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

Annual Report – March 2022

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1 Introduction

This project sets out to test the benefits of innovative plastic films for leafy salad production in Wales. The use of films which manipulate the quality of light reaching the crop has potential to enhance the colour or flavour of salad products, alongside improving produce quality, reducing pest/disease damage or growing times to improve the economic returns from these crop types. This project trials the use of diffuse plastics which increase light scattering to drive photosynthesis in the lower canopy, blue and UV-blocking plastics to modify the spectrum reaching the plant in comparison with clear plastic and open field production. These plastics were tested against a range of salad varieties – the open Green Oakleaf, the red curly Lollo Rosso and yellow curly Lollo Bionda. These show a contrasting range of growing habits and desirable market characteristics.

A single trial in the 2020 season demonstrated that the use of plastic protection was widely beneficial for overall yield compared with bare ground production, although the results suggested that the UV blocking and diffuse treatments can give the greatest benefit, in particular for the red and yellow Lollo Rosso and Lollo Bionda varieties respectively. In terms of colour the greatest pigmentation in the red Lollo Rosso was seen in bare ground, with plastic treatments giving lower overall colour. However, these results were obtained from a single trial in the late season, and it was necessary to repeat these trials across a typical season to test whether these findings were truly representative and whether any other interactions (e.g. the impact of high temperatures and high light in the summer) can be seen which would need to be accommodated by wider commercial implementation. To this end, trials were implemented in the 2021 season to address these points, while accommodating findings from the previous season to increase the meaningfulness of results.

2 Project Development for the 2021 Season

The core project methodology from the 2020 season was repeated at Mostyn Kitchen Garden, Holywell (site 1) and at Hooton's Homegrown, Anglesey (site 2). The overwintered tunnel frames were still in a robust and usable condition following winter, and were reskinned with the same plastics used in the 2020 trials. The same range of varieties (Green Oak, Lollo Rosso and Lollo Bionda) were planted as propagation plugs at the start of each trial run. Rotary cultivation, followed by granular fertiliser (125 kg/ha 20:10:10 equivalent) and organic slug pellet application preceded planting. The only principal modification was the use of a rabbit wire cage of the control plots at site 2 to mitigate the impact of rabbit damage on the trial (**Figure 1**). Rabbit damage was not of a concern with any of the plastic treatments, nor the plots at site 1. For full scale cultivation it would be recommended that a permanent fence is dug in around the entirety of the cultivation area to avoid the additional labour requirements of this approach.

Figure 1. Rabbit wire cages placed over the control plots at site one to limit pest damage. Sheets of heavy duty wire were suspended over the plots with stiff tubing, and dug in with stones around the perimeter.

Weather conditions in 2021 also proved problematic for establishing the trials. Hot, dry weather in April and May made planting and establishment difficult under dry soil conditions. Alternating dry and wet weather later in the season also made crop establishment difficult, especially balancing differing requirements between plants grown under protection (e.g. all the plastic treatments) and those grown in an unprotected control in terms of irrigation and managing temperature/humidity in the tunnels.

In addition to temperature effects, there were significant challenges for weed control, particularly at site 2 (**Figure 2**) due to proliferation of groundsel and willowherb. Weed control in salad leaf can be problematic, particularly for groundsel as it is in the same family as lettuce (Asteraceae) and is hard to control with available herbicides. The cold spring and dry June would have further impacted weed control – slow seed germination would have impacted the ability to effectively achieve a sterile seed bed prior to planting, while dry soils at planting would have reduced the efficacy of residual herbicides sprayed before planting. Large scale commercial plantings will frequently use mechanical harvesting with two or three passes in midsummer to aid weed control. Mechanical weed control was not possible with the tunnels used in this trial, and so weed growth was increased relative to what would be typical of commercial practice. However, this did not adversely impact the results of the trial, and harvested produce were still within typical commercial specifications.

Figure 2. Weed proliferation in trial plots.

Logistical issues, especially due to the ongoing covid-19 epidemic, also impacted trial implementation, although three successful plantings were achieved. Trials were planted 17th May (site 1) and 18th May (site 2) and harvested on the 23rd June and 24th June respectively. The second trial was planted 7th July (site 1) and 8th July (site 2), before being harvested 17th and 18th August. The third trial was planted on the 6th October (site 1) and 7th October (site 2), before harvest on the 17th and 18th November respectively.

3 Trial Design

Trial design replicated processes utilised in the 2020 trials. 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 3A**). 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 as each site in a randomised block design to provide statistically viable results (**Figure 4**). 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 3B**). 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 indicators 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 3. 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.

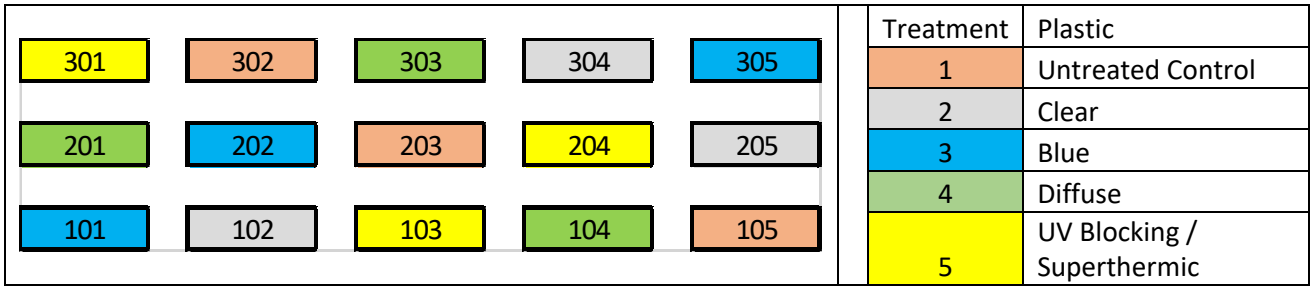

Figure 4. Trial area layout replicated at each site. Each tunnel had a 1x3m footprint.

Following germination and establishment in trays, plug plants of each cultivar were planted on the 3rd and 4th September. After harvest individual plant height and marketable weight and diameter, leaf number and condition was assessed. Leaf colour and area were also recorded.

4 Results

4.1 General Crop Responses

Concurrent with the findings from 2020, harvests were taken at both sites in all treatments despite the difficult start to the season. However, there was more uniformity in responses between treatments and the control from harvests taken over the summer period compared with the autumn harvest taken in 2020, with more comparable harvests taken from the bare ground compared with the plastic treatment. This is most likely to be due to improved climate around the plant achieved by the summer weather reducing differences in temperature-limited growth between the protected and open plots. Besides yield, there were more pronounced differences in quality between the varieties, corresponding with findings from the 2020 season.

4.2 Analysis of Yield and Quality Indicators

Total head weight was relatively consistent between treatments, with no significant differences between plastics or open ground for all three varieties (**Figure 5**). There was a minor (but not significant) increase in yield for the Oakleaf under clear plastic relative to the other treatments. This was in contrast to the results from 2020, whereby the blue and bare ground treatments gave significantly smaller yields compared with the clear, UV blocking and diffuse plastic. However, given that greater light and temperatures will have been seen in the summer months, and plants harvested before bolting it is likely that the warming benefits of plastic and differences in total light transmission will be less pronounced. However, there were small differences in head diameter between treatments, particularly with the blue plastic giving smaller, more compact heads compared with the other plastics, whilst the clear plastic gave larger heads, although these were not statistically significant (**Figure 6**). Head quality was reduced for the green oak leaf across all plastics treatments (**Figure 7**) although this was largely due to increased propensity for bolting compared with the other two varieties leading to a reduction in overall quality scores.

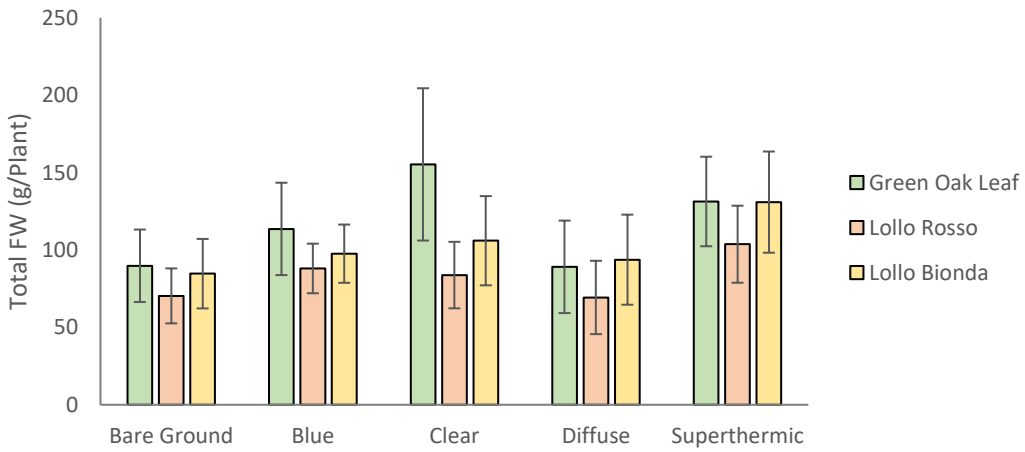

Figure 5. Average individual head weight at each harvest averaged across both sites.

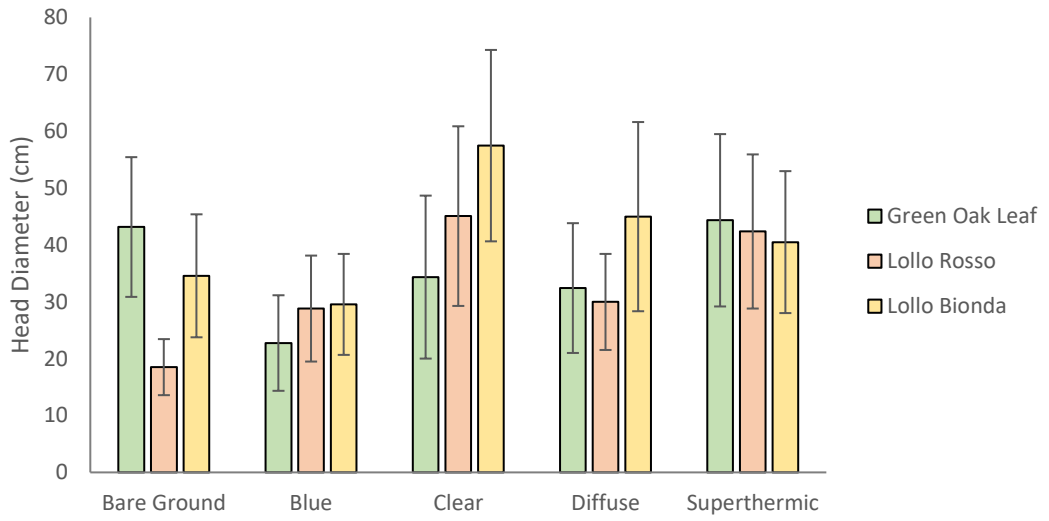

Figure 6. Average head diameter at harvest, averaged across both sites.

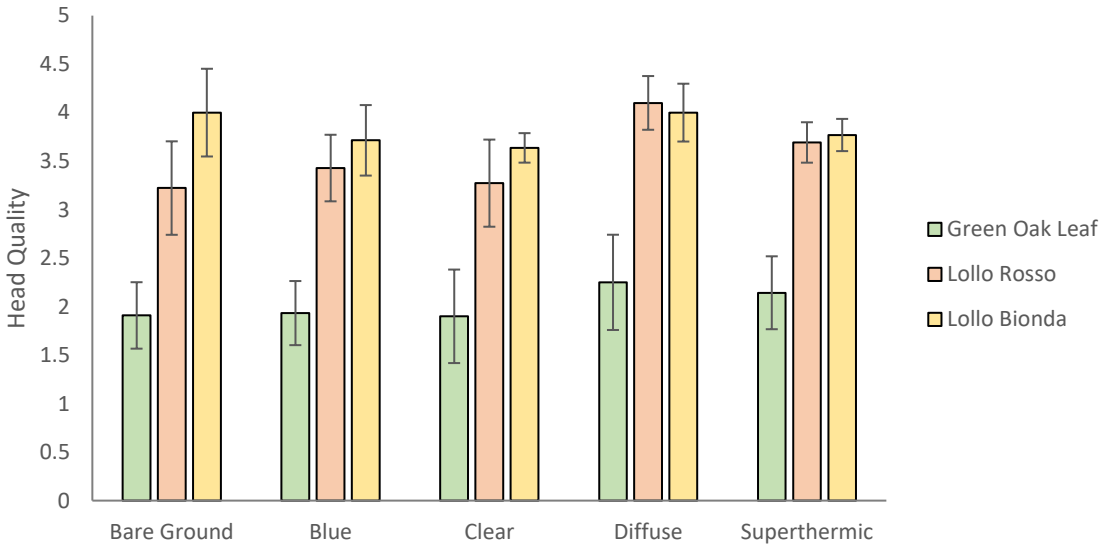

Figure 7. Average head quality (scored 1 – 5, with 5 being greatest) at harvest.

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.

4.3 Leaf Colour

Leaf greening (as examined through chlorophyll content, assessed through use of a Soil Plant Analysis Development (SPAD) chlorophyll meter) showed relatively consistent chlorophyll content in the Green Oakleaf

between plastic treatments, with no significant differences (**Figure 8**). However, for the yellow Lollo Bionda there were significantly lower SPAD values recorded for the blue, clear and diffuse plastic treatments. However, given that yellow pigmentation is a desirable market characteristic this is not considered a negative output.

Red colour development in the Lollo Rosso was stronger across all treatments compared with the trial assessed in the autumn of 2020, most likely as a result of strong light and dry soils over the summer period (**Figure 9**). In 2020 the blue and diffuse plastics gave the strongest pigmentation of the plastic treatments, and similar results have been seen in the 2021 season. It is noteworthy that the UV-blocking plastic gave the weakest pigmentation development of the plastic treatments in both 2020 and 2021.

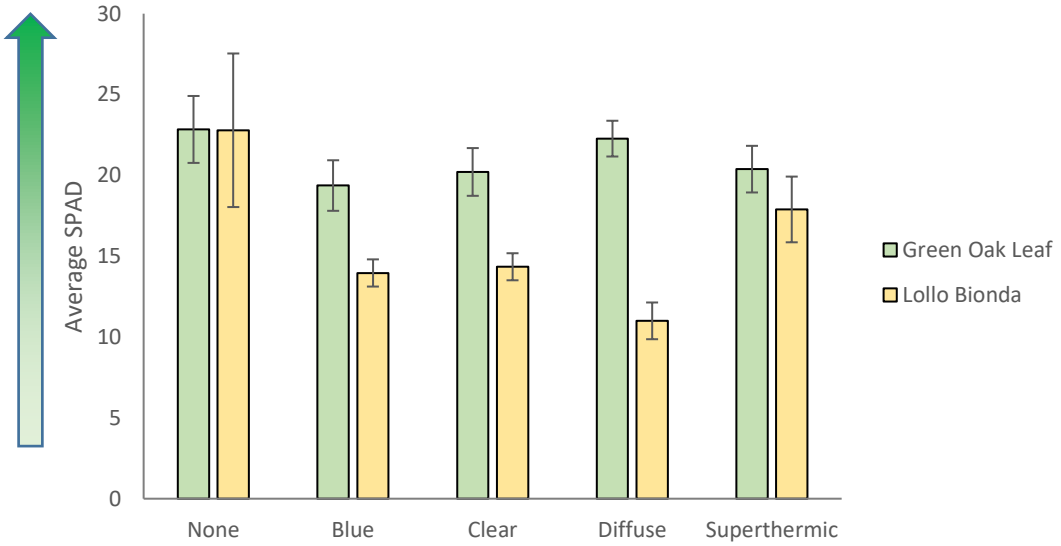

Figure 8. Average SPAD value across plastic treatments. A greater SPAD value indicates increased chlorophyll content, giving a greater depth of green to the lead material.

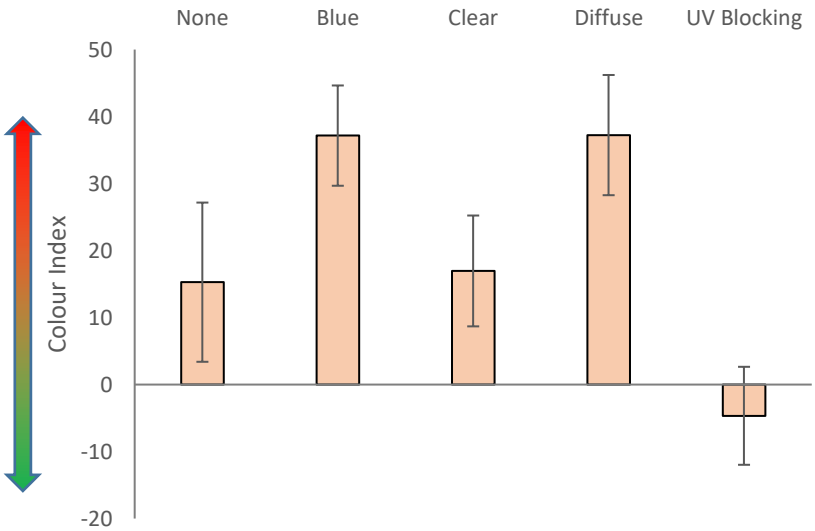

Figure 9. Average colour index values for the red Lollo Rosso variety grown under the plastic treatments.

4.4 General Comments

Results from this season have continued to support the use of plastic for leafy salads production, producing more uniform plants that were less susceptible to bird/pest damage. Improved control of rabbits in open controls, and slugs (using organic approved ferric phosphate pellets) helped to ensure a representative crop was grown at both sites. One issue not identified in the 2020 season was the increased risk of weed development created through the use of the low tunnels. These provided a physical barrier making mechanical weeding more problematic, whilst improving the growing environment for germinating weed species. Whilst these problems are typical of wider salad leafy production, they were exacerbated by the use of the low experimental tunnels. However, once scaled up to full commercial practice conventional weed control measures would be more practical to implement. Furthermore, tunnel use in the longer term may reduce weed pressure by limiting seed ingress into the growing environment. There have been no incidences of disease development, even under hot and humid conditions in the summer, which is a positive finding from this season.

5 Summary of Year 2

The continuation of this project has further demonstrated the benefits of plastic use for leaf salad production, particularly in terms of promoting early harvests, uniformity of crop and greater marketable qualities in speciality cultivars. It is noteworthy that the benefits of plastic use appear less clear cut in the summer periods, although this corresponds with a time that outside conditions are likely to be optimum for salad leafy production, and the majority of commercial production is moved outside of protection. There was some concern that increased temperatures and humidity under the plastic treatments would have led to a significant uplift in disease development, reducing the efficacy of these growing systems in the summer months. However, this has not been identified and therefore tunnels of this design could be utilised throughout the year to access other benefits of protected cultivation, including the benefits of enhanced pigmentation seen with the blue plastic. For the Lollo Rosso variety in particular the blue plastic treatment gave significantly greater colour intensity compared with the other treatments, but also the most compact head size compared with the clear plastic.

Whilst problems associated with disease were not identified, issues with weed management were encountered this year. Whilst this may have been exacerbated by conditions in the 2021 season it is likely that these issues would be encountered by growers using this approach on a more routine basis. Weed management for leafy salads – especially on the small scale that it is likely to be grown under on Welsh holdings – can benefit considerably from mechanical or hand weeding where possible. While large-scale mechanical approaches (including robotic weeding) are unlikely to be suitable for protected cultivation, it may be worth exploring whether plastic treatment has any specific impact on weed proliferation. However, this

should not be considered a specific disadvantage of this approach as it is likely that commercial scale production would be carried out on a significantly large scale whereby increased crop access could be achieved to facilitate hand weeding.

6 Plans for the Next Season

It is intended that a final trial will be implemented in the spring of 2022 before the completion of this project in April 2022. This will complete the evidence available by allowing the photoselective plastics to be tested at all points in the season. It is anticipated that plastic use will be of benefit in the early season by warming the environment around the crop to boost growth and mitigate frost risk, allowing for earlier harvests to be taken – this will be of particular interest relevant to the superthermic plastic treatments. 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.