Iceberg lettuce: Extending the season

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ICEBERG LETTUCE : EXTENDING THE SEASON

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Abstract

Iceberg lettuce were grown in protected structures at both Stockbridge House and Luddington EHS to produce an early crop during April and May.

Two trials were carried out at each site in heated and unheated structures. In the heated crop treatments were designed to investigate the effect of temperature during early and late propagation, sowing date, variety and harvest date on crop yield and quality. The lettuce were propagated at a single site.

At both Stockbridge House and Luddington the lettuce were first harvested on 4 May. All the trial treatments significantly affected crop growth. Of the two varieties assessed (Kelvin and Globe) Kelvin was slower to mature but produced bigger heads of a better quality. A high temperature (13^{o}C) during the latter part of the propagation period resulted in heavier, denser and better shaped heads, particularly on the variety Kelvin sown on 12 and 25 January.

At both sites the best quality (head weight and percentage marketable) heads were harvested from Kelvin sown on 25 January when the percentage of Class I heads was 46% at Stockbridge House and 73% at Luddington.

In the unheated crops trial treatments investigated the effect of spacing, variety, sowing and harvest dates on the yield and quality of iceberg lettuce. The first unheated crops were harvested on 13 May Luddington and 16 May Stockbridge.

At Luddington a reduction in planting density increased the head weight at harvest and also increased the percentage of Class I heads from an average of 33 to 65 per cent.

Objective

To extend the UK production of iceberg lettuce as far as is economically viable and specifically to replace April and May imports with home grown produce.

Introduction

The ever increasing popularity of iceberg lettuce, the demand for supplies 12 months of the year, together with the high prices achieved by heads during the winter and late spring period have all contributed to the current interest in extending the UK production season.

Production from the earliest outdoor sites starts to bulk up in early June. The use of crop covers will bring cropping forward by approximately two weeks but production for early May can only be achieved from protected structures.

The HDC project, initiated in 1987, has been targeted to evaluate sowing dates, varieties, plant spacing and propagation regimes as a means of maximising the number of Class I heads/m^2 cropped in early-mid May.

In 1987 the trials indicated the best results were obtained from two varieties, Globe in the heated trials and Kelvin in the unheated trials. In 1988 a series of propagation treatments have been assessed for their effect on head quality together with a range of sowing dates and some plant spacings.

Two trials have been carried out at both Stockbridge House and Luddington EHS using a heated glass structure and an unheated polythene structure.

1 Heated trials

Materials and Methods

Lettuce seedlings were propagated at Stockbridge House in 38mm peat blocks in a range of temperature regimes, as listed below. Some of the seedlings were then transported to Luddington EHS as appropriate and trials planted at both centres. The crop was grown according to good commercial practice. A pest and disease programme was implemented as considered necessary by the crop conditions.

Treatments

Propagation regimes:

A. 7°C from germination to planting
B. 7°C from germination for 12 days, 13°C thereafter until planting.
C. 13°C from germination for 12 days, 7°C thereafter until planting.
D. 13°C from germination until planting.

Varieties

1. Globe (planted at 25 x 30 cm)
2. Kelvin (planted at 30 x 30 cm).

Sowing Dates	Planting dates
1. 26 November	12 January
2. 12 January	18 February
3. 25 January	26 February

Growing house Luddington: 3 bay, E-W orientated glasshouse.

Stockbridge House: 4 compartments, E-W orientated glasshouse.

Both at 2°C minimum night, 4°C minimum day temperatures with ventilation commencing at 9-10°C.

No CO_2 was used either during propagation or during subsequent growth. Supplementary lighting (5000 lux) was used from dawn to dusk for 15 days post germination.

Statistical analysis

The statistical analysis for these trials has kindly been undertaken by R Edmondson of IHR Littlehampton.

Luddington: The experiment was of the split-plot type with sowing date treatments applied to main plots and propagation and variety treatments applied to sub-plots within main plots. Each main plot was further subdivided into half replicates by confounding the three factor interaction of the two propagation treatments and varieties with blocks. Finally sowing dates were allocated to main plots in the form of a 3 x 2 Youden square to control row and column effects.

Stockbridge: Four glasshouse compartments were used for this trial with each compartment containing a complete replicate set of the 24 treatment combinations. The three sowing dates were allocated to main plots and the eight variety by propagation treatments were randomly allocated to sub-plots within each sowing date main plot. The four compartments were divided into two sets with one set harvested at one of the two harvest dates. A factorial analysis was used with partitioning into three strata

corresponding to differences between compartments, differences between main plots (sowing dates) and differences between sub-plots (varieties and propagation treatments).

For accuracy in analysis variates expressed in percentage term have been angularly transformed. The statistical analysis given in the tables refers to transformed data which is given in brackets. Actual figures are also given alongside.

Assessments

Three harvests (two at Stockbridge) of 12 heads were taken from each plot with the first harvest being made when heads were considered to have reached a target weight of 350g and were of acceptablle head density. Each head was graded and weighed and where available five Class I heads selected for internal assessments. Head density, internal stalk development, base shape and base density were scored on a 1-9 scale for each of the five heads selected (where 9 = excellent). Unless otherwise stated, tables represent the mean of all values except those listed. Where interactions between results are significant they have been listed (V = variety, S = sowing date, H = harvest date, P1 = early propagation temperature and P2 = late propagation temperature).

Results

The mild winter conditions of 1987/88 prevented the real effects of low temperature propagation treatments being achieved. The actual propagation temperature regimes were inevitably higher than those planned.

At the time of planting however there was a marked difference in the size of the seedlings from the different propagation treatments. As might be expected those from the 'Low Low' regimes were the most compact, whilst those from the 'High High' regime the most leggy. The effects of propagation regime, variety and sowing date on the size and quality of heads at harvest is detailed below, together with the harvesting dates for each treatment.

Luddington EHS

Cropping period

The first harvest was made on 4 May and the last on 26 May. All propagation regimes were cut on the same day for a single variety/sowing date treatment. Three harvests were made for each combination between the dates listed in Table 1.

Table 1 Harvesting dates for heated trial

Sowing	Variety	
	Kelvin	Globe
1. (26 November)	12-18 May	4-12 May
2. (12 January)	19-25 May	12-18 May
3. (25 January)	23-26 May	19-25 May

Generally Globe was ready for harvest a week earlier than Kelvin although the gap was closing for the final sowing.

Varietal effects

The difference between the two varieties used in this trial is the most dominant feature to emerge.

Although there are several significant interactions with other factors, in general Kelvin produced bigger heads (higher mean marketable, total mean head weight and mean Class I head weight) than Globe and also produced a higher percentage of Class I and total marketable heads (Tables 2-5). Corresponding harvests were however up to 7 days later than Globe.

Table 2 Mean marketable head weight (grammes)

Sowing	Variety Kelvin	Globe	
1. 26 November	595.6	425.5	SED (within sowings)= 8.42*** (18 df)
2. 12 January	534.5	424.8	
3. 25 January	610.2	485.3	
Mean	580.1	445.2	

SED (between var. means) = 4.86*** (18 df)

Table 3 Mean Class I head weight

Harvest	Variety Kelvin	Globe	
1.	511.0	421.6	SED (within harvests)= 15.52*** (36 df)
2.	603.5	459.1	
3.	688.5	502.4	
Mean	601.0	461.1	

SED (between var. means) = 10.13*** (18 df)

The difference in head weight between Globe and Kelvin was most pronounced from the earliest sowing and also at the later harvests (Tables 2 and 3). The latter perhaps being a reflection of the relative frame size of each variety and the capacity for further filling at later harvests.

The smallest headweights were produced from the second sowing. This effect was most apparent in the variety Kelvin.

Table 4 Sowing date and variety effects. Total percentage marketable heads

Sowing	Variety Kelvin	Globe	
1. 26 Nov	64.2 (53.5)	47.3 (43.4)	SED (within sowings)= 3.32* (18 df)
2. 12 Jan	84.2 (70.3)	57.9 (48.8)	
3. 25 Jan	82.7 (69.8)	70.6 (59.6)	
Mean	77.1 (64.6)	58.6 (50.6)	
SED (between var. means)	= 1.92*** (18 df)		

Table 5 Harvest date and variety effects. Total percentage marketable heads

Harvest date	Variety Kelvin	Globe	
1.	83.9 (68.9)	52.4 (46.5)	SED (within harvests)= 3.14** (36 df)
2.	79.5 (68.6)	68.4 (57.0)	
3.	67.7 (56.2)	54.9 (48.3)	
Mean	77.1 (64.6)	58.6 (50.6)	
SED (between var. means)	= 1.92*** (18 df)		

Assessments of certain head characteristics indicate Globe was in general more dense than Kelvin, more particularly at the second and third sowings (Table 6). Measurements on the length of the flower stalk inside the heads

also indicate that Globe was in a more advanced stage of flower initiation, and that this was emphasised from later sowings and at the later harvests.

Table 6 Head characteristics (scored 1-9, where 9 = excellent)

Variety	Base shape	Base density	Head density	Stalk length
Kelvin	7.01	7.17	6.42	5.38
Globe	6.81	6.50	6.65	3.40
SED (between vars) (18 df)	0.081 *	0.062 ***	0.055 ***	0.080 ***
Signif interact.	SxV HxSxV	SxV P2xV	SxV P2xV HxSxV	SxV P2xV HxV HxSxV

This corresponds to the fact that Globe is a glasshouse lettuce bred for spring cropping crisp lettuce around April whilst Kelvin would normally be grown outside for a late-early crop maturing in mid June.

In terms of base shape Kelvin was better than Globe at the second and third sowings but in both varieties scores were deteriorating by the later harvests of final sowing, probably because excessive trimming was required by this stage. Kelvin also produced a better filled base than Globe,(Table 6) particularly at the later sowings (Table 7).

Table 7 Base density scores (scored 1-9, where 9 = excellent)

Sowing	Variety Kelvin	Globe
1. 26 November	6.96	6.47
2. 12 January	7.23	6.81
3. 25 January	7.31	6.23
SED (within sowings)	0.107*** (18 df)	

Effect of sowing and harvest dates

The highest percentage of Class I heads and overall percentage marketable was generally cut, for both varieties, from the first or second harvest when heads were slightly immature or just mature. Leaving heads longer to fill out or increase in weight did not generally improve the quality (Table 8).

Table 8 % Class I heads

Harvest	Sowing 1		Sowing 2		Sowing 3	
	Kelvin	Globe	Kelvin	Globe	Kelvin	Globe
1.	40.8 (39.4)	36.1 (36.4)	47.3 (43.4)	18.1 (21.4)	69.7 (57.3)	51.0 (45.6)
2.	8.2 (13.2)	14.4 (20.7)	59.2 (50.9)	17.5 (21.0)	73.3 (60.0)	38.9 (38.4)
3.	15.8 (21.3)	24.1 (28.6)	56.6 (49.9)	41.0 (40.2)	53.6 (46.9)	12.0 (16.7)
Mean	21.6 (24.6)	24.9 (28.6)	54.4 (48.0)	25.5 (27.5)	65.5 (54.7)	34.0 (33.6)

SED (within same harvest and variety) = 5.63*** (36 df)

SED (within same harvest and sowing) = 5.62*** (36 df)

SED (between sowing and variety) = 4.50*** (18 df)

The highest percentage of Class I heads was cut from the second or third sowing of Kelvin. There was no significant difference between the three sowings of Globe (Table 8).

As previously illustrated, head characteristics were also affected by sowing and harvest dates. In Kelvin base shape was improved from later sowings although the reverse trend was true for Globe (Table 9).

Table 9 Base shape scores (scored 1-9, where 9 = flat)

Sowing	Variety	
	Kelvin	Globe
1.	6.40	7.27
2.	7.25	6.74
3.	7.38	6.41

SED (within sowings) = 0.139*** (36 df)

Propagation treatment effects

Initial visual observations of mature plants did not indicate a marked effect of propagation on the lettuce. However, after analysis of the results, there is strong evidence to suggest that the different regimes have an influence on head size and quality.

No effects were apparent from the different temperatures during the early propagation period (12 days post emergence). However, the higher temperature regime during the latter part of propagation increased both the mean head weight, mean marketable head weight and mean Class I head weight (Tables 10 and 11). This effect was apparent only at the second and third sowings and the response was more marked in Kelvin than in Globe.

Table 10 Mean Class I head weight

Sowing	Late propagation temperature Low	High	
1. 26 Nov	542.1	517.5	SED (within sowings) = 17.54* (18 df)
2. 12 Jan	466.8	516.9	
3. 25 Jan	577.1	613.9	
Mean	517.9	544.2	

SED (between propagation treatment means) = 10.13*** (18 df)

Table 11 Mean marketable headweight

Varieties	Late propagation temperature Low	High	Mean	
Kelvin	554.0	606.2	580.1	SED = 6.87*** (18 df)
Globe	437.9	452.5	445.2	
Mean	496.0	529.3		

SED (between prop. means) = 4.86*** (18 df)

No effect of the different propagation treatments was apparent in the final percentage of marketable heads although there is some evidence that the percentage of Class I heads was increased in the first and second sowings but decreased in the last sowing, with the high late propagation regime (Table 12).

Table 12 Percentage Class I heads

Sowing	Late propagation temperatures Low	High	
1.	20.0 (23.7)	26.4 (29.5)	SED (within sowings)= 2.79** (18 df)
2.	37.4 (36.0)	42.6 (39.6)	
3.	55.5 (48.5)	44.0 (39.8)	
Mean	37.6 (36.1)	37.7 (36.3)	

In the 1987 trials one of the major reasons for which lettuce heads were downgraded was poor shape with angular petioles and misshapen bases. The extreme development of the flower stalk inside the heads was considered to be partly attributable. The high temperature propagation treatments were investigated as means of reducing this stalk elongation and improving head shape.

In terms of head characteristics the high late propagation treatment did improve base shape and increase head density, especially on the earlier harvests and from the later two sowings (Table 13). The response in head density was more marked in Kelvin (Table 14). In contrast however the internal flower stalks were more developed in this treatment particularly on Kelvin (Table 15).

Table 13 Head characteristics

Late propagation temp.	Base shape (Scored 1-9)	Base density	Head density	Stalk length
Low	6.78	6.87	6.40	4.50
High	7.03	6.80	6.67	4.28
SED (18 df)	0.081 **	NS	0.035 ***	0.080 *
Interaction		VxP	SxP VxP	VxP

Table 14 Head density scores (scored 1-9, where 9 is very dense)

Late propagation temp.	Variety Kelvin	Globe	Mean
Low	6.19	6.61	6.40
High	6.64	6.69	6.67
SED (between prop. means)	0.078** (18 df)		

Table 15 Length of internal stalk (scored 1-9, where 9 = no extension)

Late propagation temp.	Variety Kelvin	Globe	Mean
Low	5.59	3.41	4.50
High	5.18	3.39	4.28
Mean	5.38	3.40	
SED (all comparisons)		0.113* (18 df)	
SED (prop. means)		0.080* (18 df)	

Stockbridge House EHS: Heated Trial

Cropping period

Table 16 Harvesting dates

Sowing	Planting	Variety Kelvin	Globe
1. 26 November	12 January	11-13 May	4-10 May
2. 12 January	18 February	12-19 May	10-17 May
3. 25 January	26 February	17-23 May	13-19 May

Lettuce were harvested when the majority of heads in a plot had reached a target weight of 350g when trimmed and had an acceptable head density. The variety Kelvin reached this weight earlier than Globe but required longer to produce a firm head. Kelvin was harvested over the period 11-23 May and Globe over the period 4-19 May.

Varieties

Kelvin produced heavier head weights than Globe and this direct effect of varieties is very highly significant at the 0.1 per cent level.

Table 17 Mean marketable head weight (g)

Kelvin	Globe	
628.2	466.7	SED 7.11*** (42 df)

There is also evidence of a variety by sowing date interaction. Kelvin and Globe both produced lower head weights from the second sowing compared with the first and third sowings.

Table 18 Mean marketable head weight (g)

Sowing	Kelvin	Globe
26 November	623.4	475.3
12 January	587.2	445.7
25 January	673.9	479.2
SED	16.84** (42 df)	
SED (within sowings)	12.32 (42 df)	

There was also a harvest date effect.

Table 19 Mean marketable head weight (g)

Sowing	Harvest 1		Harvest 2	
	Kelvin	Globe	Kelvin	Globe
26 November	604.4	466.3	642.4	484.2
12 January	465.3	408.3	709.0	483.2
25 January	641.4	401.4	706.5	557.0
SED (within harvests)	23.82*** (42 df)			

The late propagation temperature also had a very significant effect at the 0.1 per cent level. A high temperature late in propagation produced heavier heads.

Table 20 Mean marketable head weight (g)

Late propagation temperature	
Low	High
530.4	564.5
SED = 7.11*** (42 df)	

The high late propagation temperatures had a positive effect on the second and third sowings but not the first.

Table 21 Mean marketable head weight (g)

Sowings	Late propagation temperature	
	Low	High
26 November	550.2	548.5
12 January	494.5	538.4
25 January	546.6	606.5
SED (within sowings)	12.32** (42 df)	

The response was more marked in the variety Kelvin.

Table 22 Mean marketable head weight (g)

Variety	Late propagation temperature	
	Low	High
Kelvin	600.3	656.0
Globe	460.5	473.0
SED	10.06** (42 df)	

The effects of the early propagation temperature are not easy to interpret.

Table 23 Mean marketable head weight (g)

Sowings	Harvest 1 Early propagation temperature		Harvest 2 Early propagation temperature	
	Low	High	Low	High
26 November	545.6	525.1	538.2	588.4
12 January	424.5	449.1	610.1	582.1
25 January	496.8	546.0	635.9	627.6
SED (within harvests)	23.82*** (42 df)			

At the first harvests, the trend from the first sowing was for a low early temperature in propagation to be beneficial. However, the second and third sowings gave higher head weights from a high early temperature. At the second harvest these trends were reversed.

There is also evidence of a four factor interaction effect involving harvests, varieties and both propagation treatments. Heaviest heads were obtained from the second harvest of Kelvin at the high early and high late propagation temperature.

Table 24 Mean marketable head weight (g)

Variety	Kelvin				Globe			
Early temp.	Low	Low	High	High	Low	Low	High	High
Late temp.	Low	High	Low	High	Low	High	Low	High
Harvest 1	507.2	629.4	563.1	581.9	418.8	400.7	409.9	472
2	688.6	682.4	642.4	730.3	484.2	523.6	529.1	495.7
SED				21.39*** (42 df)				

Low head weight was the main reason for heads being unmarketable. As a result, Kelvin has a higher mean percentage marketable figure (93.8 per cent) than Globe (84.9 per cent). Kelvin produced a higher percentage of Class I quality heads than Globe in the crops from the second and third sowings.

Table 25 Quality (% Class I) (Angular transformation)

Sowing	Kelvin	Globe
26 November	5.2 (8.71)	5.7 (8.27)
12 January	20.8 (26.50)	6.8 (6.67)
25 January	29.7 (30.91)	6.2 (8.73)
SED (within sowings)	3.366*** (42 df)	

Sowing	Harvest 1		Harvest 2	
	Kelvin	Globe	Kelvin	Globe
26 November	9.4 (15.33)	2.1 (4.19)	1.0 (2.10)	9.4 (12.35)
12 January	15.6 (22.83)	12.5 (11.25)	26.0 (30.18)	1.0 (2.10)
25 January	13.5 (19.44)	0.0 (0.0)	45.8 (42.39)	12.5 (17.46)
SED (within harvests)		4.986***		

There is some evidence that the late propagation temperature affected quality, but the varieties performed differently.

Table 26 Quality (% Class I) (Angular transformation)

Variety	Late propagation temperature	
	Low	High
Kelvin	15.6 (19.64)	21.5 (24.45)
Globe	9.7 (11.91)	2.8 (3.87)
SED	2.748** (42 df)	

A high temperature in the late propagation stage improved the head density.

Table 27 Head density score (Scored 1-9, where 9 is most dense)

Late propagation temperature	
Low	High
5.899	6.47
SED	0.123*** (42 df)

The effect was more evident with Kelvin.

Table 28 Head density score

Variety	Late propagation temperature	
	Low	High
Kelvin	5.54	6.51
Globe	6.26	6.43
SED	0.174** (42 df)	

Globe tended to have a higher head density than Kelvin at the first harvests but at the second harvests this trend was reversed.

Table 29 Head density score

	Variety	
	Kelvin	Globe
Harvest 1	5.29	6.15
Harvest 2	6.76	6.54
SED (within harvests)	0.174*** (42 df)	

In addition to the improvement in head density, a high late propagation temperature also improved the base shape.

Table 30 Base shape score (scored 1-9 where 9 is a flat base)

Late propagation temperature Low	High
6.639	7.02

SED - 0.079*** (42 df)

There is some evidence that the early propagation temperature influenced the base shape, but the effect was not consistent at each sowing.

Table 31 Base shape score

Sowing date	Early propagation temperature Low	High
26 November	6.66	7.14
12 January	6.84	6.66
25 January	6.68	7.01

SED (within sowings) 0.137** (42 df)

The base shape of the first dowing of Globe was less pointed than that of Kelvin, but from the second and third sowings Kelvin had the preferred shape.

Table 321 Base shape score

Sowing date	Kelvin	Globe
26 November	6.10	7.69
12 January	7.03	6.47
25 January	7.04	6.65

SED (within sowings) 0.137*** (42 df)

Kelvin produced heads with better base density than Globe.

Table 33 Base density score (scored 1-9 where 9 is well-filled)

Variety Kelvin	Globe
5.170	4.44
SED 0.1245*** (42 df)	

This was more evident at the second harvests and from the second and third sowings.

Table 34 Base density score

	Variety Kelvin	Globe
Harvest 1	4.90	4.79
Harvest 2	5.44	4.09
SED (within harvests) 0.176*** (42 df)		

Table 35 Base density score

Sowing date	Variety Kelvin	Globe
26 November	4.47	4.49
12 January	5.21	4.49
25 January	5.83	4.34
SED (within sowings) 0.216*** (42 df)		

Conclusions

Results from two sites indicate that:

1. Kelvin produces heavier heads with a higher percentage marketable and/or Class I than Globe. Kelvin does, however, take longer to reach maturity, especially from early sowings.

2. Kelvin also possessed a better shaped head which was better filled than Globe, although overall heads were generally less dense.

3. The effect of high or low temperatures during the early part of the propagation period was not distinct but a high temperature during the latter part of propagation produced heavier heads (especially in Kelvin from the later two sowings) which were more dense and with a better shaped base.

4. High temperatures during the later propagation period did not reduce the development of the internal stalk at the Luddington site.

5. At both Stockbridge House and Luddington the best combination of head weight and quality was recorded from Kelvin sown on 25 January (third sowing) and harvested in the third week of May. The percentage of Class I heads at this time was 46 per cent and 73 per cent respectively.

II Unheated trials

Luddington EHS

Materials and methods

Lettuce seedlings raised in 43 mm blocks at Luddington were planted, as detailed in the treatments below, into an E-W orientated four bay polythene house. The lettuce were grown according to good commercial standards.

Treatments

Varieties
1. Globe
2. Kelvin

Plant spacing

Globe
a. 25 x 25 cm (16 pl/m^2)
b. 25 x 30 cm (13 pl/m^2)
c. 30 x 30 cm (11 pl/m^2)

Kelvin
a. 25 x 30 cm (13 pl/m^2)
b. 30 x 30 cm (11 pl/m^2)
c. 35 x 30 cm (9.5 cm pl/m^2).

Sowing dates	Planting dates
1. 12 January	1 March
2. 26 January	14 March
3. 9 February	17 March

Propagation regime: $7^{o}C$ day and night (no lights or CO_2)

Growing house: Unheated

Statistical analysis

This has been undertaken by R Edmondson of IHR Littlehampton.

The experiment was designed to examine the effects of three factors, spacing, variety and sowing date on the yield and quality of iceberg lettuce grown in unheated glasshouses.

The experiment was of the split-plot type with the three sowing date treatments forming the main plots of the experiment and the six combinations of two varieties and three spacings forming the sub-plots within each main plot. Sub-plots were randomised within main plots and the main plots were randomised within complete replicate blocks. There were two complete replicates with each replicate in a separate bay.

Three harvests were made from each experimental plot.

For improved accuracy variates expressed in percentage terms have been subject to angular transformation. The statistical data given in the tables refers to transformed data, which is represented in the tables in brackets.

Assessments

These were made as detailed in the heated trial report (p 4). All spacings for a single variety and sowing date combination were harvested on the same date.

Results

Cropping period

Harvesting commenced with the earliest sowing of both Globe and Kelvin on 13 May and continued through until 1 June. Three harvests for each sowing date/variety combination were made between the dates listed in Table 1.

Table 1 Harvest dates

Sowing	Variety	
	Kelvin	Globe
1. (12 January)	13-20 May	13-20 May
2. (26 January)	20-27 May	17-25 May
3. (9 February)	25 May-1 June	25 May-1 June

In contrast to the heated trial Globe and Kelvin appeared to mature at a similar time.

Plant density effects

Given that Kelvin and Globe were known to be very different lettuce types and that Kelvin has a larger sized frame a different range of spacings was chosen for each variety.

Both Kelvin and Globe appeared to respond in a similar way over their individual range of plant densities. In each a lower plant density resulted in a heavier mean marketable head weight, mean Class I head weight and mean total head weight (Tables 2 and 3).

Table 2 Mean marketable head weight

Spacing	Variety Kelvin	Globe	Mean
1.	598.7	488.7	543.7
2.	613.1	543.4	578.3
3.	711.6	602.8	657.2
Mean	641.1	544.9	

SED (between var. means) = 11.1*** (15 df)

SED (between spacing means) = 12.4*** (15 df)

Table 3 Mean Class I head weight

Spacing	Variety Kelvin	Globe	Mean
1.	614.3	501.1	557.7
2.	644.5	560.4	602.5
3.	724.2	611.9	668.1
Mean	661.0	557.8	

SED (between var. means) = 10.33*** (15 df)

SED (between spacing means) = 12.65*** (15 df)

Increasing the spacing between plants not only increased the head weight but also resulted in an improvement in the percentage of Class I heads and a corresponding decrease in the percentage of Class II heads (Table 4).

Table 4 Percentage of Class I + Class II heads (of total)

Spacing	Class I	Class II
1.	33.3 (32.7)	36.1 (35.0)
2.	47.5 (42.7)	25.5 (27.3)
3.	65.0 (55.6)	16.7 (19.3)
SED (15 df)	4.41 ***	2.95 ***

Plant density also affected other aspects of head characteristics. Increasing plant spacing resulted in an improvement in base density and base shape (Table 5).

Table 5 Head characteristics

Spacing	Base density	Base shape
1.	6.52	6.21
2.	6.87	6.52
3.	7.14	6.67
SED (15 df)	0.111 ***	0.104 ***
Signif interaction		VxHxSp

The weak variety, harvest and spacing interaction indicated that the highest plant density produced poorer base shape in Globe only at late harvests.

Variety effects

There were marked differences in the performance of Globe and Kelvin.

Overall Kelvin produced a heavier head than Globe, especially at the later harvests (Table 6). This is a reflection of the relative frame size and natural growth habit of each variety.

Table 6 Mean marketable head weight (grammes)

Harvest	Variety Kelvin	Globe
1.	563.9	494.6
2.	637.5	541.9
3.	722.1	598.4
SED (within harvests)	= 15.05	(29 df)

At an early harvest (harvest 1) the percentage of marketable heads was unchanged by sowing date in the variety Globe, whilst in Kelvin the percentage increased from later sowings. At later harvests both Globe and Kelvin produced fewer marketable heads from later sowings (Table 7).

Table 7 Percentage marketable heads

Sowing	Harvest 1		Harvest 2		Harvest 3	
	Kelvin	Globe	Kelvin	Globe	Kelvin	Globe
1	63.9 (53.3)	90.3 (77.7)	87.5 (73.2)	91.7 (76.4)	77.8 (63.2)	77.8 (65.0)
2	84.7 (71.7)	91.7 (74.8)	63.9 (54.1)	97.2 (81.4)	40.3 (38.6)	63.9 (56.0)
3	95.8 (81.6)	90.3 (75.7)	77.8 (62.8)	66.7 (57.6)	55.6 (48.3)	27.8 (28.4)

SED (within harvest) = 5.92*** (29 df)

In terms of head characteristics Globe was in general more dense inside the head, had a poorer shaped base and had a more developed internal stalk than Kelvin (Table 8). Some of these factors were however also influenced by the sowing date and time of harvest. For instance, Kelvin showed a large increase in head density at later harvests, whilst Globe was relatively unaffected (Table 9). At an early harvest Kelvin also showed more stalk growth than Globe from later sowings (Table 10).

Table 8 Head characteristics, scored1-9, where 9 = excellent

Variety	Head density	Base shape	Base density	Internal stalk
Kelvin	6.61	6.75	6.93	4.99
Globe	7.32	6.19	6.76	3.15
SED	0.106 ***	0.085 ***	NS	0.098 ***
Signif. interactions	VxS VxH SxH	-	-	VxS VxH VxSxH

Table 9 Head density scores (scored 9-1, where 9 = most dense)

Harvest	Variety	
	Kelvin	Globe
1.	5.82	6.92
2.	6.73	7.41
3.	7.29	7.62

SED (within harvests) 0.138*** (30 df)

Table 10 Internal stalk length (scored 9-1, where 9 = least developed)

Sowing	Harvest 1		Harvest 2		Harvest 3	
	Kelvin	Globe	Kelvin	Globe	Kelvin	Globe
1.	6.16	3.97	4.97	3.43	5.07	1.73
2.	5.67	3.93	4.55	3.00	4.03	2.58
3.	5.30	4.20	4.97	3.33	4.23	2.12

SED (within harvests) 0.237** (30 df)

Sowing date effects

A range of sowings were used to provide continuity of supply during a period in early-late May. Different sowing dates, and the climatic differences experienced by each did, however, affect not only the period of harvest but also the way in which the lettuce heads developed. Most of these effects have already been highlighted since they interact with either variety or spacing effects.

Stockbridge House EHS

Materials and methods

Treatments

Varieties: Globe

Kelvin

Sowing date	Planting date
12 January	11 March
25 January	23 March
9 February	23 March

Cultural details

Sown in 3.8 cm blocks and propagated at 7°C after chitting.

Spacing: Globe 25 x 25 cm. Kelvin 30 x 30 cm.

Growing house: Single span E-W orientated polythene tunnel, unheated.

Statistical analysis

The tunnel was divided into two halves and the two varieties were allocated to different halves. Four blocks ran the length of the tunnel with each block containing all six treatment combinations. Each treatment was replicated four times and each plot was harvested twice with 12 heads cut at each harvest. There are no significance tests for direct variety comparison because the variety comparison was confounded with tunnel position.

Results

Cropping period

Harvesting commenced earlier for Globe than Kelvin. Although Kelvin reached an acceptable weight before Globe, its head density required more

time to reach iceberg standard. The cropping period for Globe was shorter than in the heated glass and the second and third sowings were harvested at the same time. The harvesting period for Kelvin in this trial was similar in duration to that under glass. When common sowing dates were compared, both Kelvin and Globe matured up to two weeks later in the unheated trial.

Table 11 Harvest dates

Sowing	Kelvin	Globe
12 January	24 May-1 June	16-23 May
25 January	26 May-1 June	24-26 May
9 February	1 June-3 June	24-26 May

In terms of mean marketable weight, there were significant differences between sowing dates.

Table 12 Mean marketable head weight (g). Mean of two varieties

Sowing	12 January	25 January	9 February
	577.4	638.4	644.4
SED	14.86** (12 df)		

When the varieties are considered separately the pattern is different for Kelvin and Globe. Weights were higher from the second and third sowings than from the first sowing when the varieties are meaned.

Table 13

Variety	Sowing 12 January	25 January	9 February
Kelvin	710.7	755.2	823.5
Globe	444.1	521.7	465.4

SED (within varieties) 21.01** (11 df)

The marketable head weight of Kelvin increased with the later sowing dates. The second date produced the heaviest heads of Globe.

Table 14 Mean marketable head weight (g)

Sowing date	Harvest 1	2
12 January	489.1	665.8
25 January	575.3	701.6
9 February	610.8	678.1

SED (within harvests) 19.42** (11 df)

At the first harvest, the mean marketable head weight was greater from the later sowing date. This was not the case for the second harvest.

Table 15 Percentage marketable heads (Angular transformation)

Sowing 12 January	25 January	9 February
74.0 (62.8)	77.6 (65.1)	96.4 (83.8)

SED 4.47*** (12 df)

The highest percentage of marketable heads came from the third sowing date (9 February). This would appear to hold true for both varieties as there is no significant evidence of a sowing date x variety interaction.

Overall the quality of the heads improved at the later sowing dates.

Table 16 % Class I heads (Angular transformation)

Sowing 12 January	25 January	9 February
1.0 (2.1)	11.5 (13.9)	37.0 (36.9)
SED	3.13*** (12 df)	

The quality of Kelvin was better from the second and third sowing dates, but Globe had a low percentage of Class I heads from the first two sowings.

Table 17 % Class I heads (Angular transformation)

Variety	Sowing 12 January	25 January	9 February
Kelvin	2.1 (4.2)	20.8 (23.7)	31.2 (33.2)
Globe	0 (0)	2.1 (4.2)	42.7 (40.5)
SED (within varieties)		4.42** (12 df)	

The analysis of the scores of base density show strong evidence of an effect of sowing date. The third sowing produced heads with the highest density.

Table 18 Base density score (scored 1-9, where 9 is well-filled)

Sowing 12 January	25 January	9 February
4.740	4.41	5.74
SED	0.18*** (12 df)	

The improvement in base density from the third sowing was greater for Globe than Kelvin.

Table 19 Base density score

Variety	Sowing 12 January	25 January	9 February
Kelvin	5.58	5.65	6.15
Globe	3.90	3.17	5.33
SED (within varieties)		0.248** (12 df)	

The third sowing date produced heads with the best head density.

Table 20 Head density score

Sowing 12 January	25 January	9 February
5.93	6.65	7.47
SED	0.265*** (12 df)	

The head density improved with time and was higher at the second harvests.

Table 21 Head density score

Sowing	Harvest 1	2
12 January	4.98	6.88
25 January	5.48	7.81
9 February	7.08	7.85

SED (within harvests) 0.339** (12 df)

There is also strong evidence of interaction effects between sowing date, variety and harvest date.

Table 22 Head density score (scored 1-9, where 9 is most dense)

Variety	Sowing 12 January		25 January		9 February	
	Harvests 1	2	1	2	1	2
Kelvin	4.63	8.29	4.96	8.38	7.88	8.21
Globe	5.33	5.46	6.00	7.25	6.29	7.50
SED			0.480*** (12 df)			

The pattern was not the same for the two harvests and there is also evidence that the pattern from the two harvests was different for the two varieties.

There is strong evidence of significant treatment effects on the internal stalk length.

Table 23 Internal stalk length score (scored 1-9, where 9 is a low stalk length and showing no sign of bolting)

Sowing 12 January	25 January	9 February
4.250	3.92	4.93
SED	0.179*** (12 df)	

A high score indicates shortest stalk length and least tendency to bolting. When the varieties are considered separately, Kelvin showed no difference between sowing dates whereas Globe showed the longest stalk length from the second sowing and shortest stalk length from the third.

Table 24 Internal stalk length score

Variety	Sowing 12 January	25 January	9 February
Kelvin	5.69	5.92	5.67
Globe	2.81	1.92	4.19
SED (within varieties)		0.253*** (12 df)	

There was a tendency for internal stalk length to increase at the second harvest indicating a higher risk of bolting.

Table 25 Internal stalk length scores

Sowing	Harvest 1	Harvest 2
12 January	5.29	3.21
25 January	4.31	3.52
9 February	5.04	4.81
SED (within harvests)	0.241*** (12 df)	

Conclusions

In contrast to the heated trials the response of the varieties Globe and Kelvin to different sowing and harvest dates was not consistent at the two sites.

Luddington

1. Both varieties showed a marked response to plant density. When grown at wider spacings (lower densities) head weight, percentage marketable and percentage Class I heads were increased.
2. As in the heated trial Kelvin produced a heavier head weight than Globe, particularly at later harvests.
3. The response to sowing date was not consistent. At the earliest harvest, the percentage of marketable heads was increased in both Globe and Kelvin from later sowings. At later harvests the trend was reversed.

Stockbridge House

4. At Stockbridge House later sowing dates increased the mean marketable head weight, percentage of total marketable and Class I heads.
5. At Stockbridge House overall the most acceptable heads were produced by Kelvin sown on the latest date (9 February).