European Innovation Partnership (EIP) Wales

Using Photoselective Films to Enhance Profitability of Leafy Salad Production in Wales

Annual Report - 2020

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1 Introduction

Leafy salad and herb crops are common components of mixed horticultural production holding in Wales, and while some products (e.g. iceberg) have such low profit margins that it can be difficult to compete with the supermarket trade, other leafy crops that can be marketed on the basis of colour or flavour can be an attractive crop type. These crops also benefit from the small supply chains typical of Welsh production, promoting the conservation of leaf colour and flavour. These are typically grown under protection to improve quality and extend the season, usually under plastic polytunnels as a low-cost alternative to glass. This creates an opportunity for growers to exploit newly emerging technologies, such as plastics which manipulate light quality to drive improvements in outputs through manipulation of the growing environment. Photoselective plastics can manipulate the growing environment in a variety of ways. The direction of light can be altered by diffuse plastics – normal sunlight travels in a single direction giving a high level of shadow as upper canopy layers achieve the greatest level of exposure. Plastics which scatter light to achieve a more homogenous distribution of light within the polytunnel allow light to penetrate deeper into the canopy giving greater productivity and potentially increasing yield outputs. This is also important in maintaining leaf quality in older leaves lower down in the canopy, helping to maximise the proportion of the crop that is marketable. In addition to light direction, light quality can also be manipulated to impact a variety of plant quality indicators. Leaf dimension, pigment quality, flavour/antioxidant content and postharvest longevity can be altered by the use of plastics which selectively transmit only part of the spectrum to enhance the red, blue or UV proportion reaching the crop. This effect is used in high-control vertical farming using LED light sources, but photoselective plastics can provide growers access to the approach at a fraction of the cost.

The relative novelty of this approach, coupled with a scarcity of information regarding the practical use of these materials, can be a hinderance for growers wishing to unlock these benefits on their holdings. This EIP project was set up to demonstrate the benefits of these plastics for leafy salad production Wales, and to provide evidence as to how best they can be utilised.

2 Trial Design

The project set out to test a range of photoselective plastics at two sites in North Wales (Mostyn Kitchen Garden, Holywell, and Hooton's Homegrown, Anglesey) over the course of three growing seasons. Due to delays with the onset of the Covid-19 outbreak a single planting was achieved in 2020, but it is anticipated that multiple successive plantings will be carried out in 2021 and 2022 to test the impacts of plastic use over multiple seasons.

The plastics used in the trial are summarised in **Table 1** below. These were chosen on the potential to achieve a variety of affects, alongside the inclusion of a clear plastic and a bare ground control to allow comparisons

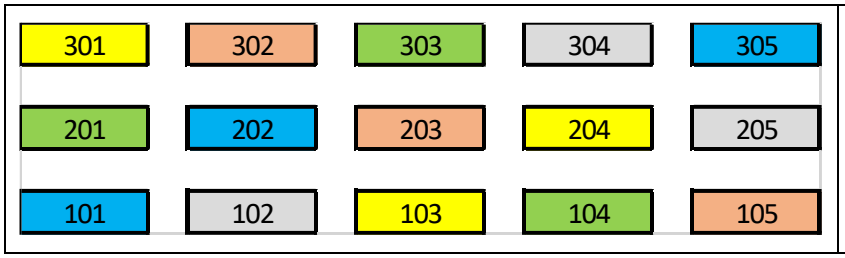
to be made with typical production methods. These plastics are commercially available, and were obtained from an industry supplier to ensure that other growers can easily adopt this approach on their sites.

Each plastic was used to skin individual low polytunnels with 1x3m footprint and a 1m maximum height (**Figure 1A**). These were designed to be mobile to allow for soil cultivation and planting, alongside liftable sides to provide ventilation and provide access for watering. Three tunnels skinned with each plastic (or equal area of bare ground) were used at each site in a randomised block design to provide statistically viable results (**Figure 2**). Three typical leafy salad cultivars were planted under each tunnel at typical commercial densities of 9 plants/m^2 in a replicated block pattern (**Figure 1B**). Lollo Rosso (curled red leaf), Lollo Bionda (curled yellow) and Green Oakleaf (open head) were chosen as representative commercial cultivars which showed a range of quality indictors that are likely to be impacted by the plastic treatment such as leaf pigmentation, canopy shape and shelf life.

Table 1. Photoselective plastics used in the trial. A clear plastic and a bare ground treatment was included for comparison as a control.

Plastic	Properties	Proposed Benefits
Clear	Conventional clear plastic.	Microclimate modification, high light transmission.
Diffuse	High light scattering.	Increased light penetration into closed canopy, improved older leaf condition.
Blue	Absorbs red and green portion of the spectrum, transmitting blue light.	Compact habit and enhanced colour development in pigmented leaves.
UV Blocking	High transmission light transmission but UV blocking.	Enhanced pest and disease control.
Untreated	Bare ground	N/A

Figure 1. A - Example tunnel at harvest. The tunnels were designed to have retractable sides to allow access for watering and harvest. **B** – Replicate block planting of Lollo Bionda, Green Oakleaf and Lollo Rosso taken from a bare ground control plot.



Treatment	Plastic
1	Untreated Control
2	Clear
3	Blue
4	Diffuse
5	UV Blocking

Figure 2. Trial area layout replicated at each site. Each tunnel had a 1x3m footprint.

Following germination and establishment in trays, plug plants of each cultivar were planted on the 3rd and 4th September. Plots were examined for plant damage (e.g. slug/rabbit), pest/disease incidence and agronomic oversight every two weeks until harvest on the 7th and 8th October. After harvest individual plant height and marketable weight and diameter, leaf number and condition was assessed. Leaf colour and area were also recorded.

3 Results

3.1 General Crop Responses

Good harvests were achieved at both sites in all treatments, with marketable produce being harvested from all treatments. Representative pictures of the crops at harvest are given in **Figure 3** below. Clear differences were present between the bare ground treatment and those under plastic – smaller, more compact plants were produced most likely as a result of the cooler temperatures seen without plastic. Growth responses were relatively comparable between the clear, diffuse and UV-blocking plastics, although the blue plastic treatment produced slightly smaller and more compact plants compared with the other treatments. Pigmentation differences were evident, particularly in the Lollo Rosso, with the strongest colour seen in the bare ground treatment, although this may have been linked with the reduced plant development seen in open field growth. The pigmentation of the Lollo Rosso was generally reduced in the plastic treatments, more significantly in the blue and UV blocking plastics. However, general marketability of the crops was good across all treatments and the plastic use did not show any significant detriment to production.

Figure 3. Representative photographs of crops at harvest.

3.2 Analysis of Yield and Quality Indicators

There was no significant statistical difference across the samples at either site for any of the parameters measured, so measurements were pooled and treated as a single sample for analysis. Due to the small number of heads planted, and the impact of pest damage in the control plots, treatments were analysed on a per head basis rather than per m^2 to minimise the impact of this effect on the trial. It should be noted that this analysis is based on a limited number of assessments (three heads per plot, or 18 heads per treatment in total) and so will carry significant margins of error, although this will be addressed with the multiple plantings planned for the 2021 and 2022 seasons.

Bare ground gave the lowest marketable head weight compared with the plastic treatments, although the blue plastic treatment also gave reduced overall yield (**Figure 4**). Greatest yields were seen in the Green Oak Leaf in the clear, UV blocking and diffuse plastics, with a marginally greater yield in the latter. Average yields for Lollo Rosso and Lollo Bionda were greatest under the UV blocking plastic, although these differences were not significant compared with the clear and diffuse plastics. Head diameter for Green Oak Leaf was greatest in the UV blocking, diffuse and bare ground treatments (**Figure 5**), although there were no significant differences between these averages. There were no significant differences in head diameter between the treatments, including the bare ground control. There were no significant differences in the marketability of crops between the treatments.

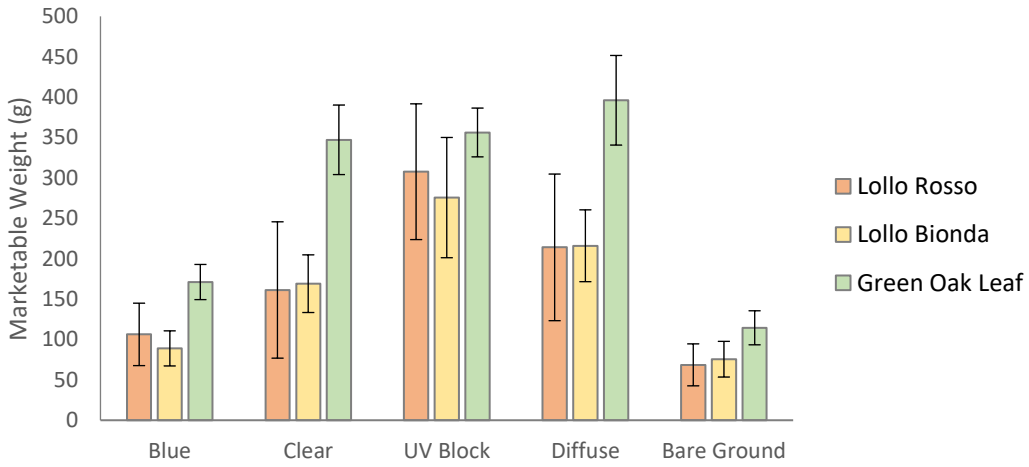


Figure 4. Average individual head weight at each harvest averaged across both sites.

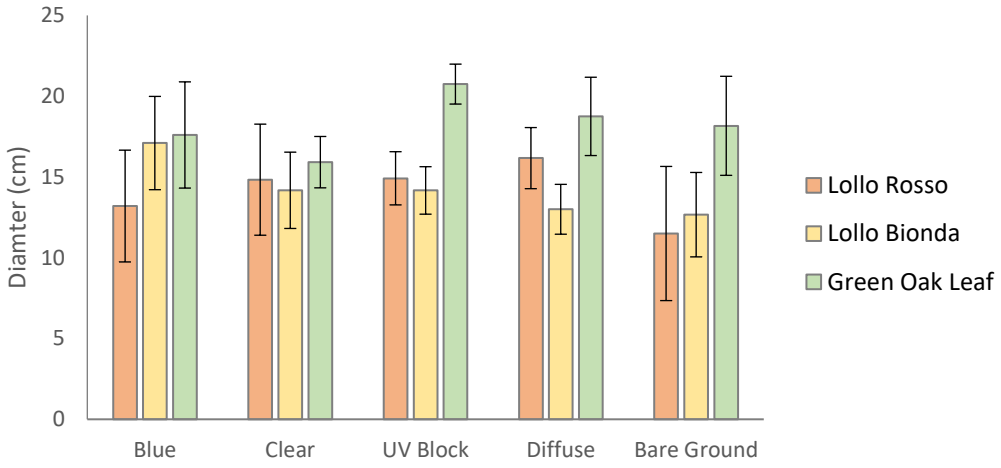


Figure 5. Average head diameter at harvest, averaged across both sites.

In terms of overall impact, plastic protection has a beneficial impact on yield. For the Green Oak Leaf, there were no significant differences between the clear, UV blocking and diffuse plastics, which may indicate that the benefits of protection may be linked primarily with the microclimate modification as opposed to light manipulation specifically. However, both Lollo varieties gave a greater (although not statistically significant) marketable weight in the UV blocking and diffuse treatments compared with the clear plastic. The curled nature of these varieties leads to a more compact head compared with the Green Oak Leaf, so the increased scatter of the diffuse plastic may be beneficial in aiding light penetration into the head.

3.3 Leaf Colour

Leaf colour was measured through two routes: i) SPAD value, as a measure of the total leaf chlorophyll content (depth of green) and ii) Colour Index, a quantitative expression of leaf colour on a transition from red (positive) to green (negative). SPAD value was greatest in the blue and bare ground treatments, with only marginal differences in chlorophyll content seen between the clear, UV blocking and diffuse plastics (**Figure 6**). Similarly, there was also a significant impact of treatment on leaf colour index, particularly for Lollo Rosso. The greatest depth of red colour was seen in the bare ground treatment, with the plastic treatments showing weaker pigmentation and increased proportion of green. This was most pronounced in the blue plastic treatment, where the average colour index for Lollo Rosso was approaching that of the Lollo Bionda and Green Oakleaf varieties.

As a general response leaf colour is the inverse of that seen in overall yield – the deepest green colour was seen in the blue plastic and clear ground treatment, alongside the lowest yield. The increase in colour may be due to a variety of effects. Firstly, smaller more juvenile plants with less expanded leaves may show increased pigment content, especially if these are grown in colder conditions – this may also result in the increased red pigmentation in Lollo Rosso grown under bare ground.

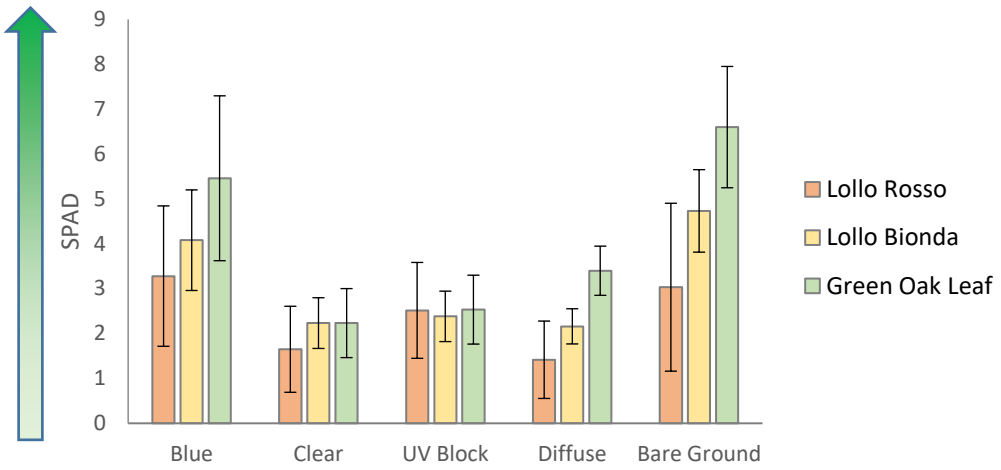


Figure 6. Average SPAD value across plastic treatments. A greater SPAD value indicates increased chlorophyll content, giving a greater depth of green to the lead material.

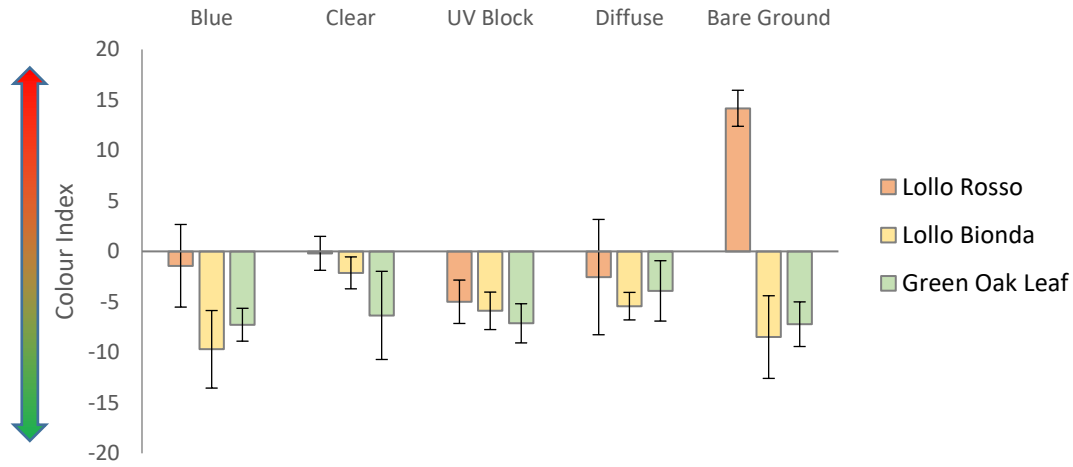


Figure 7. Average colour index values for each variety grown under plastic treatments. A more positive value indicates a deeper red, whilst a lower or negative value indicates increased greenness.

3.4 General Comments

Other areas of agronomic focus were also identified during the trial. Tunnel use provided a suitable protection from larger pests like birds and rabbits, although the bare field treatment did see some damage. This will be addressed in the next season using netting to prevent access after planting. Conversely, there was an increased incidence of slug damage under plastic protection, mostly likely as a result of the more humid environment. This necessitated the increased use of slug pellets to limit damage, although the use of ferric phosphate slug pellets is compatible with organic production and does not carry the environmental problems of conventional metaldehyde pellets. There were no significant pest/disease issues seen in this trial, although these are liable to be more of a concern in later plantings as temperature and humidity within the tunnels are likely to increase in the summer period. Growers would need to respond to this with careful control of the tunnel vents and control programmes to mitigate any increased risk.

4 Summary of Year 1

Despite the significant challenges created by the Covid-19 epidemic, the initial trials of this project have been successfully implemented, and a single complete growing cycle for leafy salads completed. We have been able to demonstrate that the use of plastics can improve overall productivity, and have started to develop the evidence case for the use of light-modifying plastics in leafy salads production. Use of the UV blocking plastic in particular has improved yield outputs, potentially as a result of providing both a modified microclimate and light spectra that is reduced in oxidative stressors for the plants. The evidence produced also highlights a trade-off that may be seen between gross yields and marketable quality – the conditions that gave the greatest yields gave the weakest colours. For green salads products like the Oak Leaf Green and Lollo Bionda this may not be of a concern, but may be an issue for the marketability of the Lollo Rosso variety which can be marketed on the basis of a strong red colour. However, the leaves of Lollo Rosso grown under these conditions did still show some pigmentation, and were not scored as unmarketable in the round, so this may be of negligible influence when marketing to customers.

The evidence obtained so far is from a single trial at the end of the season, and therefore the impact of the results is limited. Firstly, further replication will be required to improve the precision of the results and reduce the impact of anomalies, and this can only be achieved through additional replication. Secondly, this evidence was developed for a crop grown in early autumn, where shorter daylengths and lower temperatures are likely to have impacted overall production. It will be necessary to further test the impact of these materials in crops grown in the summer period, particularly as this will overlap with key periods of customer demand. This period will also overlap with periods of increased risks of pest and disease development as a result of longer, warmer days, and increased risk of high humidity in protected structures. These periods are also when the additional benefits of the photoselective plastics, such as the UV- blocking plastic, have potential to have a more significant impact compared with clear conventional plastics.

5 Plans for the Next Season

The trial approach adopted this year will be continued into the 2021 season, with the first production cycle starting in March 2020 once the risk of frost has lifted. It is anticipated that the tunnels will be used for continuous production though successive plantings, producing a large volume of evidence relating to the benefits of this approach. Adaptations will be made to address any encountered pest/disease risk and to develop practical expertise relating to the use of plastics and their impact on crop management. This will also allow for assessment of the plastic properties to be made over continued use to test for the impacts of the degradation of plastics on their ability to drive favourable responses in the crop.