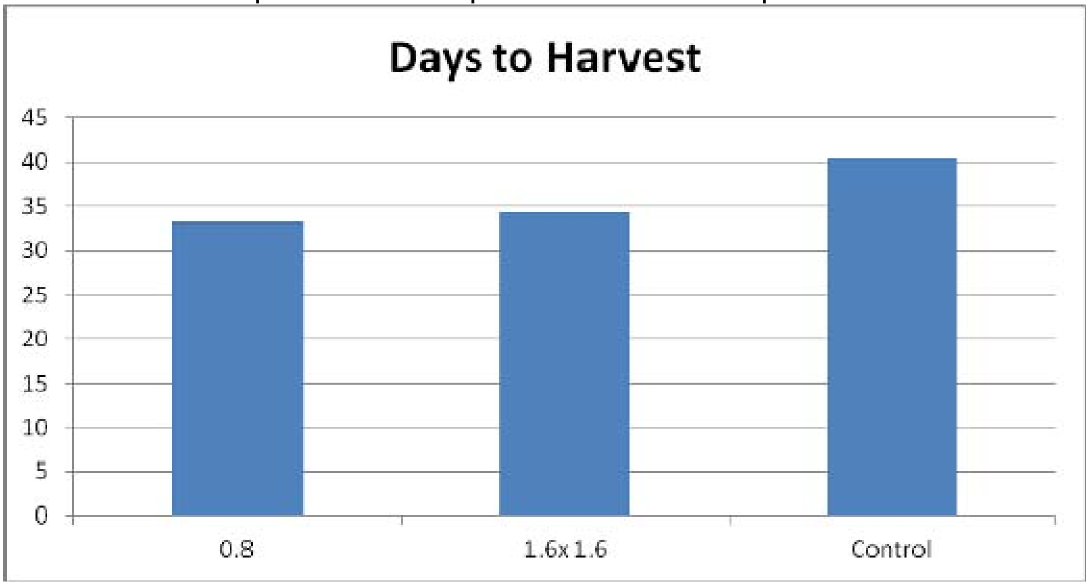
    i. Heavy rain is far more prevalent and is responsible for more damage to baby leaf salads than hail
    ii. Soft baby leaves such as spinach are very easily affected by tearing and bruising from heavy rain.
    iii. This is more damaging when rain falls with high winds
        1. Britton Farms frequently experience serious rain damage to unprotected crops
    iv. During the years of trialling Hail nets similar to Image 20 above we observed that these nets provide a physical barrier where water is broken up into smaller particles as it passes through nets.
        1. The rain droplets are slowed and broken up into tiny droplets causing a misting affect as it travels through netting, thus minimising much of the potential damage caused.
        2. Discussions with some European baby-leaf growers indicate that at certain times of the year they may

periodically lay crop covers over sensitive baby-leaf only when heavy rain is predicted and remove it again once the immediate threat has passed

## viii. Creation of micro-climate

a. The creation of a microclimate around a growing can plant can provide either beneficial or detrimental effects.
b. One of the most standout results was the effect on soil temperature
    i. Trials held over winter showed improvements in soil temperature of 2-4 degrees.
    ii. This in combination with the factors discussed in this paragraph led to an increase in crop growth speeds, shortening crop cycle growing times by up to 2 weeks.
c. Floating crop covers generate a micro-climate that provides certain benefits to the crop under certain conditions
    i. There is an observed general enhancement to quality and a reduction in crop variability
        1. During prolonged wet weather events higher disease levels were observed although this was identified across both netted and non netted trials.
    ii. The microclimate created under crop covers improved water retention and germination rates and produced faster growing rates
        1. All trials were direct seeded
        2. Improvements to seed germination rates was observed, particularly during hot weather were thermo-dormancy and poor moisture retention plays a large part to a successfully germination.
        3. Less improvement in consistency of product grown under netting was observed in average (favourable) climatic conditions
        4. However, when conditions are dry the ability to maintain more consistent soil moisture levels dissipates the effects from uneven watering and reduces other weather induced stress effects
        5. The plants seem to have lower stress levels in these conditions resulting in more mature crops and higher yields.
        6. Quality may be affected in multiple ways, but baby spinach in particular displayed minimal changes to leaf colour, shape and leaf thickness in comparison to unprotected leaf.
    iii. The primary observed quality improvement was less insect holes and decreased physical damage.
    iv. Crops grown under crop covers consistently displayed a decrease in growth cycle times
        1. This was most obvious during early and late shoulder seasons

v. The chart below demonstrates a growth cycle reduction of 19.8% for baby spinach grown in 0.8 mm flea-beetle net when compared to the unprotected control crop





*[Image 21 – the net has been pulled back to reveal more prolific growth under the net compared to the unprotected crop alongside]*

## ix. Extension of the growing season (both early & late season)

a. There is clear evidence that growing seasons can be extended through the application of floating crop covers. The microclimate induced under the covers increases both soil and air temperatures during the cooler months and further provides wind and frost protection.
b. However, these benefits become a restraint during particularly hot and humid conditions.
   i. It is a lot harder to cool growing conditions than to warm them.
   ii. The 0.8 mm flea-beetle and 16x16 were very effective in creating a favourable microclimate during cold conditions, but

may not have been the best selections for extreme heat conditions
   iii. Further work is required to determine if any of the covers can provide a protective environment for high heat and humidity
- c. There is also the evidence that in times of drought those seasons can be extended due to the water saving characteristics of the netted ground.
- d. In order to optimise the net selection for season extension the multiple environmental conditions of insect control, wind protection, rain and hail protection and heat / cold must be simultaneously considered.
- e. All of these factors and more our influenced by the application of net covers.  In regions and periods where these factors produce challenges from time to time it is likely that the application of targeted crop covers will provide assistance in growing.

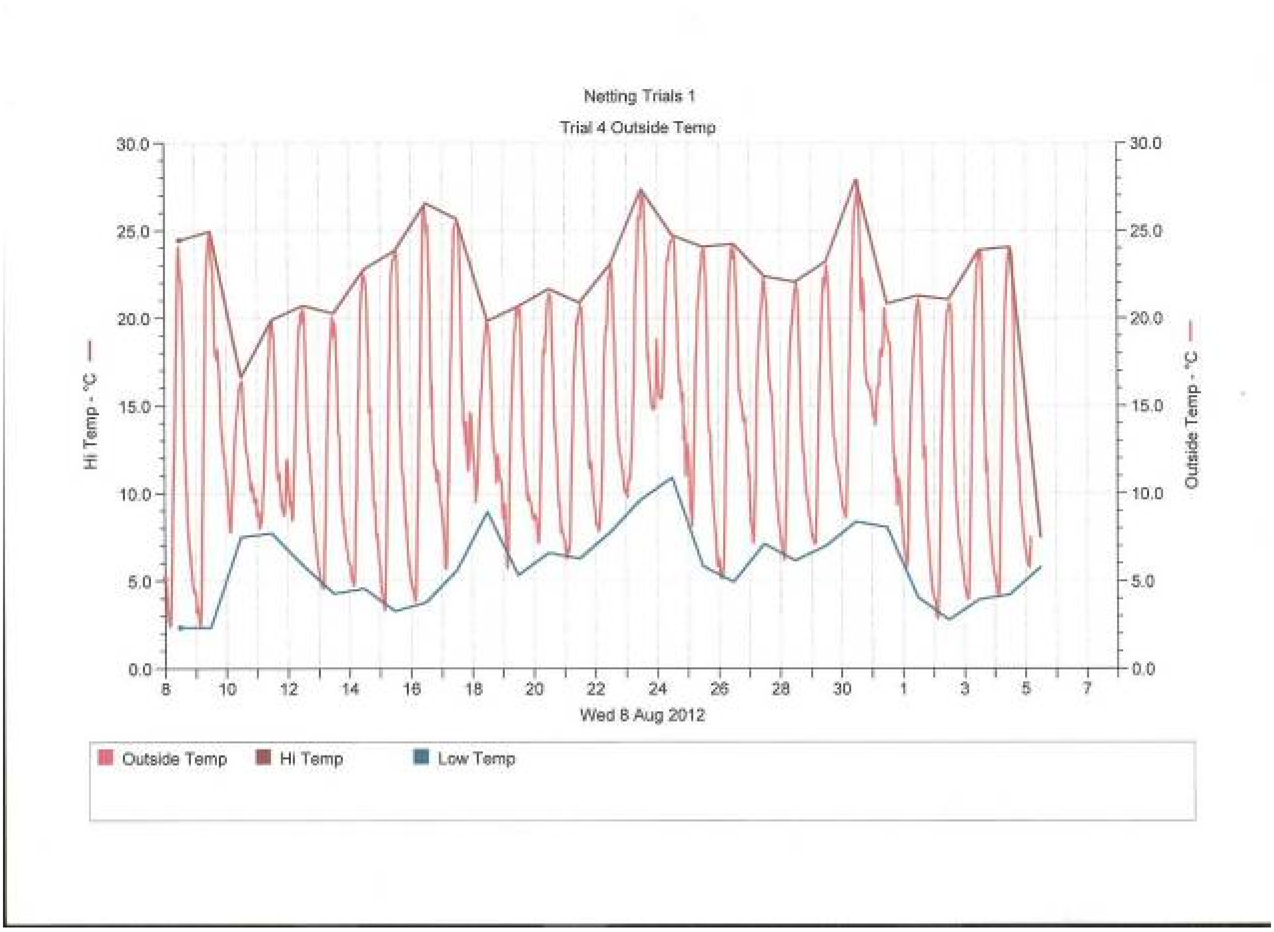
**x. <u>Frost protection</u>**

- a. Crop covers provide protection from tip burn and bronzing caused by light frost
- b. No protected crops were adversely affected by frost damage during the duration of the trials.
    - i. The crop cover creates a physical barrier between the product and the net and the frost settles on the net not on the product
    - ii. Together with the temperature increase of the soil under the nets it was evident that any of the net types worked in this way.
- c. Frost causes substantial damage to crops of all types
    - i. This a major reason for the use of netting covers overseas.
    - ii. Frost does not always kill crops but may just cause enough damage to make the products unsaleable.
        1. For example with spinach may experience a small level of tip or margin burn from early frost which may be sufficient to make them unsaleable
- d. Many Australian climates experience ideal day time growing conditions whilst experiencing low night time temperatures that makes growing difficult
    - i. The application of crop covers was demonstrated to optimise winter day time growing conditions whilst protecting crops from sudden drops in night time temperatures.
- e. Floating crop covers provide greater protection than traditional hail net structures as frost can still form beneath hail nets.

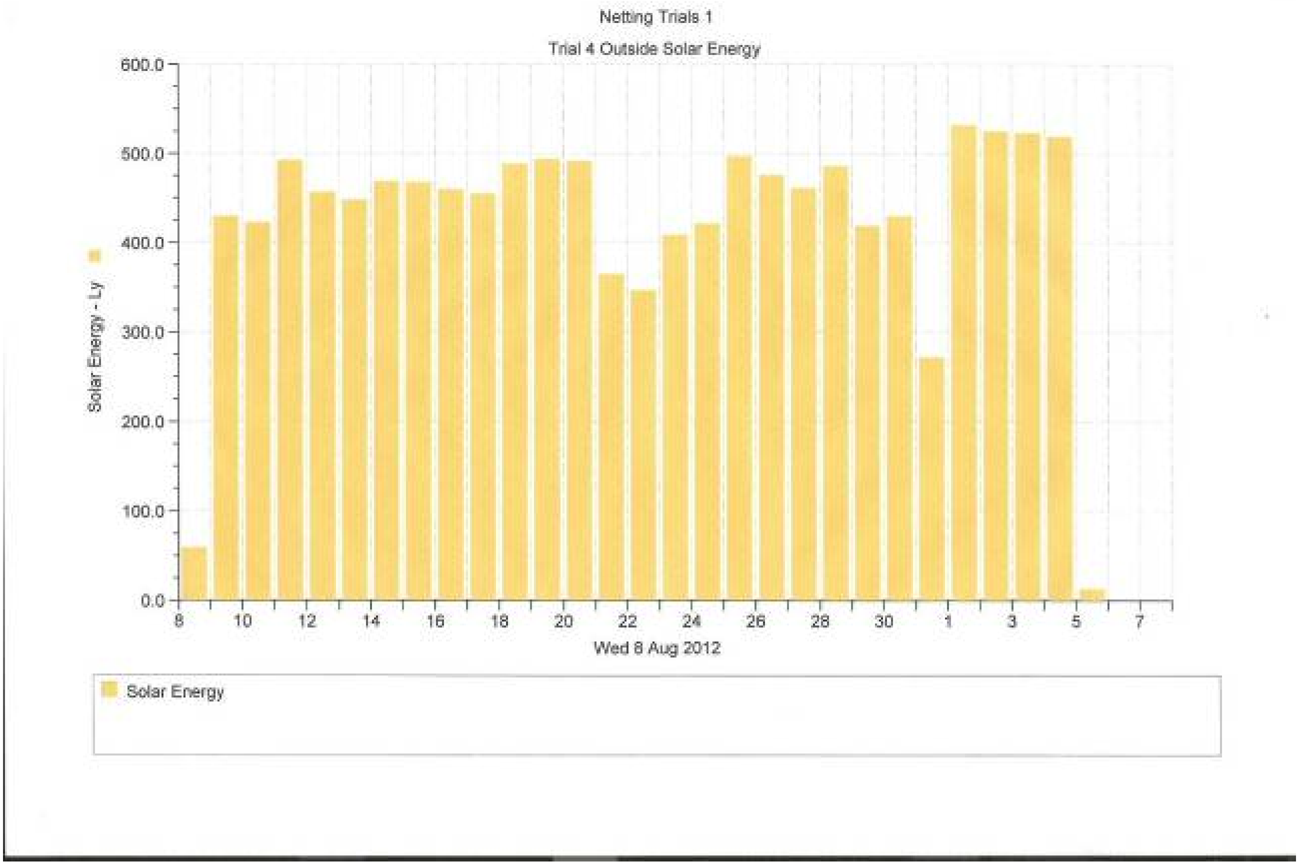
*[Image 22 – the net has been pulled back to reveal un-frosted product adjacent to frosted unprotected crop]*

## xi. Examples of some of the Records kept and studied

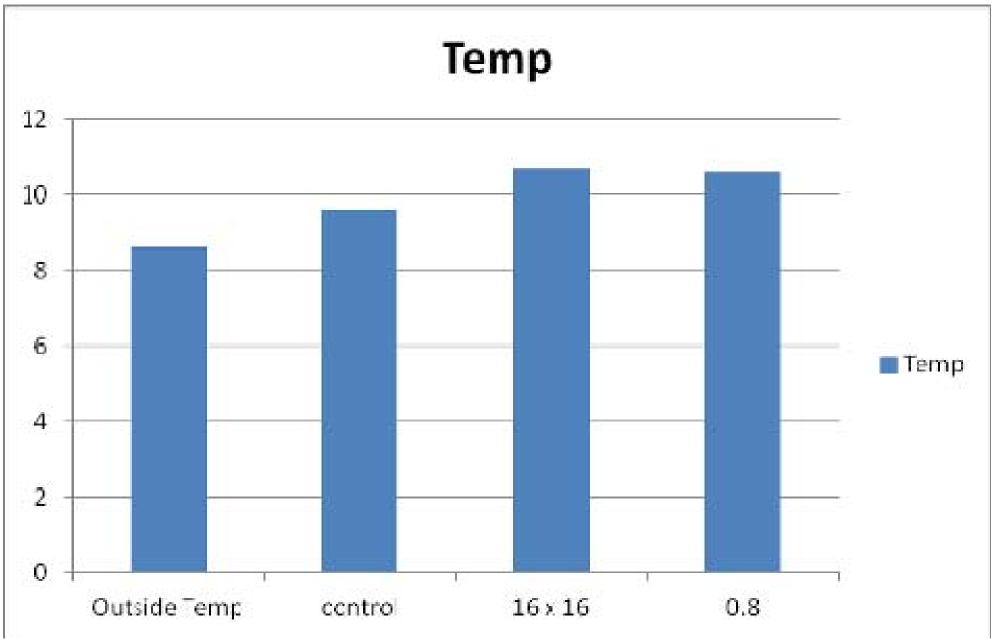
a. Example of ambient max / min temperatures recorded



b. Example of hours of sunlight recorded

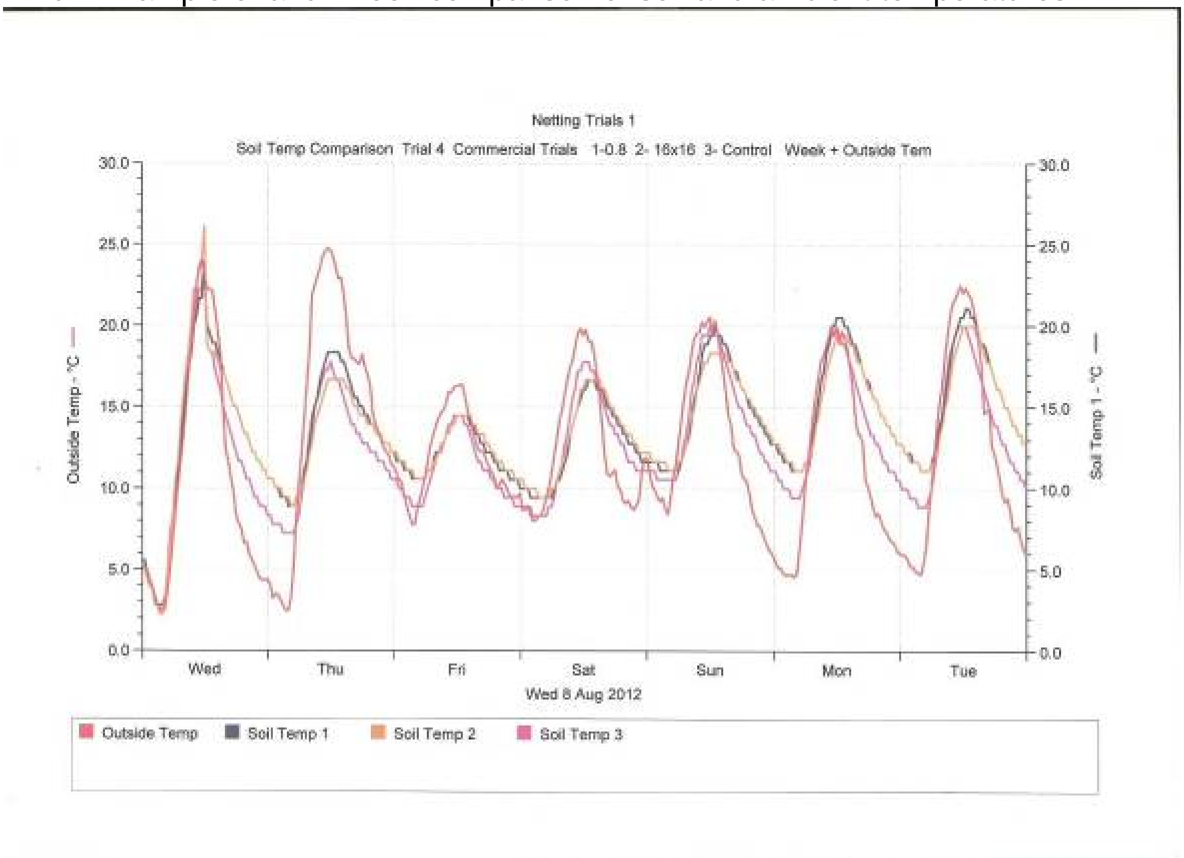



c. Example of soil temperatures recorded (using remote sensing devices where appropriate)



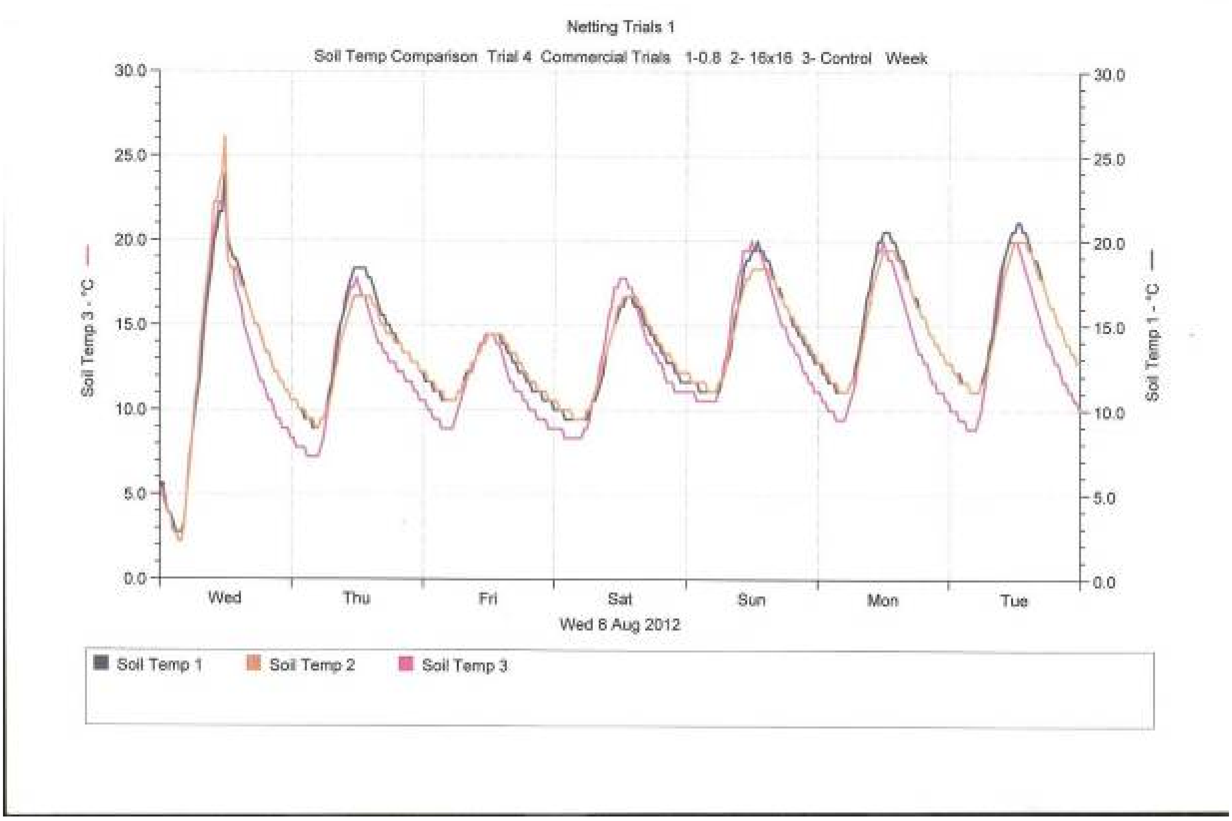

i. This chart illustrates and average soil temperature increase of 2$^0$C. over ambient under the crop covers. In some trials greater increases were recorded. In summer increases in soil temperature were smaller than that of winter.

d. Example of a full week comparison of soil and ambient temperatures

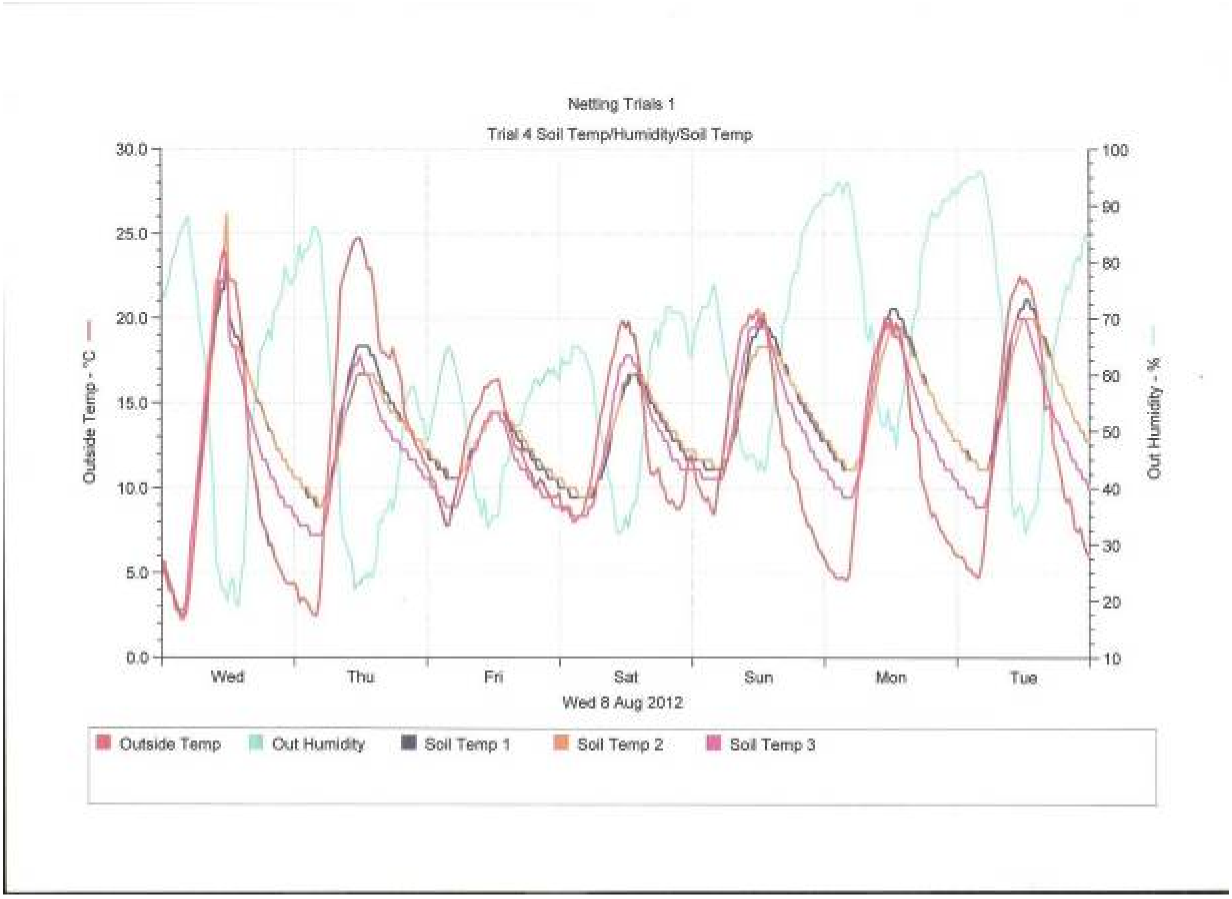


i. This chart clearly illustrates minimum soil temperatures are elevated by up to $5^0$C. on cooler nights
ii. This effect is most apparent when the day / night temperatures fluctuate by 15-$20^0$C.
iii. The variation is less when the ambient range is in a narrower band
iv. Throughout this entire winter week the soil temperatures under the covers are maintained in an optimum growing band of 10-$20^0$C. whilst ambient temperatures have ranged between 3-$26^0$C.

e.




f. An example of microclimate soil temperatures, air temperatures and humidity within the test structures (using remote sensing devices where appropriate)




i. Outside ambient temperature and humidity fluctuates through a broader ranger than those under the protected environment

**xii. <u>Applied irrigation water</u>**

a. Throughout the duration of this project Queensland experienced significantly above normal rainfall and two record breaking floods were experienced.
b. As a consequence artificial irrigation was not required for 90% of our crops through this period.
c. As discussed previously soil moisture monitors provided detail information across all trials which showed a 30 % increase in available moisture over the trials
d. The project experienced only two definitive periods over the duration of the project where very little rain was received
   i. During these periods small quantities of irrigation water were applied
   ii. The application rate required by the crop-cover protected trials was 33% less than that for the unprotected crops.
e. Soils types and prevailing climate at will have a major impact
   i. Further trials carried out on much heavier soils in the Lockyer Valley indicated a water application reduction of 50%( every second watering was omitted).

## xiii. Fertilisers applied, herbicide / pesticides treatments applied;

a. The same fertiliser program was applied to all trials and controls
   i. A complete base fertiliser at 400 kg / ha
   ii. Follow up fertigations of Calcium Nitrate, Potassium Nitrate, Magnesium Sulphate and some trace elements
b. Very little spraying was done on trials and foliar sprays were not applied
c. All trials were sprayed with herbicides just prior to the covers being laid using standard herbicides such as Dual Gold
d. At no stage were any insecticides sprayed on netted product (a primary project goal was to evaluate the insect protection qualities of the covers)
e. Control blocks were sprayed with standard insecticides such as Movento and Coragen as the product would not have been harvestable without them.

## xiv. Germination periods

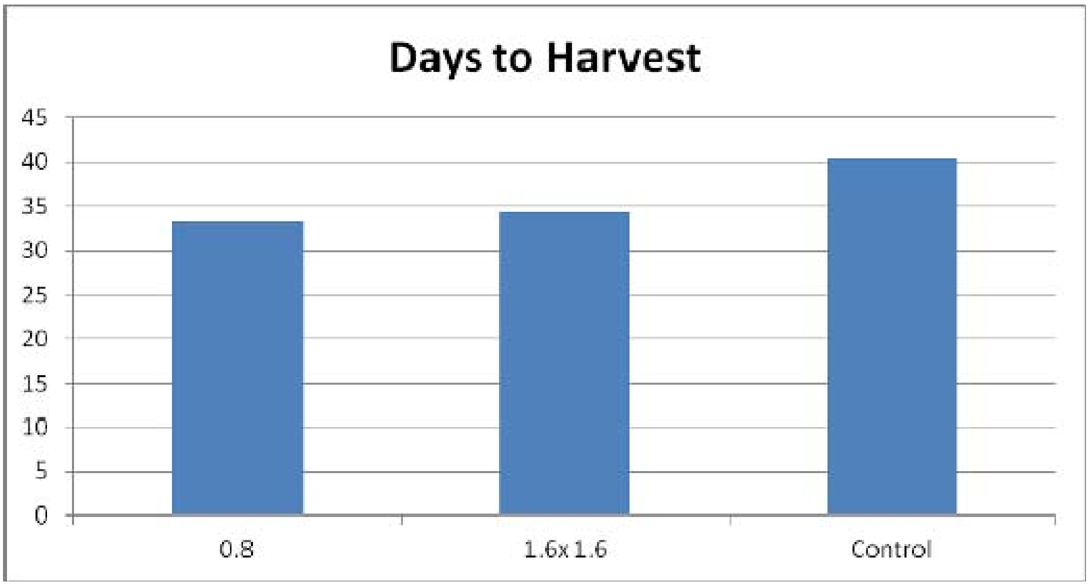
a. Germination rate was recorded for each trial
b. Protected crops achieved a 10-30% increase on germination rates
c. This deepened on the time of the year amount of rainfall and outside temperatures.
d. Seeds generally germinated quicker under nets also but again time of the year played a part in these results.
e. It was a noticeable difference in winter time with improved soil temps and moist growing environment germination of 100% of seed was up to week quicker.
f. In summer the crop cover nets providing more even moisture retention, germination was only one day earlier, but the % of seed germinating across the whole block was higher.
g. As seen with the below trial there is a vast difference in germination from netted to non netted product

*[Image 23 – control – patchy germination]*

*[Image 24 –netted - high germination]*

## xv. Figure 1: Comparison between treatment and control densities.

a. Growth cycle length;
   i. The following chart shows an average across multiple trials of the average growth period to harvest in days.
   ii. It was evident that winter trials had a greater difference in days to harvest than summer crops.




*[Image 25 –growth under net v. to side of net]*

*[Image 26, 27, 28 –growth under net v. to side of net]*




b. A, B, and C were all sown at same time in adjacent blocks
c. 0.8 mm flea-beetle net (B) is clearly more defined and mature than that of 16x16T and the control trial.
d. The control is significantly smaller than the two treatments and was not mature enough to harvest at the same time
e. Trial B (0.8 mm) illustrates strong plant vigour and uniformity
    i. No visible insects
    ii. No signs of insect damage on the leaves
    iii. No sign of disease.
f. The leaves were of desired size for optimum yield and were of high product quality.

**xvi. <u>Yield of harvested crop;</u>**

a. Crop yield of netted product was typically slightly less or equal to control product
    i. When poor germination affected the control trials, the yield of netted product was slighter higher.
    ii. However, typically the harvest of control product would occur one week later than the covered products as the control was too immature to harvest at the same time. If the control samples had been harvested at the same point there would have been a greater reduction in yields.



**Control labelled A, 0.8T labelled B, and 16x16T labelled C.**

b. Due to the faster growth speed of covered product there was times in warmer weather where yields of netted product were lower
    i. There seemed to be less leaves per plant
    ii. This is probably attributable to the faster speed of growth.
    iii. Alternately product grown in the cooler months grew quicker and still achieved yields comparable to the controls.
c. An interested anomaly was repeatedly observed around protected crop yield.
    i. When product was harvested directly after removing the covers the yield was typically very similar to the control trials of similar size
    ii. However when protected crops were left in the block for a further 2 days after the cover had been removed yields increased by up to 45% when compared to the unprotected control.
    iii. The additional unprotected growing time appeared to allow the crop leaves and stems to thicken and gain weight
    iv. No great increase in size was observed, but density improved.
d. As baby-leaf salads are grown for multiple plantings per season, the true crop yield is not based upon a single growth cycle, but over the full season (e.g. kg / $m^2$ of cultivated ground over the season)
    i. When factors such as crop losses from weather, insects and water savings are taken into consideration the yield of crop / $m^2$ is much greater than that of unprotected product.
    ii. It should also be appreciated that with quicker growth comes less inputs and more available ground for production.

## xvii. Farm Quality assessments

a. Assessments were completed for all trials throughout the duration of the project
b. These assessments were used to grade all aspects of product.
c. Immediately below is an example of one type of assessment
d. Other assessments were done at different stages and also during shelf life testing.

| | | |
|---|---|---|
| Type | 0.8 | 16x 16 |
| Trial No | 2 | 2 |
| Date Planted | 21-5-12 | 21-5-12 |
| Date harvested | 25-7-12 | 25-7-12 |
| Planting Density | 700 s/m | 700 s/m |
| Density Loss | 0 | 0 |
| Variety | Spinach Paloue | Spinach Paloue |
| Yield/m in kg | 1.77kg/m | 1.71kg/m |
| Leaf Rub (1-5) | 3% | 2% |
| Bruising (1-5) | 0 % | 0% |
| Turgor | Good | Good |
| Insects Present | none | none |
| Physical damage (%) | 3% | 2% |
| Uniformity (1-5) | 3 | 4 |
| Disease | 0 | 0 |
| Insect damage (%) | 2% | 3% |
| Colour (1-5) | 2 | 2 |
| Leaf shape | Good | Good |
| Height (cm) | 8-16cm | 9-16cm |
| Width (cm) | 5-6cm | 5-5.5cm |
| Stem length (cm) | 5-9cm | 5-9cm |
| Root Length (cm) | 13cm | 13cm |
| Visible Moisture Bed (1-5) | 2 | 2 |
| Peg distance (cm) | 4m | 4m |
| Net Damage | none | none |
| Foreign materials | weeds | weeds |
| Cut leaf (%) | 2% | 2% |
| Shelf Life 5 Days | | |
| Shelf Life 10 days | | |
| Comments | weeds more advance than control | |

## xviii. Reduction of pesticide use

a. Trends in Europe are increasing restrictions on insecticide usage
    i. It is highly likely that these trends will be followed in Australia
    ii. As pesticide use becomes more restricted pressure increases for growers to successfully meet customer's standards with less chemicals
b. The trials consistently demonstrated that in most conditions baby-leaf salad leaves can be grown under the protection of crop covers with no chemical applications and still meet customer expectations.
    i. The broad range of crop cover specifications available allows the optimum cover to be selected for specific crops and pests
c. All crops grown under the crop covers received no pesticide applications during the project
d. A single protected trial suffered an aphid infestation
    i. This trial had the covers removed for a 2 day period beyond the planned harvest date due to a large rain event.
    ii. In all other trials pest damaged to covered product was absent or minimal.
e. Controls were sprayed as the product would have been unmarketable if not sprayed.

## xix. Root Development

a. Root development was general grater with crops that were grown under crop covers
b. This is most likely a consequence of the more favourable microclimate created under the covers


*[Image 29, 30, 31 – tap root length development]*

**xx. <u>Limitations and Constraints</u>**

a. During extended periods of excessive rain the crop covers did not allow soil to dry rapidly enough.
   i. On occasions this may lead to disease damage that is greater than non covered product.
   ii. During periods of extreme rain events, covers should be removed to assist in the drying process of water-logged soils and limit disease
b. In extreme heat conditions (e.g. outside normal planting windows) some crop covers can generate a microclimate that may severely damage or even destroy the crop
   i. When ambient temperatures exceeded 38$^{0}$C over several successive days (experienced in some Gatton trials during summer) crop damage was severe.
   ii. This may be controllable by selecting lighter nets with more air movement for extreme temperatures
c. Laying and retrieving is a complex process but is individual to the farm that it is based on.
   i. Different locations may require different solutions specific to the farm infrastructure set up.
   ii. Machinery to assist this process will need to be individually designed or purchased from overseas to suit the grower's individual setup.

d. The specific crop cover selection may differ, depending on climate so individual trials must be carried out on individual farms prior to implementation.
    i. Factors such as wind, rain, soil type, must be considered
    ii. There are multiple crop cover specifications available to suit different climatic and environmental conditions.
e. Spraying a crop through the crop cover may be difficult depending on the specific farm setup and cover selected
    i. Sprays were generally not applied during the trials as the assessment of relative insect damage was a major part of the project
    ii. As far as practical sprays were applied prior to laying of the covers
    iii. Spraying must be considered to individual farm requirements and equipment available
f. If a protected crop is partially harvested over a period of time then the crop cover must be replaced after each harvest.
    i. If left exposed the crop will be vulnerable to insect infestation
    ii. This adds addition resources to harvest and is dependent on individual farm setup.
g. Rubbing may occur in high wind situations
h. This was not experienced with the covers selected for the commercial trials
i. Floating crop covers add an additional cost to normal growing techniques.
    i. Each different cover will be suitable for multiple uses but this will vary with specification selected, individual farm and prevailing conditions
    ii. Protected crops may not generate a premium price return in competitive markets
    iii. However, floating crop covers do assist in the reduction of use of costly chemicals, provide very significant benefits in reducing foreign materials, reduce loss to bird damage and generally provide benefits that assist in customer retention
    iv. The industry may see this as a benefit and help growers fund these changes
j. Bed width and block sizes should be standardised
    i. Crop covers are supplied in specific widths
    ii. Non-standard widths are more expensive and have
k. Securing crop cover edges can be challenging, especially in high wind conditions
l. Working around fixed irrigation systems may be challenging and will differ on each farm setup

### xxi. <u>Performance comparison of Chinese v. European crop covers</u>

a. The Project trialled a fleece crop cover manufactured in China during the early stages
b. It was similar to a fleece cover sourced from Europe.

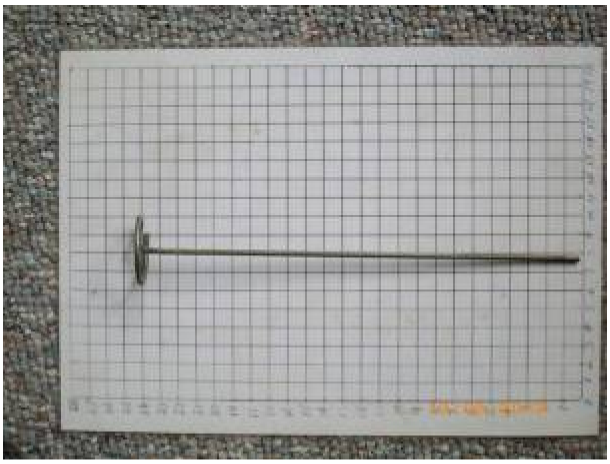
    i. All fleece covers were observed to tear significantly more readily than heavier woven covers
    ii. Little difference was observed between the qualities of the covers from Europe and Chinese nets
    iii. There is a much broader variety of types and density from European manufactures
  c. The project did not assess the UV stabilization of the covers or the potential life of covers from different sources
    i. No apparent UV breakdown was observed during the short duration of the trials
      1. Crop Solutions Ltd are bringing a new very light weight woven net to market in the near future
      2. CSL claim that this cover has the properties of fleece but the strength and durability of a net
      3. The author has seen trials of this product in the UK, but it was not assessed as part of this project
    ii. Crop covers may be classified in g / $m^2$, indicating how much material is used in production and may provide an indication of the relative strength of individual products

**xxii. <u>Efficacy of overhead spraying through the crop covers</u>**

  a. Crops under covers were successfully sprayed during the project
    i. Major limitation is that tractors cannot be driven over covers as they cause the net to drag and may cause product damage
    ii. This problem is more pronounced with 4wd drive tractors
  b. Best results obtained were by “power spray” from adjacent roadways
    i. Air allows spray to travel through net
  c. Most trials were not sprayed but found we had to spray through the wet periods for diseases

**xxiii. <u>Securing crop covers</u>**

  a. Methods for securing the crop covers including, but not limited to:
    i. CSL supplied Tri Pegs, Standard Pegs & Roundhead Peg



Steel Peg - Light in design, bends easily, poor in windy conditions

*[Image 32 – steel peg]*

Plastic round head peg - light in design, easily broken, poor in windy conditions

*[Image 33 – plastic peg]*

Plastic multi point peg -Stronger in design, harder to break, specific design with 3 points to grip net, ribbed so harder to remove, allot better in windy conditions

*[Image 34 – plastic multipoint peg]*

Plastic Multipoint peg at 2 meter spacing's with 0.8 Net

*[Image 35 – plastic multipoint  peg]*

Damage caused by wind when using with Fleece nets

*[Image 36 –wind damage to fleece]*

*[Image 37 – fleece tears]*

Nets torn from Peg

a. Pegs
    i. The images above illustrate that pegs work reasonably well with heavy net types at a close spacing
    ii. With lighter fleeces a large amount of tearing was observed.
        1. As the spacing's increased so did damage to the covers
        2. Pegs are required every 2 meters to avoid damage
        3. Optimum spacing is dependent upon the wind speeds likely to be experienced
    iii. It is recommended that sand bags or burring be used with lighter nets
        1. Sand bags do not cause damage to lighter nets
        2. Pegs are expensive, break relatively easy and pose significant foreign material risk
        3. Plastic round head peg
            a. Light in design, easily broken, poor in windy conditions
        4. Plastic pegs multi point
            a. Broke in hard ground
            b. The ribbed construction did not pull out of ground as easily as steel pegs.
        5. Plastic Pegs were sourced from CSL
        6. The project also evaluated steel pegs
            a. Found these were too light
            b. Pulled out of ground very easily and bent
b. HDPE sand bag tubes

*[Image 38 – sand-bag sat 5 m – auto weather station in foreground]*

Sand bags used to secure nets at 4-5 meter spacing

*[Image 39 –sand-bags at 10m]*

Sand bags used to secure nets at 10 meter spacing

*[Image 40 – UV exposed sand-bag]*

Sand bags come in many forms, ensure they are uv stabilised as they will break down quickly

a. Sand bag tubes
    i. Replacing pegs with sand bags eliminates the tearing of covers at the point where the peg penetrates the net
    ii. Sand-bags are cheap and pose no foreign material risk but are cumbersome and heavy to move

   iii. If the bags are not UV stabilized they will breakdown and tear within a 12 month period
   iv. Bags location is required every 2 to 10 metres, depending on the cover type
   v. The project standardised on bag spacing at 4- 5 meters to deliver the optimum results
   vi. This spacing provided sufficient closure of the covers to prevent Insect infestation and optimum results of holding the covers in place

b. Heaped soil mechanically positioned by rotary discs along the cover edges
   i. The project evaluated a process of using soil to cover the edges of the covers
   ii. It was very difficult on the test farm as there were no roadways to move dirt from the next block to cover edges
   iii. The project trialled using a single disc plough to bury the edges of the covers
   iv. This process was very successful but only works if there is space to run this machine at the edge of the cover
   v. It was observed that the light covers tended to tear very easily when removing the covers.
   vi. The project also trialled applying shovels of soil at 4 meter spacing
   vii. The quantity of soil required varied on soil type and wind strength
   viii. This process was slow and time consuming when removing dirt from the covers
   ix. It was also observed that in heavy soils (Gatton) it was nearly impossible to remove the soil from the net
   x. The large clumps of sticky dirt that were stuck to edges of the net then spread over nets when rolled up
   xi. This method is far as is the best method to seal and secure the edges of the covers in high wind areas but is difficult to implement in heavy sticky soils and requires room around the covers and blocks to drive heavy machinery around

**xxiv. <u>Validate a sanitation process for retrieved crop cover</u>**

a. After extensive discussions with CSL and overseas growers it was determined that sanitation of the crop covers was unnecessary

**xxv. <u>Validate the technology for baby-leaf crops other than spinach</u>**

a. Trials were carried out over large volumes of baby leaf crops including Tatsoi, Mizuna, Baby lettuce
   i. All products trialled were successfully were grown under nets
b. No major differences were observed between growing spinach and these other crops
c. Some damage was caused to Mizuna in high winds, especially with lighter weight covers

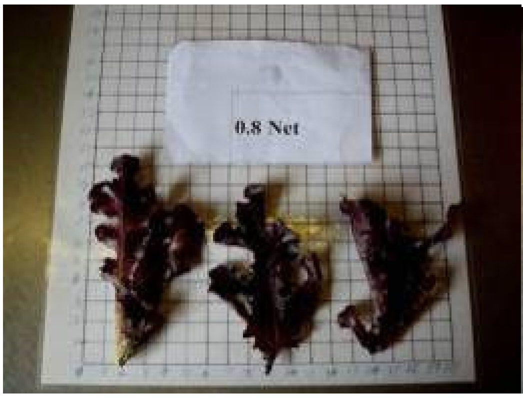
d. These covers seem to float more and can cause rubbing to softer leaf crops


Tatsoi

[Image 41 – Tatsoi grown under 0.8 mm insect net]


Mizuna

[Image 42 – Mizuna grown under 16x16 insect net]





[Image 43 & 44 – Red Oaks grown under 0.8 mm and 16x16 insect net]

[Image 45 & 46 – Green Oaks grown under 0.8 mm and 16x16 insect net]



*[Image 47 & 48 – improved vigour grown under 0.8 mm insect net]*

**xxvi. <u>Demonstrate project can be scaled up to a commercial scale and that significant financial, quality, risk and food safety benefits can be demonstrated</u>**

a. See Appendix 1 – Proposal from processor OneHarvest to extend trials to other suppliers and regions

**xxvii. <u>Conduct an On-farm field day</u>**

a. A Field Day was held in Thulimbah
b. It was considered of high importance that the industry is introduced to the project with the viewing of a full scale commercial trial
c. Senior Technical, Supply Management & Commercial Managers of Harvest FreshCuts were invited to view the trials in conjunction with Senior buyers and technologists from Coles
    i. Harvest FreshCuts sources baby-leaf and lettuce through 30 contracted growers on c.100 farms in Tasmania, New South Wales, Queensland and Western Australia and annually consumes more than 4,500,000 kg of leafy product
d. The HFC contracted growers are not exclusive suppliers and most supply leaf to other processors, supermarkets and to the greengrocer channel via the Central Markets
    i. This event was considered to present the best possible opportunity to promote the technology to the industry for the following reasons:-
        1. Discussions with individual growers over the duration of the project have always resulted in resistance to the idea of a making a capital investment in crop covers in the absence of a clear crop sell price benefit, and;
        2. It is unlikely that industry will pay a premium for baby-leaf grown under crop covers

ii. It is now clear that the greatest opportunity for widespread adoption of crop covers will be driven through quality benefits and in particular by the protection against insect foreign body complaints associated with ready-to-eat packaged baby-leaf
iii. Coles buys packaged fresh-cuts from all of the major Australian fresh-cut processors
iv. Coles has a very strong focus in driving a reduction in foreign body complaints and is driving this desire up through the supply chain to processors and growers.
v. OneHarvest is the largest single processor of baby-leaf in Australia
vi. Coles and OneHarvest combined interact with 90% + of the baby-leaf growers in the country

e. See Appendix 3 report from OneHarvest Technical Manager

**xxviii. <u>Technical paper will be prepared and submitted to leading electronic and hard copy journals</u>**

a. AUSVEG published a summary of the project in their journal Vegenotes, addition #35 in January 2013.
b. This article was picked up by multiple publications including Food Processing Australia in February 2013, and TASCountry (Feb 2013)

**xxix. <u>Presentation at Ausveg Annual Conference</u>**

a. A formal request was made to AUSVEG to make a presentation of the project findings at their Annual Conference (May 2013)
b. However, due to the successful previous publications made of the project in January & February 2013, this request was declined

**xxx. <u>Project Conclusions</u>**

Floating Crop Covers have been widely adopted in Europe, but so far their adoption in Australia has been very limited. This Project VG09188 has demonstrated their effectiveness in significantly reducing insect infestation populations, insect damage, bird damage and foreign body exclusion in baby-leaf salad vegetables in a cost effective manner. As a consequence they have a very significant role to play in the reduction of foreign body incidents for the fresh-cut processing industry.

The project has demonstrated that field losses can be drastically reduced, although the losses can only be enumerated on a farm by farm basis over successive seasons.

It has been further demonstrated that crop covers will extend the growing season for baby-leaf salads at the early and late part of the season and additional crop cycles can be harvested. This presents an opportunity to drastically extend the growing season and annual yield per hectare, particularly in cooler climates.

Floating crop covers very significantly reduce soil moisture losses, although the almost continuous wet conditions of the last 3 years in the trial regions has prevented this benefit from being adequately measured. We believe that this attribute will be very beneficial when the Australian climate returns to more typical drier conditions.

Project VG09188 was limited by design to the evaluation of baby-leaf crops. The broad applications observed overseas over multiple crop types demonstrates that the opportunities above can be extended across a broad range of horticultural crops. In particular, the opportunity for bringing early season crops to harvest earlier and the opportunity to extend late season crops even later is likely to have a major long term impact upon horticulture production in Australia. It further opens opportunities to commercially produce cold sensitive crops in regions which are otherwise considered too high risk from winter frosts.

## *Future Modifications*

A key strategy going forward will be to conduct formal trials in different growing regions and on different crops. As previously discussed the OneHarvest Group is expected to drive this adoption across the Australian baby-leaf grower supply base with support from major supermarket chains.


## *Acknowledgments*

The project team would like to thank the following organisations for their input into this project:

- Horticulture Australia Limited
- AUSVEG
- Crop Solutions Limited UK
- Harvest FreshCuts Pty Ltd

# APPENDIX 1

Attached documents

Report from OneHarvest National Technical Manager

## Floating Crop Covers – OneHarvest Project Summary

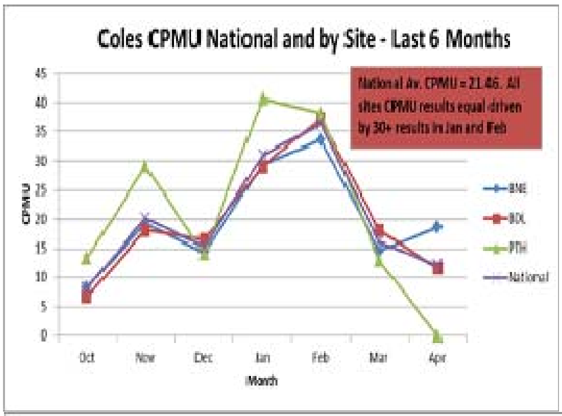
**Overview / Exec Summary of OneHarvest Project Interest.**

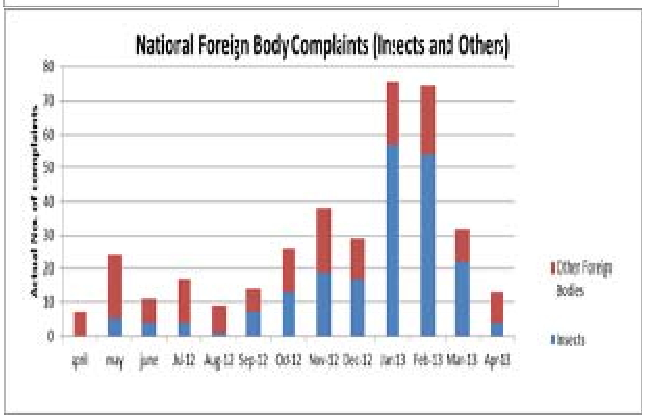
OneHarvest is a processor of value added fruits and vegetables selling into the major retail chains in Australia. Brittons produce is a key supplier of babyleaf to our Brisbane operation.

Our interest in this project is the potential benefits that floating crop covers may provide from both a foreign material control perspective but also from a crop protection perspective.

**Potential commercial benefits of interest to OneHarvest**

We believe that current growth of the Value Added Leafy Greens category could be further stimulated but is being restricted due to several factors. One of the key factors is quality of product, including incidence rates of foreign contaminants. Below is a representation of our complaint levels through last summer (Oct 12-April 13). It can be seen that complaints spike to 3 times normal levels due to insects and foreign contminents during the highest volume period.




Aside from disappointing consumers, there is a risk to the business is rejections or suspended production. Aside from a couple of specific rejections in summer 12/13, the retailers have not taken this approach yet but it has been considered at senior levels of retail management. This is a real risk for future summer periods. A single rejection of one product batch can cost approx. $3000. Using our worst performing complaint product over this summer period, the potential cost of future rejections or lost sales could be in excess of $500,000.

We have also taken steps through this period to reduce levels of complaints such as investing in optical sorters, slowing wash lines down and trialling black box and light traps through the supply chain. Further investments in factory and field control improvements are planned. However, all current actions are designed to focus on removing insects once they are present; there is less current focus on root cause of population increases and control options. This project has identified one possible method of field control.

The level of complaints indicates that the consumer is dissatisfied with the product and this decreases the likelihood of repeat purchase. This could be one factor preventing category growth. Although difficult to quantify; we do know that for example, Australia's frequency of purchase for Saladleaf is approx. half that of the UK. Although there will be several factors influencing this disparity, it is inevitable that level of complaints relating to contaminants would be contributing to restraining growth.

We believe that the outcomes of this project, if possible to commericalise, could help to reduce incidence of foreign material in crop and therefore reduce complaints, helping to stimulate category growth.

Further to the potential benefits of foreign body reduction, we also believe there is a potential commercial benefit if crop security / assurance of supply can be improved through use of this technology. In the period Dec 12-April 13 we missed sales orders of approx. $800,000 due to lack of raw material supply on the East Coast. A similar pattern occurs each summer. If this could be reduced by use of a crop cover systems, there is a significant commercial benefit.

**<u>Experiences about meeting these benefits in trial and field observations</u>**

Trials to date have shown negligible impact on shelf life of product by use of nets and have validated that there are less insects present when crop covers are utilised.

**<u>Key drivers for these benefits</u>**

OneHarvest believe that the benefits seen to date show significant potential in solving the problems noted above.

**<u>Plans of adoption going forward?</u>**

OneHarvest are actively pursuing how a larger commercial trial of floating crop covers could further validate the findings to date.

# APPENDIX 2

## HFC Factory assessment of crop covered spinach

**Raw Material Assessment Control vs. 0.8 vs. 16x16**

| | Size (mm) | Cut Leaf | Wilted Leaf | Tip Burn | Insect Damage | Cotyledons | Other |
|---|---|---|---|---|---|---|---|
| **0.8** | 45 - 120 | 11% | 13% | 1% | <1% | 1% | - |
| **16x16** | 40 - 120 | 5% | 11% | 1% | 1% | 1% | - |
| **Control** | 40 - 110 | 13% | 21% | - | - | 1% | 2 x Weed |

- Cut leaf percentage 50% less for 0.8 than 16x16 and control. .
- ~80% improvement on wilted leaf for both against control with 0.8 marginally better than 16x16.
- No weeds found in netting samples from assessment.
- No significant difference in leaf size. All within specification.
- Insect damage not significantly different between the 2 samples. 0.8 marginally better than 16x16.

**Organoleptic/Shelf Life Result (P+9).**

Product was bagged as per normal process and organoleptic assessment taken over life (see attached spreadsheet). Please be aware that there would be some product crossover between each due to process.

From assessment, there is no significant difference over life between current and netted leaf quality. All passed.

**Next Step**

Larger trial runs over numerous days to allow full data collection. Samples size in has only been enough to get a general view of leaf and as stated, there was some mixing of leaf through process.

# APPENDIX 3

Report from Louise Pavihi – National Technical Manager for the OneHarvest Group

*Date of Visit : Tues 27th November, 2013*

*Present : Louise Pavihi, James La Budde, Alan McCluskey (Senior Food Technologist – Coles) , Kristy Lee Dimovski (Category Manager – Coles)*

*Purpose of Visit : To review ground net trials, understand process and trial programme to date and discuss next steps.*

*We viewed 2 beds of spinach grown under ground nets. Colin explained the different types of nets trialled and how he has narrowed down best fit nets for his environment and crop. Colin also demonstrated some of the test results to Coles. The team discussed the potential benefits of nets, specifically on insect control both through crop growth cycles and at harvest.*
*The investment cost factor was also discussed but possible yield benefits may contribute to offset this (no specific numbers or data was shared on this topic).*
*Coles were very interested in this technology as a potential to reduce insect presence.*
*Several questions were asked on where the nets come from, how they are applied, secured and removed for harvest.*

*Post Visit*
*Unfortunately due to unforseen crop losses so far this summer, we have been unable to conduct any further trials to validate the possible insect benefits. However, this will be planned shortly.*
*Coles remain interested on how we can commercially trial this technology across other regions and farm operations.*
*No plan has been developed as yet to deliver this.*

Secondly, thanks for your help to run some more ground net trials before summer is over to test effectiveness for insects.
To confirm our discussion, you will plant out some Asian greens crops next week with 3 methods; as currently grown, no nets no sprays, netted.
We will need min 50kg of each to trial in the factory and would expect crop to be ready to harvest in approx. 3 weeks time.
I will come out if it's ok and take a look with you or your team prior to and at point of harvest.
We will talk over the next few weeks on how we are progressing to complete the trial.
We will of course send you back the results of the factory trials including shelflife evaluation and insect counts from drums and sorters.

Let me know if you have any concerns or queries at this point.

Best Regards
Louise

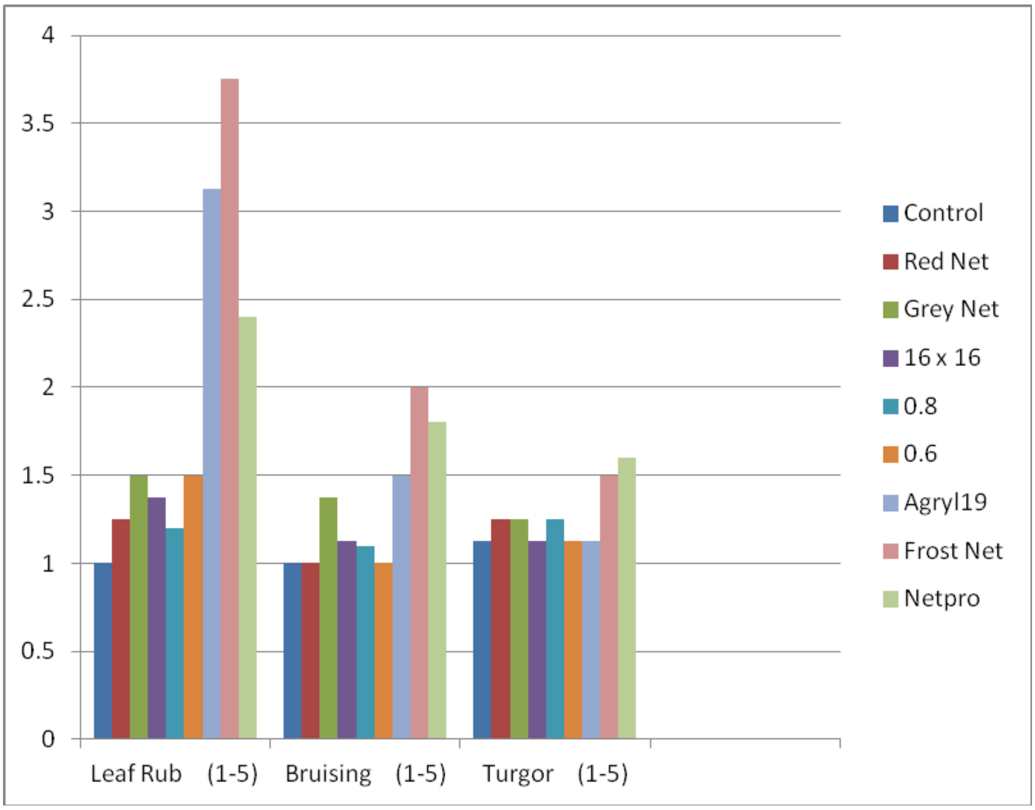
# APPENDIX 4

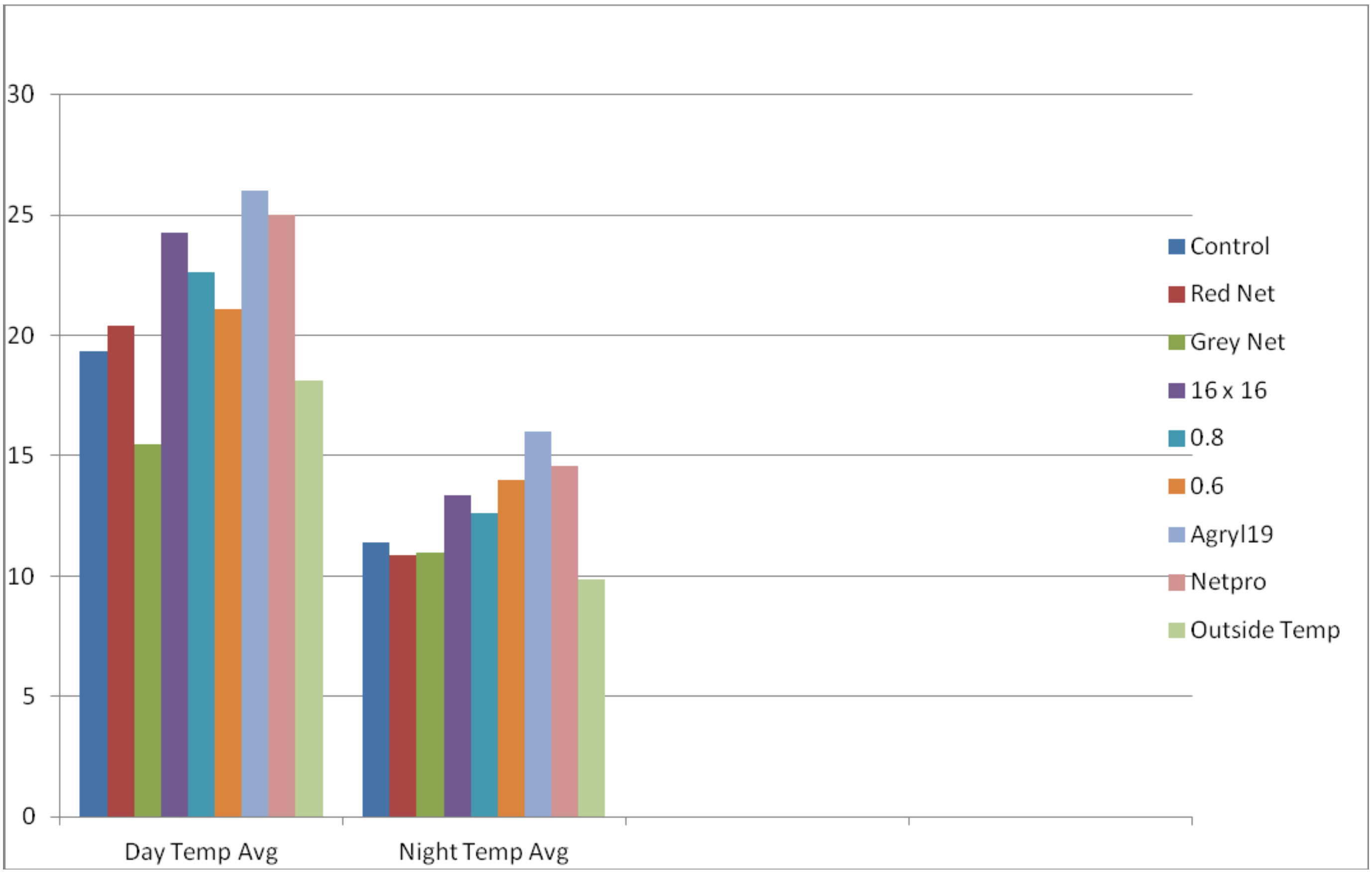
| | | | | | |
|---|---|---|---|---|---|
| **Cost Analysis of Floating Crop Covers (indicative only)** | | | | | |
| Convert £ to AUD | | | 1.50 | | |
| Convert acres to ha | | | 2.471 | | 10000 |
| Sq metre net reqd per acre | | | 4,700 | | |
| Output per sq metre | | | 1 | kg | |
| Cost of net ex-UK (pounds) | | 0.325 | | | |
| Australian Distributor margin | | 25% | | | |

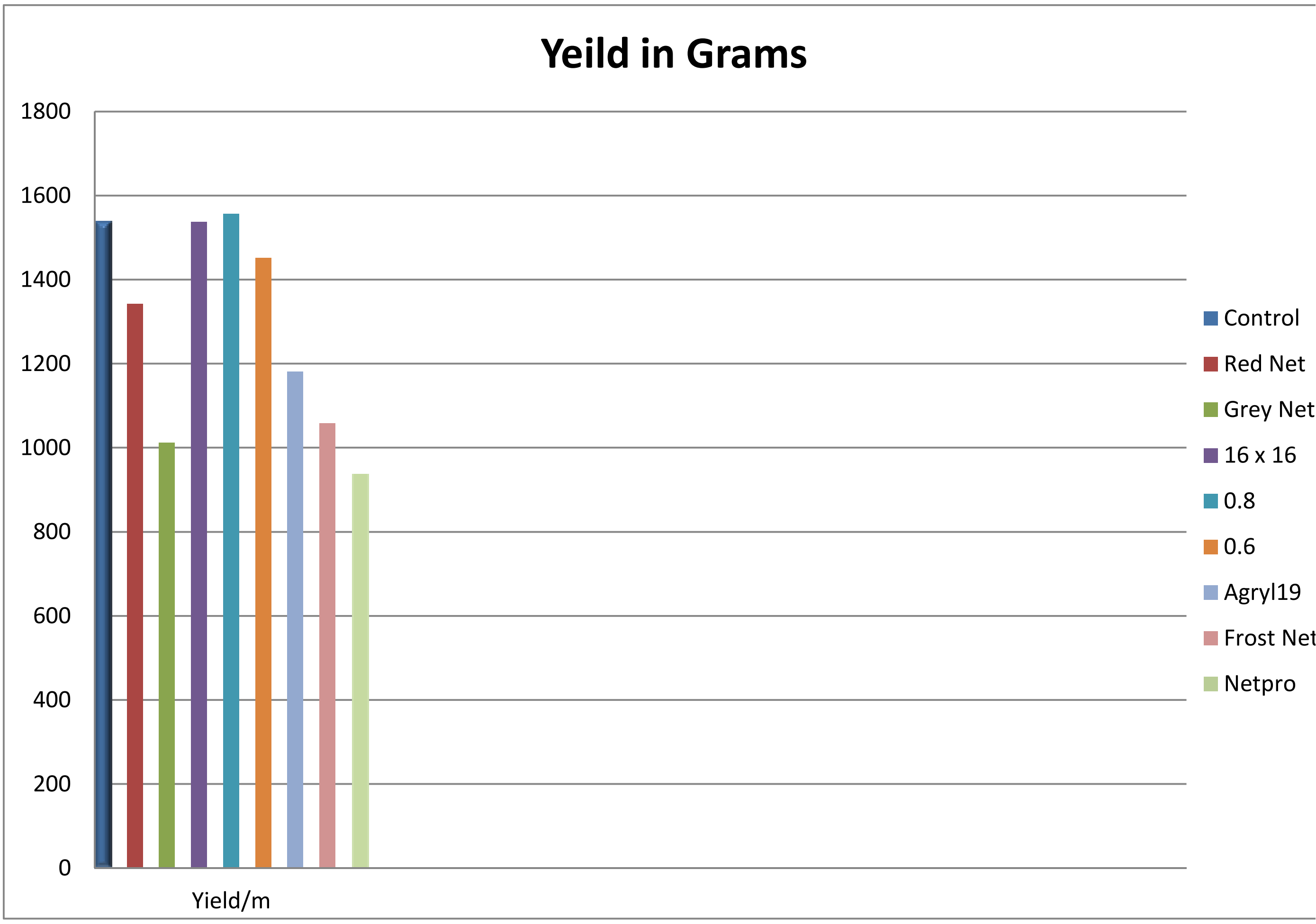
| | **CROP COVER (0.8 mm insect net)** | | | | |
|---|---|---|---|---|---|
| Description | | £ | $ | $ | $ |
| *# of crops per year* | 5 | | | per $m^2$ | per ha |
| **CAPEX** | | | | | |
| 0.8 mm Flea | | 0.33 | | 0.49 | 5,662 |
| **SHIPPING** | | | | | |
| Duty | 5% | | | | 283 |
| ha of net per 40' container | 14 | | | | |
| Shipping (1 x 40') | | | 4,000 | | 286 |
| Clearance Costs | | | 3,200 | | 229 |
| Distributor cost | | | | 0.12 | 1,415 |
| | | | | | 7,874 |
| **Cost of Net** | | | | | 0.16 |
| Crops per year | | | 5 | | |
| Efficiency of land use | | | 77% | | |
| **Total Year 1** | | | | | **10,227** |
| | | | | | |
| **Cost per kg Year 1** | *(kg/$m^2$)* | 1.00 | 50,000 | | **0.20** |

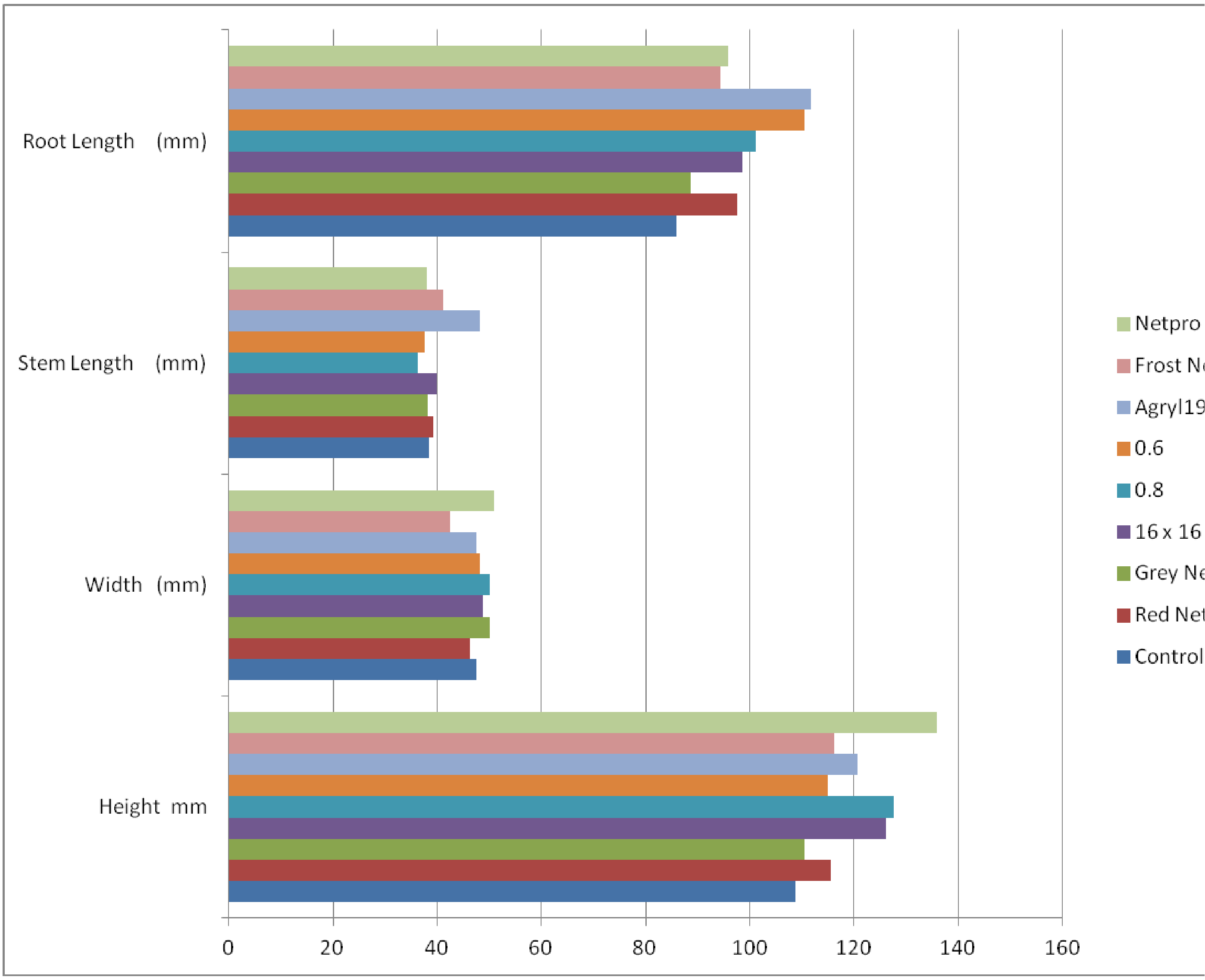
# APPENDIX 5

Various data charts collected throughout the Project

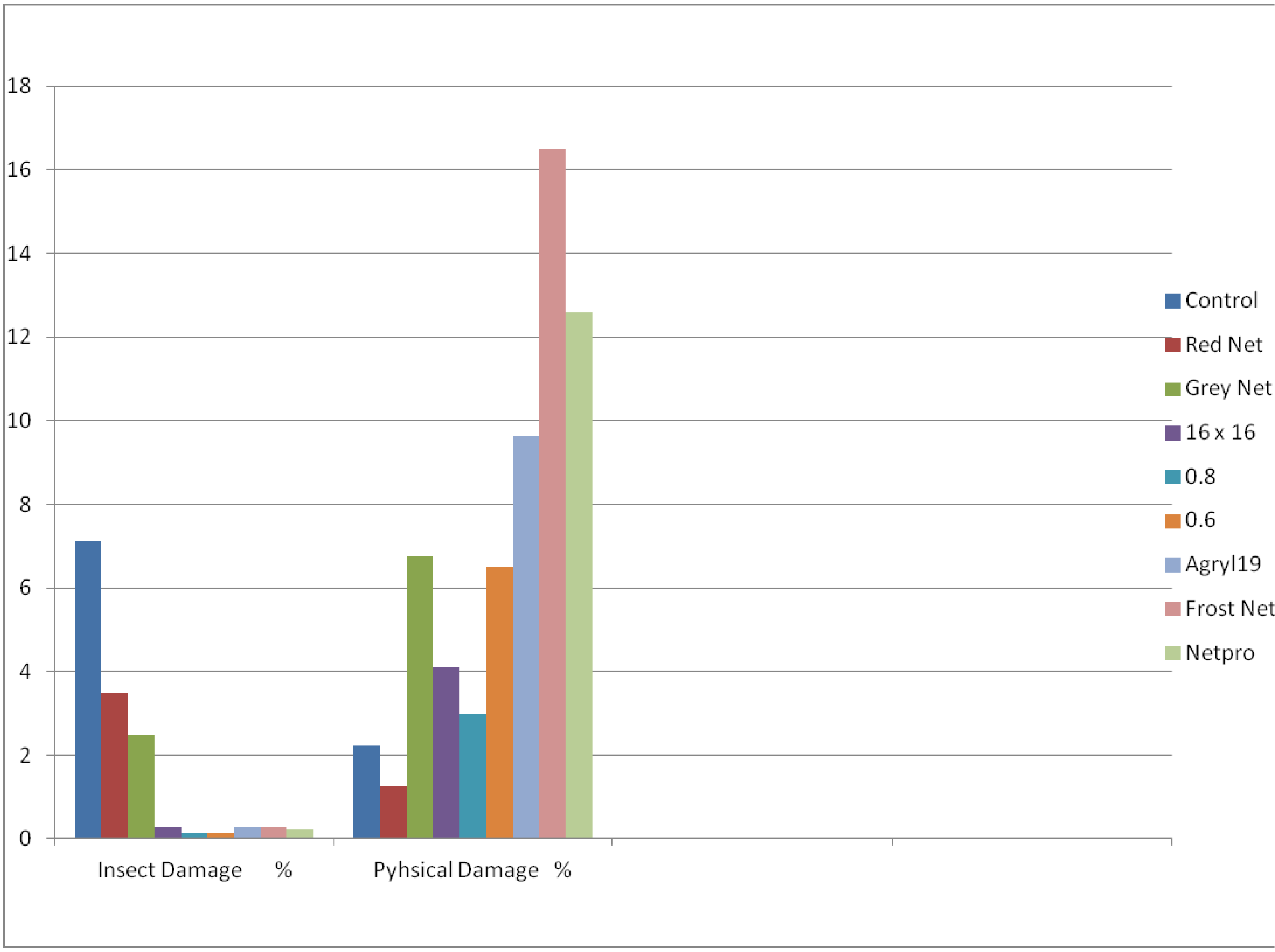



30
25
20
15
10
5
0
Day Temp Avg
Night Temp Avg
Control
Red Net
Grey Net
16 x 16
0.8
0.6
Agryl19
Netpro
Outside Temp


Yeild in Grams
1800
1600
1400
1200
1000
800
600
400
200
0
Yield/m
Control
Red Net
Grey Net
16 x 16
0.8
0.6
Agryl19
Frost Net
Netpro



Root Length (mm)
Stem Length (mm)
Width (mm)
Height mm
0
20
40
60
80
100
120
140
160
Netpro
Frost N
Agryl19
0.6
0.8
16 x 16
Grey Ne
Red Net
Control


18
16
14
12
10
8
6
4
2
0
Insect Damage %
Pyhsical Damage %
Control
Red Net
Grey Net
16 x 16
0.8
0.6
Agryl19
Frost Net
Netpro

# APPENDIX 6

**Brittons WMEM Mizuna by HFC**
**Wacol Plant**

Initial Assessment (composite of all 3) : 1% moisture, 80-200mm
Light soiling, 2% bruising, 10% overlength 160-200mm

**56kg of Mitzuna 19/2/2013 (PM) line 1 - Standard cut in-protected crop**

| GRIDDLE PLATE | HAND SORTED | BATH 1 | BATH 2 |
|---|---|---|---|
| Lots of tiny stones | Soil | 1 twig | 2 tiny insects |
| Soil | Mud | 1 moth | 1 twig |
| Bruised leaves | Insect damage | 6 lady bug | 1 lady bug |
| 1 lady bug | 1 Yellow leaf | 10 tiny insects | 1 soldier beetle |
| Brown spots on leaves | Tiny stones | Minor bruised leaves | Damaged leaves |
| Insect damage | 5 xWeeds | | 1 brown leaf |
| | | | 1 yellow leaf |
| | | | Soil |
| | | | 1 small piece of foam |

**54kg of Mizuna under net (0.8mm Flea-Beetle Cover**

| GRIDDLE PLATE | HAND SORTED | BATH 1 | BATH 2 |
|---|---|---|---|
| Lots of tiny stones | Soil | 3 lady bug | 2 tiny insects |
| Soil | Insect damage | 5 tiny insects | 1 lady bug |
| Bruised leaves | 2 Yellow leaves | Minor bruised leaves | |
| Brown spots on leaves | Tiny stones | | |
| Insect damage | 3 x Weeds | | |
| | | | |

47kg of Mizuna under net and sprayed

| GRIDDLE PLATE | HAND SORTED | BATH 1 | BATH 2 |
|---|---|---|---|
| Few tiny stones | Insect damage | 1 lady bug | 1 ladybug |
| Bruised leaves | 2 Yellow leaves | Minor bruised leaves | |
| Brown spots on leaves | | | |
| | | | |

**Insect population reduction under Crop Covers**

**Analysis**

| Insects | | Other Foreign Bodies | | Insects / kg | Other FB/kg |
|---|---|---|---|---|---|
| | 2 | 1 | | | |
| 1 | | | 1 | | |
| 6 | 1 | | | | |
| 10 | 1 | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | 1 | | |
| | 21 | | 3 | 0.38 | 0.05 |
| | | | | | |
| 3 | 2 | | | | |
| 5 | 1 | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | 11 | | 0 | 0.20 | - |
| | | | | 46% | |
| | | | | | |
| 1 | 1 | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | 2 | | 0 | 0.04 | - |
| | | | | **89%** | |

# APPENDIX 7

**Report on Overseas Visits**

The following section is a report on visits made to Europe during the duration of the project to meet with leading supplier Crop Covers Limited and to meet independently with growers and users of floating crop covers. Whilst these visits were un-funded by and out of the scope of this Project VG09188, the information gained was invaluable to the project and has been included as support material. The following section in italics describes comment, observations and learning acquired during these visits.

*During the course of this project the author visited the UK on 5 separate occasions, meeting with Ian Campbell of Crop Solutions in Perth Scotland, and visiting numerous growers who were using the technology.*

*"I was surprised at the vast amount of fleece and netting being used in South Lincolnshire – there were hundreds and hundreds of acres, perhaps thousands, under cultivation (March/April 2011). I had never seen this scale of adoption in previous visits, although possibly I have not visited at this critical early spring period for a few years. It has certainly become main-stream for salad crops. It should be noted that this region is low lying and close to the sea, and experiences relatively severe winter frosts and coolish summers."*

*"I visited Belgium the following week and saw significant crop areas growing under floating covers. A few weeks later I also observed significant areas of floating covers in northern Switzerland."*

## *Crop Cover Quality:*

Comments made during discussions with Ian Campbell, CEO of leading supplier Crop Covers UK in South Lincolnshire, March 2011. These comments provide the reader with insights into the nature and application of floating crop covers in Europe.

- *As a former grower, Ian Campbell of Crop Solutions has trialled all commercially available suppliers. He rates the suppliers in order of quality as "Good" – France and Germany; "OK" – Spain; "Poor" – Eastern Europe and mainland China.*
- *Quality is described by Ian as uniformity of product, even distribution of the material across the cover, uniformity of application of the UV protection, consistency of stitching, use of the "right" materials, and delivery to schedule.*
- *"With **Fleece** from "good" suppliers you can get 2 years use; from poor suppliers, only one year and the results are inconsistent. The cost between "good" and "poor" fleece is only \$0.015 / $m^2$."*
- *Crop Solutions **Net** products are lasting 10 years+ in Europe and have been in use for 6 years in Asia with no obvious deterioration. Based on this Ian suggests at least 5 years should be achievable in Australia.*
- *Full loads of nets are shipped direct from the factory in Central France and part-loads from Perth, Scotland*
- *Crop Solutions has exclusive distributor rights to French manufacturer Fibreweb. Fibreweb manufacture products to Crop Solutions design and specifications.*

- *Crop Solutions supplies directly to UK, Ireland, Channel Islands, Scandinavia, Australia / NZ and to other global regions via customers who have off-shore operations*
- *Crop Solutions claim Fibreweb products are the best quality*
    - *This was endorsed by a number of customers I visited independently, some of whom used crop covers from several sources.*
- *Crop Solutions source Fleece from Asia, but NOT from mainland China. They describe the product quality and service of crop covers from China as very poor.*

## *Spraying:*

- *Water, fungicides, herbicides, trace elements and fertilisers can all be sprayed through the covers when in solution. The finer nets and fleeces can increase the risk of mildew in wetter periods. Fungicides are typically applied at half the dilution used for unprotected crops and a wetting agent (Silwet) is added.*

## *Uses:*

- *Most popular use of insect nets in UK is for Swede, followed by baby-leaf and then Organics. The major driver around adoption in the UK is supermarkets increasing their demand for zero insect damage and a reduction in fertiliser use.*
- *Ian says 0.8mm Flea Beetle net is his most popular product.*
- *This protects against a number of insects including the Silver Y moth*
- *The pressure to use insect nets is growing. Under supermarket pressure, processors are monitoring factory insect levels – this is the driver.*
- *The principal use of nets is described as follows:*
    - *Insect protection*
    - *Temperature protection*
    - *Evaporation control*
- *You can't drive a tractor over nets and fleeces – the covers cause a 3% wheel slip which pulls the cover over the crop causing damage – the cover isn't damaged, but the crop is. Blank beds must be left to allow for sprayer wheel tracks*

## *Laying Crop Covers:*

- *Thermal **fleece** covers should be applied as taut as possible. The cover will stretch as the plant underneath grows. A loose cover will flap in wind, potentially causing rub damage.*
- *The trial I observed was secured by soil; as the **fleece** is laid, a labourer loosely secures the cover's edge with a shovel of soil every few metres. This is followed by a plough furrow that firmly secures the entire length of the cover.*
- *Polypropylene **Fleece** is beginning to become an environmental issue in UK – single use is creating a lot of plastic, and it is non-recyclable. Growers are paying £85 per tonne for landfill disposal.*
- *One growers I spoke to was getting a 60% grant for re-using **fleece** covers on radish*
- *Ireland is awarding grants for thermal nets (self-sufficiency) and pesticide reduction*
- *Crop Covers Ltd is currently developing a **fleece** that will last for 8 years*
- *The manufacturing of **nets** produces no waste or pollution*
- *On-line customer environmental audit declarations in the UK now include around 40 questions on carbon footprint compared to only 3 questions a year ago*
- *As a rule of thumb, a **fleece** should be the width of the beds + 1 metre. 4,500 $m^2$ is required per acre.*
- *With **fleece** covers you get what you paid for.*
    - *High quality covers can be readily pulled tight whereas cheaper covers will tear.*

  - *Cheaper **fleece** may have poor joins which are brittle and may crack and break.*
- ***Net** covers should be applied loosely and a hoop may be used to prevent the net from contacting the crop. As a rule of thumb, a **net** should be the width of the beds + 2 metres. 4,700 $m^2$ is required per acre.*
- *The use of covers reduces the $N_2$ requirement from 160kg / ha to 70-80kg / ha*

### *Net Recovery:*

- *Recovery is done with the Crop Covers system.*
- *There is no need to wash or brush covers for re-use, but care must be taken to take the covers up cleanly and avoid dragging them over the ground.*
- ***Fleece** is harder to recover and it more porous*
  - *NB heavy soil staining will take the shade value from13% to 40%*

### *Orders (*nets*):*

- *Standard **Nets** take 4-6 weeks to manufacture*
- *A non-standard **net** takes 16-20 weeks to set up on a loom*
- *A single Loom produces 400 linear metres per 24 hrs*
  - *One loom produces 1 acre of woven net in 2 days*
  - *It takes one week to reset a loom to a new weave (similar to textiles)*
  - *It takes 120 machine days to make a full shipping container*
- *Multiple looms are used – the loom design is very important – China and Eastern Europe tend to use old, worn and antiquated looms, hence the quality of **net** is inferior*
- ***Net** is typically 5 to 6 times the cost of **fleece** – it contains 70g of material / $m^2$ (compared to 17g / $m^2$ for **fleece**), and has sewn joins and seams compared to welded seams for **fleece**. Cheaper competitors use low strength polypropylene thread to seam and join **nets** whereas Crop Covers specify very strong polymer threads.*

## *Meeting with Ian Campbell Crop Solutions*

*Perth Scotland 9-10th September 2012*

*Nets*

- *Protection of Swede is the biggest crop cover use in Europe, followed by radish, organics & lettuce*
- *1.3 mm net is typically used for cabbage root fly protection*
- *Competitor's woven joins are poor quality – they stretch and flies can lay eggs through it*
- *Crop Solutions have developed sewn joins. These are much higher quality*
- *When you pull the net you need to bunch it to prevent stretching pressure on the joins*

*Fleece*

- *Early Swede crop is sown and covered in fleece*
- *The 1.3 mm net protection is applied 3 weeks later*
- *The harvested yield of Swede is typically 2 to 3 times better than unprotected product*
- *On unprotected block birds and rabbits removed many of the plants*
- *Spain uses fleece for early crops and nets for organics*

*Costs & Specs*

- *Very few Asian companies can make the larger widths. Asia can only offer 2, 3, 5 metre widths; Ian can source 12, 16, 20, 25 m widths*
- *Pricing has increased 40% over the last few years*
  - *In 2008-09 UK cost of nets were typically £0.23 / $m^2$*
  - *Now the cost is £0.29p / $m^2$*
    - *They are oil-based products*
    - *Shipping costs have double in last 12 months*
    - *Costs of sewing widths together has increased*
      - *NB prices above are indicative only*
      - *Prices will vary with volume and specification*
      - *Australian costs will be impacted by freight, foreign exchange, duty, clearance and distributor costs*
  - *Widths up to 5 metres are un-sewn*
  - *Fleeces can be supplied as 250 & 500 metres long (polypropylene)*
  - *Nets are supplied as 50, 100, or 200 metre long (HDPE)*
- *Nets contain much more material and are therefore heavier – a 200m length weighs around 500kg*

*Crop Solutions Limited (CSL)*

- *Ian was the first grower to use insect net*
  - *CSL design all of their own nets*
  - *CSL has bought industrial sewing machines and has designed the threads for sewing nets together*
  - *CSL has 12 years experience in textiles and logistics*
  - *CSL is the largest European supplier by volume*
  - *Their supply base is tried and tested*
- *There is a massive market in the UK for second-hand net*
  - *Damaged fly net is being sold after 10 years as bird-net for 50% of the current cost (£0.12 v.£0.24)*

## *Observations and comments from independent Grower visits:*

## *Grower 1 (G1):*

- *Mainly uses fleece as a thermal protection for whole head lettuce. They grow 400 ha of leaf salads and harvest 42 million heads a year. A "sister company" farms 600 ha, and produces whole head and baby-leaf.*
  - *"The field I saw was growing Salanova under thermal fleece topped with clear, perforated polythene sheet (a double layer). The crop had been planted in early March (late winter in UK, and the poly was removed in early April, leaving the fleece underneath intact. This process was claimed to create a 60 day seed to harvest cf to 90 days for unprotected crop."*
  - *GPS guided tractors prepare beds to 2 cm accuracy; the same guidance was used to close net edges. This grower secured the nets by heaping a furrow of soil along the edge. But it is harder to take the fleece up without damage as the weight of soil causes it to tear*
  - *Caution: fleece is sensitive to $Cl_2$ and will break down more quickly if town water is used for irrigation"*
- *G1 used net extensively to protect head lettuce against pigeon damage. The drivers for this grower's adoption of crop covers are salad processors and supermarkets who require unblemished heads. Sandwich makers require even higher quality. Sandwich makers are 3% of G1's business. G1 indirectly supply all the major retailers and food service customers in the UK. They start planting in week 9 (early*

*March) and finish 1st week of September. They maintain fleece cover until week 14. G1 was planning to grow all of their Cos lettuce under net protection this year.*

- *Their growing region is considered to be at fairly low risk to insects, as the climate is cool and a diverse range of crops is grown in the region.*
- *Poly increases temperatures by 5-6$^0$C.; fleece increases by 2-3$^0$C., but also allows much more air movement than Poly*
- *Soil temperature of 5$^0$C required for growth; >25$^0$C. growth slows*
- *G1 is also successfully growing baby-leaf under netting in North Africa, December to March; however, they are experiencing problems with poor quality fertilisers available there*

## *Grower 2 (G2):*

*G2 is a very large UK mixed crop vegetable grower, packer and marketer. They operate extensive farming ventures located across the Europe and North Africa.*

*G2 applies fleece to early season head-lettuce (iceberg, cos), radish, and root crops to provide microclimates that advance first harvesting by several weeks. They also use floating nets to protect baby-leaf spinach and rocket and 100% of their rocket crop is protected. G2 purchase fleece and net from several sources. Their leading supplier of crop covers is Crop Solutions Limited.*

*The author visited G2 in March and July 2012 and observed baby-leaf growing operations where entire paddocks of rocket were covered in insect net from post seeding to harvest.*

*Some crops were grown under a low hoop system where the net is supported 200 mm above the crop growing below. This allows the rocket to grow without stem length restriction and minimises rub-damage to the leaf that may otherwise be caused by the cover for this particular crop. The hoops are laid and retrieved by machine. G2 also used a tractor mounted roller device for laying and retrieving the covers.*

*The nets observed by the author were 2 years old and had been used multiple times over each successive season. G2 commented that they were still using some nets that were 7 years old. Grower G2 has invested more than $1 million in crop covers and associated equipment and strongly believes that these investments are commercially justified.*

*Whilst this process adds additional cost to the protection system in both labour and materials, G2 is able to create and justify additional value to their crop. The benefits derived were claimed to be earlier and extended season, more consistent leaf, insect protection without the use of pesticides, bird protection, rain/hail protection and cleaner leaf. These benefits all cumulated in a reliability and consistency of supply that was highly valued by their supermarket customers.*

*G2 extensively used fleece covers (again largely sourced from CSL) for the early season establishment of many crops. Crops sown in late winter benefit in the early establishment phase from frost protection, wind protection, bird and insect protection and enhanced soil temperatures which promote speed and consistency of early germination.G2 was using tractor mounted machinery to remove tethering pegs, hoops and the crop cover.*