FINAL REPORT

To:

Horticultural Development Council

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Protected Salads: Effect of spectrally modifying plastics on the harvest nitrate content of baby leaf and lettuce (PC 245)

January 2006

Commercial – In Confidence

Project Title:	Protected Salads: Effect of spectrally modifying plastics on the harvest nitrate content of baby leaf and lettuce.
Project number:	PC 245
Principal Project Leader:	Adrian Short, Stockbridge Technology Centre Ltd.
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The results and conclusions in this report are based on a series of carefully monitored applied experiments. The conditions under which the studies were carried out and the results have been reported with detail and accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with the interpretation of the results especially if they are used as the basis for commercial product recommendations.

Authentication

I declare that this work was done under my supervision according to the procedures described herein and that this report represents a true and accurate record of the results obtained.

Signature…Adrian Short…………………………………………………………….

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Date: 16th January 2006

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GROWER SUMMARY

Headline

Five different spectrally modified plastics used to cover polytunnels did not reduce nitrate levels in baby leaf spinach, rocket and lettuce plants grown under protection.

Background

This work was initiated in response to current EU legislation concerning the maximum levels of nitrate in lettuce and baby leaf crops and in particular to provide support for a continued derogation offered to UK Lettuce growers. This project fulfils the requirement to undertake research to support the continued derogation for UK Lettuce growers.

The aim of the work was to assess the potential ability of a range of spectrally modifying material to reduce the nitrate content in baby leaf and lettuce varieties in three particular scenarios:

1) **Baby Leaf Crops** – Could the use of these materials reduce the nitrate content of crops grown at high density for baby leaf production.
2) **Propagation** – Could the use of these materials during plant propagation affect the nitrate content of the field grown crop.
3) **Butterhead Lettuce** – Could the use of these materials following standard propagation affect the nitrate content of the tunnel grown crop.

Five Haygrove polytunnel structures covered with five different spectrally modifying plastic materials (Standard, Solatrol, Luminance, UV opaque (UVO), UV transparent (UVT)) were used for this work.

Summary of project and main conclusions

Baby Leaf (Spinach and Rocket)

Baby leaf crops, spinach and rocket were grown from two sowing dates and at maturity were harvested at two different harvest times (9 am and 1 pm).

In this trial the spectrally modifying materials had no effect on nitrate content at harvest for either crop. The sowing date did affect the final nitrate level in the crop, with those sown earlier in the season (11th June) having lower nitrate levels than the crop sown later (8th August). This was true for plants grown under all treatment materials. The time of day that the harvest was carried out did not affect the nitrate level in the crop. Spinach and Rocket crops grown under field conditions had lower nitrate levels than those grown beneath the spectrally modifying plastic treatments. The reasons for this could be due to leaching of the nutrient in the field, or perhaps slower growth in the field compared to the tunnels (plants grown in the field were smaller than those grown beneath treatment materials) leading to lower nitrate uptake.

Propagation Lettuce (Lollo Bionda)

The effects of the spectrally modifying film cover material treatments on nitrate levels at planting following propagation and at maturity after subsequent growth in the field were assessed with Lollo Bionda.

Lollo Bionda plants grown under spectrally modifying material treatments during propagation did not have lower nitrate levels at planting than those propagated under glass.

There were no differences in the nitrate content of the mature crop at harvest following propagation under the different spectrally modifying materials.

Butterhead Lettuce (Cultivar, Xandria)

The effects of different spectrally modifying film cover material used post-planting on the growth of a Butterhead lettuce (Xandria), planted for harvest in the Autumn, was assessed following standard propagation in a glasshouse.

There were no differences in nitrate content at harvest between the spectrally modifying film treatments compared to those grown in a glasshouse for this butterhead lettuce crop harvested in October.

Financial Benefits

The UK lettuce industry currently has no proven system that guarantees nitrate levels will consistently be below EU regulations. Despite a UK voluntary adherence to Good Agricultural Practice levels of nitrate in leaves of lettuce (and especially spinach and rocket) do exceed those set out in EU regulation 563/2002. An improvement in the ability to conform to the EU regulations will have significant financial benefits whilst maintaining the status of the UK lettuce industry as a leader in the provision of quality, safe food with due consideration to sustainable practice.

Action points for growers

- Spinach or rocket crops grown later in the season will accumulate more nitrate than those harvested earlier in the season.

- In early season rocket the nitrate levels in field grown plants were lower than those measured in polytunnels.

- The photo-selective plastics did not reduce nitrate levels in harvested spinach and rocket.

- There were exceedances in the EC recommended maximum nitrate level in all photo selective treatments in late harvested spinach.

- There were no differences at transplanting in the nitrate content of lettuce plants grown under photo-selective plastics compared to glass.

- In harvested lettuce nitrate levels were well below the EC limit. Nitrate content was significantly higher in plants propagated under UVT, Standard and Solatrol plastic films compared to those propagated under glass.

SCIENCE SECTION

Introduction & Objectives

Despite voluntary adherence to the code of good agricultural practice (GAP), the UK Lettuce industry currently has no proven system that guarantees nitrate levels in the harvested crop will be below EC regulation number 563/2002 (Table 1). The derogation awarded to UK Lettuce growers was reviewed in January 2005 and the Commission agreed to extend this based on evidence that codes of practice were currently applied, that UK growers have ongoing difficulties in keeping nitrate below the maximum levels, and that there are current or planned investigations to help identify ways to lower these levels (FSA update, July 2005). Exceedances of nitrate concentration in lettuces mainly occur after periods of low irradiance, particularly in the winter. Low rates of photosynthesis in these instances result in a slower plant growth that does not appear to be matched by a decrease in nitrate uptake.

Table 1. Summary of maximum levels in European Commission Regulation (EC) No. 563/2002.

Product	Harvest Period	Maximum nitrate levels mg/ kg fresh product
Spinach (Fresh)	1st November - 31st March	3000
	1st April – 31st October	2500
Lettuce (protected and open-grown lettuce)	1st October – 31st March	4500
	1st April – 30th September	3500

Nitrate uptake into the xylem of plants is a process that requires energy and it has also been shown that nitrate itself can stimulate its own uptake (Taiz & Zeiger, 1992). Once inside the plant cell, nitrate is converted to ammonia before assimilation into organic compounds. The enzyme that is responsible for the initial conversion of nitrate to nitrite is nitrate reductase (NR). This enzyme is therefore extremely important in the prevention of accumulation of excess nitrate in the vacuoles of plant cells. Genetic or environmental factors that decrease NR activity will affect the levels of nitrate accumulated in leaves.

The balance between carbohydrate supply and demand, rather than just photosynthesis determines the level of soluble sugars and hence nitrate in plants (Munzinger, 1999, FAIR-CT98-4362). As carbon and nitrogen metabolism are principle processes in plants, the level of nitrate will be intimately associated with this.

HDC report, PC 88, highlighted that there was a great deal of variation within heads of the same cultivar and that there were no obvious differences between cultivars tested. The timing of harvest did not affect nitrate levels, even on sunny days. However, there is a tendency for lower nitrate residues in lettuce after bright days than after dull weather.

Byrne *at al* (2001) looked at the distribution of nitrate within the plant and found that lettuce heart contained the least nitrate (2880 mg kg^{-1}), surrounding leaves 4703 mg kg^{-1} and outer leaves 6000 mg kg^{-1}. This agrees with work in other areas and highlights the importance of removing older leaves as a means of decreasing nitrate in the product at point of sale.

Previous work by Byrne *et al* (2001) has investigated the feasibility of using different polythene films (selected for a range of light transmitting properties) for growing lettuce with low nitrate content. Although only one lettuce head was analysed for nitrate content from each treatment, it was found that the polythene film that had the lowest light transmission resulted in lettuce with the highest nitrate content.

An HDC-funded project, CP 19, located at STC and now in its second year, seeks to evaluate how a range of photo-selective plastics covering Haygrove tunnels can influence in a range of plants at different planting times the resistance to pests and diseases, need for artificial growth regulators, essential oil content of herbs and colour intensity of flowers and foliage. There are five photo-selective plastics being investigated in this project (Table 2) and it was hypothesised that since nitrogen uptake is influenced by irradiance, a spectral modification of the light incident on a lettuce or baby leaf crop may affect the subsequent accumulation of nitrate in the leaves. Of particular interest and perhaps a more promising candidate for reducing lettuce nitrate content in this trial is the UVO material. Recent work by Quaggiotti *et al* (2004) has found that exposure of Maize seedlings over a 13-day growth period to UVB-radiation resulted in lower NR activities in leaves and roots compared with controls. Therefore, it is proposed that the UVO material in this series of trials, due to its ability to block UV-B radiation, may show potential in terms of allowing optimum activity of NR and therefore reduction in leaf nitrate level.

Table 2. Characteristics of Haygrove tunnel cladding material.

Treatment	Properties
Standard	High transmission of over 90%, with low diffusion (20%) and a thermic heat retention of 30%.
Sola0trol	Alters the Red: Far-red ratio by absorbing light in the far-red wavelength.
Luminance	Reduces infrared radiation and enhances useful light in the PAR (photosynthetically active radiation) range.
UV-Opaque (UVO)	Absorbs UV radiation
UV- Transparent (UVT)	Transparent to very short wavelengths

Work Objective

The aim of this work was to establish if spectrally modifying materials could influence nitrate accumulation in lettuce and baby leaf crops. The work programme is separated into 3 sections.

Section A: Spinach and rocket were chosen as the baby leaf crops for this work. Assessments of the effects of time of harvest and sowing date on nitrate levels, in addition to the effects of growth under five spectrally modifying materials, were undertaken.

Section B: The effect of a spectrally altered light environment during propagation and any carry through effects after planting in the field was studied using a green Lollo Bionda known to accumulate more nitrate than iceberg types.

Section C: The effect of a spectrally altered light environment during the growth in an Autumn lettuce crop was investigated using a Butterhead lettuce, following standard propagation under glass.

General Methods

Soil Preparation

Soil analysis was carried out in each Haygrove tunnel to determine pre-planting levels of nitrate. Additional fertiliser (Ammonium nitrate) was then added before sowing or transplanting to adjust the soil nitrate level to 100ppm, in accordance with good agricultural practice, or to follow guidelines in RB209 for the outdoor crop.

Leaf Nitrate Analysis

Once prepared, all samples were analysed according to the hot water extraction protocol developed in HDC Project PC 218. In brief, samples were weighed, ensuring all traces of soil were first removed from leaves, and then blended with 200-350 ml deionised water. Once fully homogenised the pulp and all residues were transferred to a 1 litre conical flask and left to stand in a heated water bath until the temperature reached more than 70 degrees C. The pulp was then cooled to room temperature and made up to 1 litre volume with deionised water. A sample from this solution was poured into a 100 ml beaker and folded filter paper was inserted to obtain a pulp-free solution. Nitrate test strips (Merckoquant) (3 replicates per sample) were dipped in this solution and the nitrate concentration read using a Nitrachek 404 meter previously calibrated with a range of nitrate standards (50-400ppm NO_3). The results were processed using the HDC Plant Nitrate Calculator to determine plant nitrate concentration. It should be noted that the nitrate concentrations obtained for rocket were based on the correction factor for spinach and so may under or over-estimate true values, as no correction factor for rocket was available. However, comparisons between treatments remain valid.

Tunnel Environmental Monitoring

Temperature and humidity in each treatment polytunnel was monitored throughout the trial. The data are presented in Appendix I. Readings were taken hourly and are presented as means for respective 24hr periods. Meteorological data were also recorded and are presented in Appendix II.

Statistical Analysis

Single factor analysis of variance was calculated from the raw data set obtained for each crop and a comparison was made between means based on the least significant difference (LSD) derived from this. A 95% confidence interval was used for all analyses.

Section A: Baby Leaf

Materials & Methods

Spinach and rocket seeds were drilled by hand in five Haygrove tunnels with five spectrally modifying materials (Standard, UVT, UVO, Solatrol, Luminance) as cladding on two sowing dates (11th June and 8th August). Seeds were sown into beds of dimension 5 m x 1.5 m and plants were sampled when they reached commercial harvest size (31st August and 19th October). Irrigation, when necessary, was applied via a lance.

Samples for nitrate analysis were taken at two time points (9 am and 1 pm), with a 1 m length of row (enough for a 200 g bulked sample) being harvested on each occasion and divided into three samples for analysis.

Spinach and rocket were also grown in field plots to allow a comparison with current industry practice.

Results & Discussion

The results for each sowing date are presented in Figures 1 and 2.

Figure 1. Mean (±SE) nitrate concentration in baby leaf crops grown under respective photo-selective treatments. (Sowing 1, harvested 31st August).

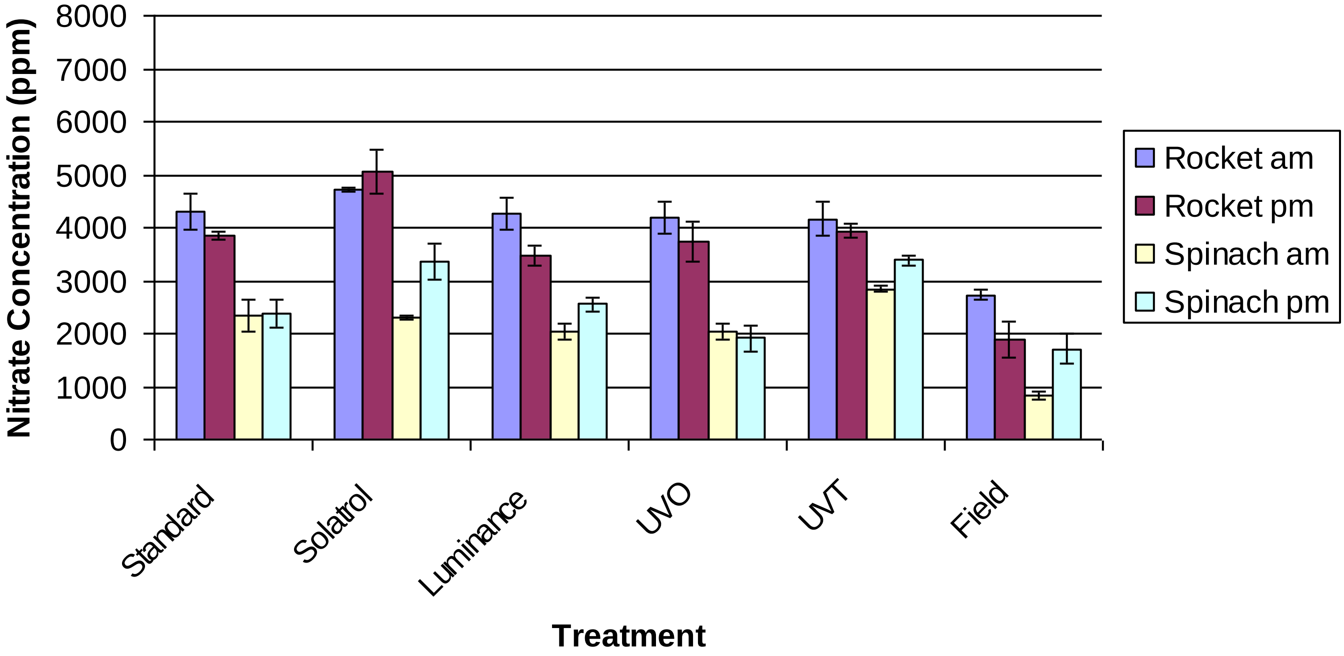

Figure 2. Mean (±SE) nitrate concentration in baby leaf crops grown under respective photo-selective treatments. (Sowing 2, harvested 19th October).

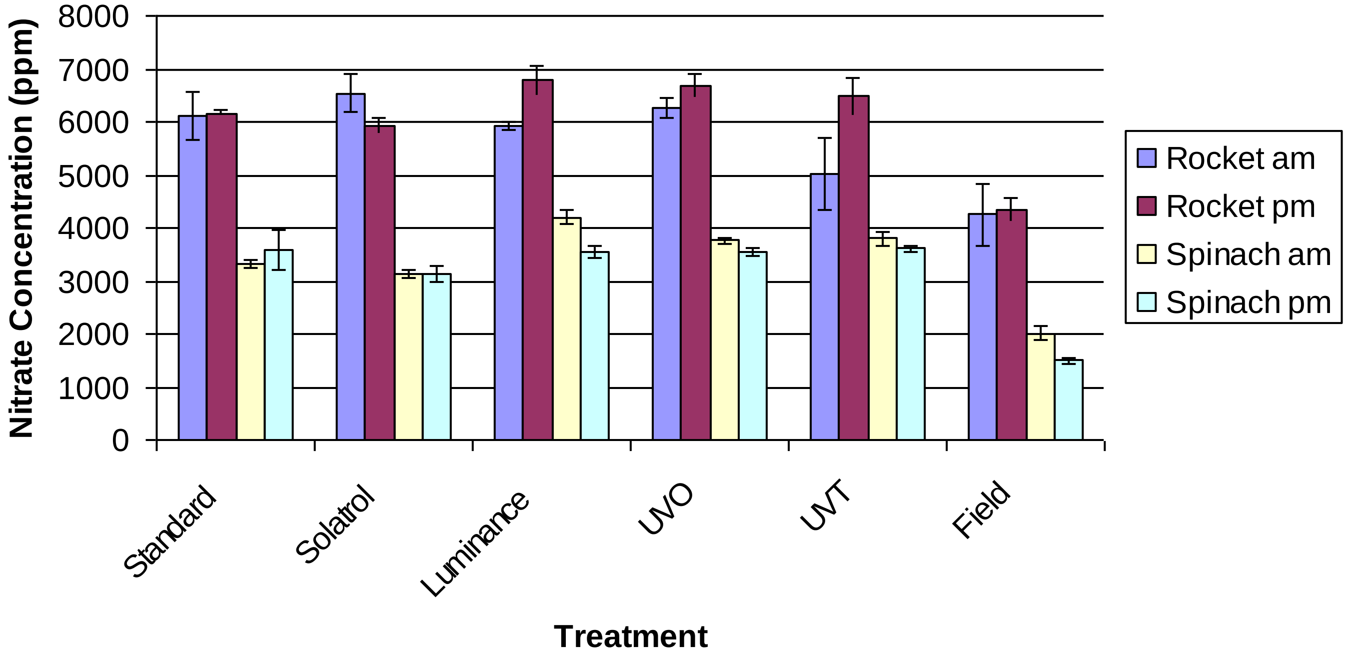

Table 3. Summary table of mean nitrate content for rocket (ppm)

Rocket	**Standard**	**Solatrol**	**Luminance**	**UVO**	**UVT**	**Field**
Sow 1 am	4293	4711	4264	4201	4169	2732
Sow 2 am	6124	6546	5925	6269	5007	4246
Sow 1 pm	3836	5059	3461	3736	3935	1883
Sow 2 pm	6169	5928	6777	6666	6476	4350

Table 4. Summary table of mean nitrate content for spinach (ppm)

Spinach	**Standard**	**Solatrol**	**Luminance**	**UVO**	**UVT**	**Field**
Sow 1 am	2346	2293	2044	2027	2845	831
Sow 2 am	3319	3130	4201	3763	3797	2014
Sow 1 pm	2369	3360	2563	1915	3377	1717
Sow 2 pm	3588	3141	3549	3551	3614	1499

The difference between the two sowing dates in this trial (Tables 3 and 4) clearly demonstrates that spinach or rocket crops grown later in the season will accumulate more nitrate than those harvested earlier in the season. The cumulative total hours of sunshine from the seven days leading up to the harvest for the first and second sowing are 39.7 and 10.2 hrs respectively (see data in Appendix II). This difference in light quantity incident on the crops is the reason for the difference in nitrate levels. This is due to the fact that the enzyme nitrate reductase is light dependent and also assimilates from photosynthesis (which increases with increasing light levels) are used for the conversion of nitrite to nitrate (Taiz & Zeiger, 1992). These two factors interact to prevent an excessive accumulation of nitrate.

In the first sowing of the rocket the only statistically significant differences were the field grown plants where the nitrate levels were lower than those measured in the tunnels. There were no significant differences between the different photo-selective plastics. This was also true for the second sowing, although only UVO and Solatrol treatments had significantly higher nitrate levels than field-grown rocket. For the afternoon harvest the results for the first and second sowing followed the same trend as the morning sampling.

Data for spinach crops also showed no clear effects of photo-selective films on nitrate levels at harvest. For the first sowing there were no differences in the nitrate levels from plants under the photo-selective plastic treatments, but plants from field plots had significantly lower nitrate levels at both harvest times. For the second sowing nitrate levels in spinach grown under Solatrol and Standard material were significantly lower than in the other film treatments for the morning (9 am) harvest. This was not consistent as there were no apparent differences between the photo-selective plastic treatments from samples harvested in the afternoon (1 pm).

Leaching from the soil may have caused nitrate losses in the outside plots. Also, plants grown outside were smaller at harvest than those grown in the tunnels. This slower growth under cooler conditions might result in lower nitrate uptake.

In this study the photo-selective materials used did not have a consistent significant effect on the nitrate levels in spinach or rocket crops. There were exceedances in the EC recommended maximum nitrate level (2500 ppm) in all treatments at both sampling occasions for spinach harvested on 19th October.

There are currently no EU regulations stipulating the maximum nitrate levels for rocket.

Section B: Propagation Lettuce

Materials & Methods

Lollo Bionda seeds were sown into peat blocks on the 19th July and were placed in a glasshouse for germination. At the expanded cotyledon stage, six trays (approximately 100 plants per tray) were moved into each of the five treatment tunnels (Standard, UVT, UVO, Solatrol and Luminance), with six trays remaining in the glasshouse.

Samples for nitrate determinations were taken just prior to transplanting (10th August). Plants were cut at the base and then bulked together to provide a sample. This was repeated for each propagation treatment to provide three samples per treatment for analysis.

Field soil samples were taken before transplanting and additional nitrogen was applied as a subsequent top dressing to follow commercial practice (Table 5).

Table 5. Initial nitrogen levels and application rates (kg/ ha N) for field lettuce.

	Pre-planting Soil N (0-30cm profile)	8th August Application (Calcium nitrate)	1st September Application (Calcium nitrate)
NO_3	65.8	-	-
NH_4	0.4	-	-
Kg/ ha N	199	120	60

Each plot consisted of 160 plants per treatment with four rows at 0.38 m and with 40 plants at 0.30 m per row.

Irrigation was applied to the crop on 9th August (10 mm) and 1st September (20 mm). At crop maturity on 29th September, ten heads were taken from the middle two rows of each plot using a ‘W’ sampling pattern and were subsequently trimmed in the field to produce a marketable product.

For each treatment, individual heads had three slices removed from different parts of the head and were labelled samples 1, 2 and 3. This was repeated for the other 9 heads so each of the three replicates became a composite sample of the ten heads taken. Samples were processed for nitrate determination according to the method described earlier.

Results & Discussion

Samples were taken prior to transplanting and at crop maturity. The results are presented in Tables 6 and 7.

Table 6. Nitrate concentration (ppm) in Lollo Bionda seedlings prior to planting in the field.

Treatment	Mean nitrate content (ppm)	Values (ppm)
Standard	3100	2991, 3118, 3191
Solatrol	2777	2559, 2884, 2889
Luminance	3222	2905, 2997, 3764
UVO	2987	2429, 2775, 3488
UVT	3300	2596, 3332, 3971
Glass	2651	2546, 2551, 2855

Table 7. Mean head weights (g) and mean nitrate concentration (ppm) in Lollo Bionda at crop maturity (29th September).

Treatment	Mean head weight (g)	Range (g)	Mean nitrate content (ppm)	Values (ppm)
Standard	410	279-501	3042	2538, 3061, 3528
Solatrol	433	357-528	2902	2306, 3077, 3324
Luminance	346	251-439	2066	1907, 2071, 2219
UVO	367	295-461	2274	1751, 2501, 2570
UVT	396	314-492	3040	2606, 3184, 3329
Glass	365	286-513	2004	1931, 2024, 2056

There were no significant differences at transplanting in the nitrate content of lettuce plants grown under the five photo-selective plastics compared to the glass control.

At harvest, the mean nitrate levels were well below the EC limit. Nitrate content was significantly higher in plants propagated under UVT, Standard and Solatrol plastic films compared to those propagated under glass.

At harvest mean head weights ranged from 346 to 433 g, with no visible effect of propagation regime on subsequent head development.

Section C: Autumn Lettuce

Materials & Methods

Butterhead lettuce, cultivar Xandria, were sown into peat blocks on the 11th August and propagated in a standard glasshouse. Fertiliser was added to each treatment plot, based on soil analysis, to standardise the level to 100ppm as recommended by the Good Agricultural Practice guidelines (Table 8).

Table 8. Nitrogen requirement for Autumn lettuce crop in respective treatments.

Treatment	Soil analysis (0-30cm) (ppm NO_3)	Amount of ammonium nitrate required (g/m^2)
Standard	45.3	42.1
Solatrol	37.3	48.2
Luminance	51	37.7
UVO	66.5	25.8
UVT	31	53.1
Glass	12.8	67.1

Each plot consisted of 60 plants per treatment with four rows at 0.25 m and with 15 plants per row. The plots in each of the five treatment tunnels, plus a glasshouse control were planted on 30th August. Irrigation was applied via trickle lines between alternate rows.

At crop maturity (11th October) ten heads per plot were trimmed in the five tunnels and glasshouse control to provide a marketable head. Three slices were taken from each head per treatment and bulked within each treatment to give three composite samples per treatment.

Results & Discussion

The results are presented in Table 9.

Table 9. Mean head weights (g) and mean nitrate concentration (ppm) at harvest (11th October).

Treatment	Mean head weight (g)	Range (g)	Mean nitrate content (ppm)	Values (ppm)
Standard	271	215-332	3330	3137, 3335, 3518
Solatrol	282	221-337	3104	2909, 3185, 3219
Luminance	265	263-354	3137	2996, 3096, 3320
UVO	215	165-240	3425	2975, 3287, 4012
UVT	259	209-338	3081	3028, 3089, 3126
Glass	280	223-354	3546	3206, 3443, 3988

There were no significant differences in the nitrate content of trimmed heads. However, it is interesting to note that the mean head weight was slightly reduced in plants grown beneath UVO material compared to the other treatments.

Overall Conclusions

The results from this project have not identified clear effects from using the modified plastic tunnel covering materials to manipulate nitrate levels compared to standard commercial practice.

The study looking at growing baby leaf under the five films highlighted the effect of sowing date on nitrate content with higher nitrate levels in both spinach and rocket for the later drilling. Although there might be agronomic benefits from using these covering materials they had no beneficial effect on reducing nitrate levels in leaf tissue at harvest.

The study looking at the potential benefit of using these five covering materials as an alternative to the standard practice of propagating under glass did not identify any effect on nitrate content in the plants at planting. However, at harvest the nitrate content was highest for plants propagated under Solatrol, Standard and UVT compared to glass. Further work is required to confirm these effects before growers consider using these materials as an alternative to standard glasshouse propagation. These will have to be considered alongside any potential agronomic and economic benefits.

For the production of butterhead lettuce there did not appear to be any clear effect of using any of the five covering materials to manipulate nitrate content of the lettuces at harvest. Nitrate levels showed considerable variation within samples taken from plants grown under the five covering materials used in this study.

TECHNOLOGY TRANSFER

The results of this work were disseminated at the Lettuce Technology Group meeting held at STC on 8th November 2005.

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(http://europa.eu.int/comm/research/agro/fair/en/nl4362.html**)**

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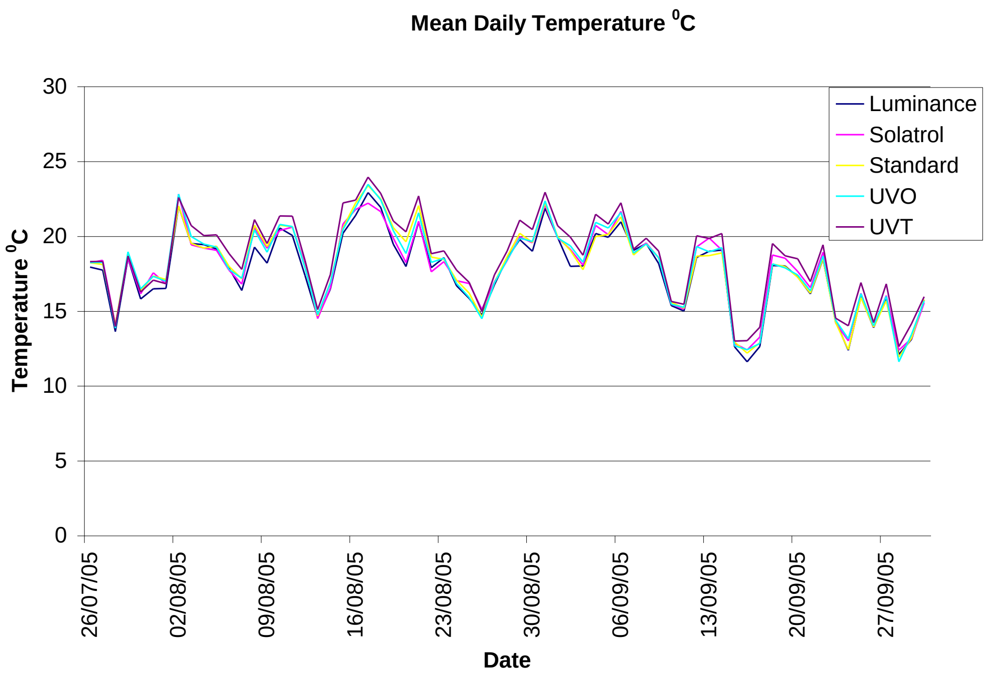
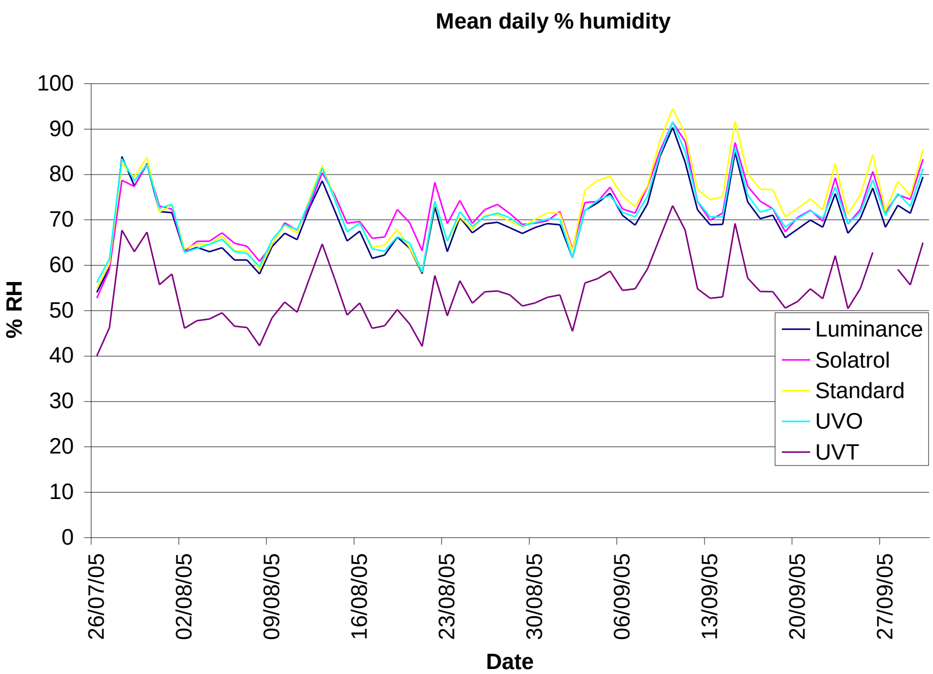
Appendix I. Temperature and humidity data for each treatment polytunnel.





Appendix II. Meteorological data at STC for July to October 2005.

Date	Daily rainfall (mm)	Screen Max (ºC)	Screen Min (ºC)	Sunlight (Hrs)	Soil Temp at 10 cm depth
1 July	2.0	22.3	9.9	5.1	19.7
2	0.0	25.0	16.1	4.9	20.2
3	0.0	24.0	14.7	8.9	20
4	0.4	16.5	11.9	0	19
5	10.2	16.9	9.8	2.7	18.5
6	6.3	19.6	10.6	1.3	17.5
7	Trace	20.5	12.0	5.6	17.9
8	Trace	19.6	8.7	8.8	17
9	0.0	25.4	10.4	10.1	18
10	0.0	28.0	12.5	11.6	21.2
11	0.0	26.8	14.6	13.3	21.2
12	0.0	26.8	13.5	11.1	21
13	0.0	27.9	13.8	6.3	23.9
14	0.0	27.9	11.0	3.1	22.4
15	0.0	23.0	14.5	9	22.5
16	0.0	23.2	12.8	10.8	21.1
17	0.0	28.0	12.7	7.5	22.4
18	1.9	22.1	14.0	8.5	22.9
19	0.1	20.2	10.1	3.9	19.2
20	0.0	22.0	11.4	10.5	19
21	0.0	22.0	11.2	5.1	19.5
22	0.0	20.6	14.2	5	20
23	0.0	20.2	12.3	2.5	19.1
24	5.0	17.0	12.5	0	18.6
25	0.0	17.0	11.0	0.1	17.4
26	0.0	18.8	10.0	3.3	18
27	7.4	20.0	12.4	1.4	18
28	19.4	18.5	17.4	0	17
29	0.2	19.5	12.6	0	18
30	6.7	18.0	14.0	0	17.5
31	0.0	18.9	11.0	4.2	15.3
1 August	0	19.4	12.4	0	16.4
2	0	24.6	11	11.1	17.9
3	0.3	21.0	11.5	8.5	18
4	0.6	21.5	12.5	2.5	17
5	0	21.8	13.2	8	18
6	0.1	20.9	9.8	6.8	16.3
7	0	19.1	8	8.1	17
8	0	23.5	9.5	11.1	17
9	0	22.0	10	2.8	17.5
10	0	24.0	8.5	2	19
11	0.6	24.7	13	7.5	19

12	10.7	20.2	13.5	1.3	18.4
13	6.5	19.0	9.8	2.8	16.4
14	0.2	19.9	12.8	2.3	15.8
15	0	22.0	10.1	12.8	17.6
16	0	19	13.9	0.9	18.5
17	0	26.9	12	9.2	18.8
18	9.6	26.6	12.4	3.4	19.8
19	1.0	21.7	14	5.1	18.9
20	0	22.4	10.8	9.1	17
21	6.2	24.6	9.2	9.1	17.4
22	2.1	24.4	16.2	3	18.6
23	1.7	21.1	9.1	6.5	17.5
24	5.5	18.5	14.5	4.2	16.5
25	1.9	18.5	10.2	8.5	16
26	1.0	16.2	10.2	0.8	15.5
27	0.2	19.7	12.4	2.2	14.9
28	0	21.9	11.1	3.9	15
29	0	21.4	15	6.4	16.7
30	0	25.2	7.5	7.5	15.5
31	2.5	29.4	12	6.2	17
1 September	0	29.4	14.9	7.2	18.4
2	0	29.4	7	11.4	16.5
3	0	21.4	6.9	4.1	16.7
4	0.3	25.6	14	6.3	17.1
5	0	25	13.5	2.2	19.1
6	0	25.5	12.5	5.8	18
7	0	22.4	14	1.6	17.5
8	15.5	21.4	17	1.2	18
9	12.6	19.3	15	0	18.6
10	5.2	15.6	14.9	0	.17.0
11	0	17.2	12.9	0	15.5
12	0	22	8.9	10.4	15
13	0	21.2	11.4	7.6	16
14	4.6	20	15.3	8.1	16.4
15	10.5	14.5	12.5	0	15.1
16	0.1	14.1	7.5	8.2	11.5
17	0	16.3	3	4.5	10.5
18	0	18.8	9.4	6.6	13.2
19	0	19.7	12.5	6	15
20	0	18.9	13	6	15.5
21	0	19.4	19	4	14.4
22	0	21.5	11.4	7.9	14.5
23	5.7	18.1	11.1	2.5	14.4
24	0.6	15.2	12.8	9.1	10.9
25	0	19.4	9	5.1	12.7
26	0	17.4	8.4	0.5	12.5
27	0	18	12.4	6.2	13.6
28	2.9	15.7	6.5	3.5	11.7
29	6.8	15.1	9	6.5	11
30	3.1	21.6	9.6	1.6	12

1 October	0	21.5	10	7.9	11.7
2	0	15.4	6	4.5	10.3
3	0	14.4	10.4	0	12.2
4	0	14.9	10.7	0.1	12.3
5	0	16.7	7.9	3.2	12
6	0	13.9	6.8	0	12.2
7	0	16.4	11.9	0	13.2
8	5.6	15.9	13.7	0	13.4
9	0	14.3	6	0.8	9.7
10	0	19.4	7.5	3.9	10
11	2.3	27	11.5	1	13
12	3.6	20	16	0.3	15
13	0	13.9	11.2	0.1	13
14	0.4	14.8	9	0	12
15	0	16.7	11.2	0	13.1
16	0	17.6	11.6	5.2	13
17	0	15	10	0	12.6
18	2.2	13.5	8.5	0.1	11.5
19	2	13.5	10.5	1	12
20	1	14.9	16.5	3.5	10.5