# Leeks. Extension of marketing season through storage and early production

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# LEEKS - EXTENSION OF THE MARKETING SEASON THROUGH STORAGE AND EARLY PRODUCTION TECHNIQUES. STORAGE OF LEEKS


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## Abstract

The object of this project was to extend the marketing season for leeks into the May/June period. Leek varieties sown in the field in May were lifted in early-mid April. They were lightly trimmed and placed vertically into ventilated crates for storage at 0-1$^{\circ}$C, 95% RH.

The effect of Controlled Atmosphere (CA) (9% $CO_2$, 3% $O_2$ storage) was compared with normal refrigerated air storage, together with the effects of a benomyl spray and a reduced pre-storage trimming treatment on quality of the leeks out of store and during a subsequent shelf life period.

Samples were removed from the air store between 6 and 10 weeks and from the CA store between 7 and 11 weeks.

Storing leeks in a Controlled Atmosphere improved the quality over air storage when removed from store. CA produced a higher marketable yield with less rotten and fewer bolted leeks.

In 1989 when assessed over a storage period of 7-11 weeks, the quality of CA stored leeks deteriorated after more than 9 weeks. However, even after 9 weeks storage, more than 80 per cent of those put into store were still marketable.

In contrast, the quality of air stored leeks significantly deteriorated after 6-7 weeks.

Sensory appraisal in 1988 indicated that the leeks from both store environments were still of good eating quality at the end of the maximum storage period.

Results from three years of trials indicate the use of a benomyl spray, pre-storage, is mildly beneficial, improving the quality of leeks out of either air or CA storage.

All three varieties assessed, Porino, Corina and Vincent, appeared to store equally well although, as might be expected, the grade out when removed from store reflected the inherent characteristics of each variety.

One year's results on the potential for reduced trimming on loading into store indicates that this technique leads to a reduction in marketable yield out of store and to a subsequent reduction in shelf life quality. A modified approach to reduce the pre-storage labour requirement requires further evaluation.

## Objective

To investigate the storage techniques required to supply the market with quality leeks during the period from mid May to early July.

## Introduction

Given the year round demand from all market outlets for good quality leeks, and the previous unavailability of such a product from UK sources during May, June and July, this project was initiated to investigate the potential and the best conditions for long term storage. Results from the previous two years indicated that storing leeks in Controlled Atmospheres (CA at 9% $CO_2$, 3% $O_2$) improved the quality out of store and also during subsequent shelf life. After 9 weeks, 87 per cent of CA stored leeks were still marketable after trimming and, in addition, they were still of good eating quality.

In contrast, air stored leeks showed significant deterioration after 6 weeks storage. The use of a fungicide spray (benomyl) had a minimal effect in maintaining quality in store.

In 1989, the final year of this project, the trial was designed to confirm the effects of CA and benomyl on storage and shelf life quality but was also extended to include a pre-storage handling treatment. In all the leek storage work prior to 1989, leeks were extensively trimmed pre-store to remove mud, senescent leaves and 70 per cent of the roots. This is a very labour consuming job and it occurs at a busy time for most growers (early April). In 1989 therefore a minimal trimming treatment was included in the trial to investigate the extent it may affect the yield and quality of leeks out of store.

**Materials and Methods**

Two varieties of winter hardy leeks, Porino and Vincent, were grown to provide a crop suitable for harvesting in April.

As in 1987/8 the mild weather during the 1988/89 winter period encouraged the continued growth of leeks during this normally dormant or slow-growing period. Crop maturity was therefore fairly advanced in spring 1989 and harvesting commenced on 3 April.

The leeks were undercut, lifted and trimmed according to treatment. After trimming the leeks were placed vertically (tops uppermost) into ventilated crates (approximately 90/crate). Any leeks showing extensive disease, softness or which were <20 mm diameter were discarded.

Treatments

| | | |
|---|---|---|
| Variety : | 1. | Porino |
| | 2. | Vincent |
| Store environment: | a. | Air, 0 to minus 1$^{o}$C; 95% RH |
| | b. | CA, 0 to minus 1$^{o}$C; 95% RH; 9% $CO_2$, 3% $O_2$ |
| Fungicide: | 1. | None |
| | 2. | Benlate spray (50% a.i. benomyl, 1g/l) |
| Trimming: | 1. | Full - Note 1 |
| | 2. | Rough - Note 2 |

Note 1 Full trim involved removal of mud, senescent leaves, 50-70% of roots and a light trimming of the tops.

Note 2 A rough trim involved removal only of some roots and tops to the height of the crate.

Storage duration: Air store: 6, 7, 9, 10 weeks

CA store: 7, 9, 10, 11 weeks.

Benlate treatment was given as a thorough spray over the top of the crates.

The stores were loaded and sealed on 6 April. At each removal, sample crates were removed from store and the leeks trimmed to a supermarket-type pre-pack specification, i.e. 10 cm flag above the lowest split, >20 mm diameter.

Assessments

A pre-storage assessment of the crop was made at the time of harvest. Individual crates of leeks were weighed into store and re-weighed on removal from store. Following trimming the marketable leeks were size graded (20-28, 29-35, 36-45 and 45+ mm) and unmarketable leeks classified according to their defects (undersized, floppy, rots and bolters). Any leek in which the flower stalk was clearly visible was considered to have bolted.

At the time of loading into store and at each of the removal dates, a sample of good quality leeks was assessed under shelf life conditions of 20$^{o}$C and 50% RH. Ten trimmed leeks from each treatment were cleaned, packed into shallow trays and overwrapped. Weight loss, disease on shank and flag and turgidity were recorded at 24 hour intervals over a three day period. Leeks were cut open at the end of the shelf life period and any internal rot or flower stalk extension similarly recorded. All shelf life assessments (except weight loss) were scored on a 9-0 scale, where 9 was excellent.

Statistical analysis

Three replicated crates of each storage treatment were randomised within each removal date in the stores. Shelf life assessments were also carried out on the same three replicates randomised in the shelf life room. Statistical analysis was undertaken by Andrew Mead at IHR Wellesbourne. Percentage calculations have been subjected to angular transformation for improved statistical analysis. Bracketed figures in the tables refer to the transformed data. Where interactions between treatments are significant they have been noted. (V = variety, S = store type, R = removal date, T = trimming treatment).

Calculations of weight loss have been analysed by analysis of covariance using the initial weight (i.e. into store or into shelf life) as the covariate.

**Results and Discussion**

Response to Controlled Atmospheres

Overall quality of the leeks out of store in 1989 was very good and most treatments gave acceptable marketable yields.

As in previous years there was a response to CA although slightly less marked in 1989. Overall CA stored leeks produced a higher percentage marketable but the response was only significant after 10 weeks. The effect was most pronounced on the rough trimmed leeks (Tables 1 and 2).

Table 1 Percentage marketable leeks (by number)

| Store | Removal (weeks in store) 7 | 9 | 10 | Mean |
|---|---|---|---|---|
| Air | 88 (70.5) | 82 (65.2) | 64 (53.3) | 78 (63.0) |
| CA | 88 (69.8) | 82 (65.3) | 79 (63.6) | 83 (66.2) |
| Mean | 88 (70.2) | 82 (65.2) | 73 (58.5) | |

SED (between stores) 0.80 *** (94 df)

SED (between removal dates) 0.98 ***

SED (other comparisons) 1.39 ***

Bracketed figures refer to transformed data to which statistical analysis applies.

Table 2 Percentage marketable leeks (by number)

| Store | Trimming Rough | Full | Mean |
|---|---|---|---|
| Air | 73 (59.9) | 83 (66.2) | 78 (63.0) |
| CA | 81 (64.7) | 84 (67.8) | 83 (66.2) |
| Mean | 77 (62.3) | 84 (67.0) | |

SED (between stores) 0.80 *** (94 df)

SED (between trimming trts) 0.80 ***

SED (other comparisons) 1.14 *

The increased percentage of marketable leeks in the CA store related to the lower percentage of rotten leeks (Table 3), reduced level of trimming required (Table 4) and the reduced percentage of undersized leeks (Table 5) in comparison to the air store. Again, most of these effects were more pronounced on rough trimmed leeks at later store removals.

Table 3 Percentage unmarketable, by number of rots

| Store | Removal (weeks in store) 7 | 9 | 10 | Mean |
|---|---|---|---|---|
| Air | 3 (7.7) | 5 (12.9) | 17 (24.2) | 8 (14.9) |
| CA | 3 (9.4) | 4 (10.4) | 6 (12.5) | 4 (10.8) |
| Mean | 3 (8.5) | 5 (11.7) | 12 (18.3) | |

| | |
|---|---|
| SED (between stores) | 0.75 *** (94 df) |
| SED (between removal dates) | 0.92 *** |
| SED (other comparisons) | 1.30 *** |

Table 4 Percentage trimming as % of total weight

| Store | Removal (weeks in store) 7 | 9 | 10 | Mean |
|---|---|---|---|---|
| Air | 42.4 | 41.8 | 44.3 | 42.8 |
| CA | 38.8 | 38.1 | 40.6 | 39.2 |
| Mean | 40.6 | 40.0 | 42.5 | |

| | |
|---|---|
| SED (between stores) | 0.58 *** (94 df) |
| SED (between removal dates) | 0.71 ** |
| SED (other comparisons) | 1.01 ns |
| Significant interactions | SxT; FxSxR |

Table 5 Percentage unmarketable by number of undersized leeks

| Store | Trimming Rough | Full | Mean |
|---|---|---|---|
| Air | 10 (17.8) | 2 (5.3) | 6 (11.6) |
| CA | 5 (11.8) | 1 (4.2) | 3 ( 8.0) |
| Mean | 8 (14.8) | 2 (4.7) | |

| | |
|---|---|
| SED (between stores) | 0.76 *** (94 df) |
| SED (between trimming) | 0.76 *** |
| SED (other comparisons) | 1.07 ** |

Given the higher percentage weight loss in the air store (Table 6) it is surprising that levels of floppy/soft leeks was highest from the CA store (Table 7).

CA storage did not consistently affect the levels of bolted leeks.

Table 6 Percentage weight loss after storage

| Store | Removal (weeks in store) 7 | 9 | 10 | Mean |
|---|---|---|---|---|
| Air | 3.78 | 9.45 | 6.87 | 5.86 |
| CA | 2.31 | 5.50 | 4.17 | 3.99 |
| Mean | 3.04 | 6.22 | 5.52 | |
| SED (between stores) | | | 0.563 *** (93 df) | |
| SED (between removal dates) | | | 0.563 *** | |
| SED (other comparisons) | | | 0.802 ns | |

Table 7 Percentage unmarketable by number of floppy/soft

| Store | Air | CA |
|---|---|---|
| | 1 (1.91) | 3 (7.00) |
| SED (between stores) | | 0.857 *** (94 df) |

CA storage not only improved the quality of leeks out of store compared to air storage but also had a positive effect on the subsequent shelf life of the stored leeks. All leeks were trimmed and cleaned to Class I quality but overall CA stored leeks tended to develop less disease on the flags and shanks (Tables 8 and 9), were very slightly more turgid (Table 10, 9 weeks only) and showed less extension of the internal flower stalk (Table 11).

Weight loss was actually higher on the CA stored leeks (Table 12) but extension growth inside the pre-packs was reduced (Table 13). Internal rots were also less evident in the CA stored leeks than the air stored samples.

Table 8 Disease scores on flag after 72 hours shelf life (scored 9-0, where 9 = excellent)

| Store | Weeks in store 7 | 9 | 10 | Mean |
|---|---|---|---|---|
| Air | 7.99 | 8.10 | 8.38 | 8.16 |
| CA | 7.77 | 8.28 | 8.60 | 8.22 |
| SED (between store means) | | | 0.060 ns (94 df) | |
| SED (other comparisons) | | | 0.074 ** | |

Table 9 Disease scores on shank after 72 hours shelf life

| Store | Weeks in store 7 | 9 | 10 | Mean |
|---|---|---|---|---|
| Air | 8.67 | 8.65 | 8.44 | 8.59 |
| CA | 8.79 | 8.62 | 8.68 | 8.70 |
| SED (between store means) | | | 0.041 * (94 df) | |
| SED (other comparisons) | | | 0.071 * | |

Table 10 Turgidity scores after 72 hours shelf life

| Store | Weeks in store 7 | 9 | 10 | Mean |
|---|---|---|---|---|
| Air | 7.78 | 7.39 | 7.75 | 7.64 |
| CA | 7.73 | 7.63 | 7.70 | 7.69 |
| SED (between store means | | | 0.040 ns (94 df) | |
| SED (other comparisons) | | | 0.069 ** | |

Table 11 Internal flower stalk extension after 72 hours shelf life (scored 9-0, where 9 = not extended

| Store | Weeks in store 7 | 9 | 10 | Mean |
|---|---|---|---|---|
| Air | 5.94 | 6.33 | 6.23 | 6.16 |
| CA | 6.09 | 6.66 | 6.40 | 6.38 |
| SED (between store means) | | | 0.087 * (94 df) | |
| SED (other comparisons) | | | 0.150 ns | |

Table 12 Percentage weight loss after 72 hours shelf life

| Store | Weeks in store 7 | 9 | 10 | Mean |
|---|---|---|---|---|
| Air | 2.20 | 2.21 | 1.88 | 2.10 |
| CA | 2.20 | 2.33 | 2.19 | 2.24 |
| SED (between store means) | | | 0.046 ** (93 df) | |
| SED (other comparisons) | | | 0.074 * | |

Table 13 Average extension growth (mm) after 72 hours shelf life

| Store | Weeks in store 7 | 9 | 10 | Mean |
|---|---|---|---|---|
| Air | 22.7 | 17.5 | 12.6 | 17.6 |
| CA | 17.1 | 15.6 | 9.8 | 14.2 |

Response to time in store

As in previous years removals from air and CA stores were staggered since the quality of leeks in the air store deteriorated more rapidly than those in the CA store in previous trials.

Air store

Table 14 illustrates the quality of leeks removed from the air store in 1989. In general, leeks stored for more than 7 weeks showed a significant deterioration over those removed earlier, although the rate of decline is most marked between 9 and 10 weeks.

Table 14 Quality of leeks out of air store

| Factors assessed | Removal (weeks in store) 6 | 7 | 9 | 10 | SED 62 df |
|---|---|---|---|---|---|
| % marketable | 86 (69.0) | 88 (70.5) | 82 (65.2) | 64 (53.3) | 1.16 *** |
| % unmkt rots | 4 ( 9.3) | 3 ( 7.7) | 5 (12.9) | 17 (24.2) | 1.48 *** |
| % unmkt bolters | 6 (12.8) | 4 (11.3) | 6 (13.2) | 7 (14.7) | 1.25 * |
| % unmkt undersized | 3 ( 7.1) | 4 ( 8.8) | 5 (10.2) | 9 (15.6) | 1.17 *** |
| % trimming | 43.8 | 42.4 | 41.8 | 44.3 | 1.07 *** |
| % weight loss | 3.99 | 3.85 | 6.87 | 4.02 | 0.648 *** (61 df) |

Figures in brackets are angular transformations.

In terms of shelf life quality there is no evidence that disease of the leek flags increased from later store removals (Table 15), although the level of disease from the shanks did increase at the end of shelf life after more than 9 weeks storage. Turgidity scores appeared to be declining at 9 weeks but were higher again after 10 weeks, so do not suggest an overall deterioration in turgidity. Similarly the extent to which flower stalks had extended was erratic and must be attributed to the natural variation in a crop. Levels of internal rots were increasing at later removals and although the scores in Table 15 suggest otherwise after both 24 and 48 hours, removals after both 9 and 10 weeks were significantly more rotten inside than those from earlier removals. Weight loss actually appears to decrease with later removals. Overall, the quality of leeks after 10 weeks storage in air and after 72 hours shelf life was still very good.

Table 15 Shelf life quality after 72 hours shelf life - Air store

| Weeks in store | Disease on flag | Disease on shank | Turgidity | Extension flower stalk | Internal rots | % wt loss |
|---|---|---|---|---|---|---|
| 6 | 8.00 | 8.68 | 7.76 | 5.88 | 8.95 | 2.36 |
| 7 | 7.99 | 8.67 | 7.78 | 5.18 | 8.87 | 2.26 |
| 9 | 8.10 | 8.65 | 7.34 | 5.42 | 8.80 | 2.27 |
| 10 | 8.38 | 8.44 | 7.75 | 5.76 | 8.92 | 1.94 |
| SED (62 df) | 0.112<br>* | 0.073<br>** | 0.061<br>*** | 0.189<br>** | 0.051<br>* | 0.067<br>***<br>(61 df) |
| Significant interactions | TxR | - | - | - | TxR<br>FxTxR | |

<u>CA store</u>

The quality of leeks in the CA store is very similar to that in the air store through to 9 weeks. As in the air store, there is a small but significant reduction in marketable yield between removals after 7 and after 9 weeks. In contrast however to the air store, results of CA stored leeks do not indicate a further large reduction in quality even after 11 weeks storage, when 77 per cent of those leeks put into store were still marketable after trimming (Table 16).

Corresponding levels of rotting, bolting and undersized leeks (excessive trimming required) increase with the length of period in store as does the amount of trimming required.

Table 16 Quality of leeks out of CA store

| Factors assessed | Removal (weeks in store) 7 | 9 | 10 | 11 | SED 62 df |
|---|---|---|---|---|---|
| % marketable | 88 (69.8) | 82 (65.3) | 79 (63.6) | 77 (61.5) | 1.52 *** |
| % unmkt rots | 3 ( 9.4) | 4 (10.4) | 6 (12.5) | 6 (14.4) | 1.13 *** |
| % unmkt undersized | 1 ( 3.4) | 4 ( 9.4) | 5 (11.0) | 5 (10.7) | 1.46 *** |
| % unmkt floppy | 1 ( 3.6) | 5 (10.0) | 2 ( 7.4) | 4 ( 8.7) | 1.86 ** |
| % trimming | 38.8 | 38.1 | 40.6 | 41.9 | 0.621 *** |
| % weight | 3.09 | 5.41 | 5.44 | 6.20 | 0.899 (61 df) |

The shelf life quality of the leeks out of the CA store indicates a corresponding loss of quality from later store removals but only for certain characteristics. There is no evidence to suggest the amount of disease which developed on the leek flags increased with the period of storage (Table 17). However there is a small but significant increase in disease on the shank of the pre-packed leeks from later store removals (Table 18). Turgidity scores also drop for later store removals (11 weeks) as does the score for internal flower stalk extension.

In addition there is a significant increase in weight loss between 10 and 11 weeks storage.

Table 17 Disease on flag scored after 72 hours shelf life - CA store

| | Weeks in store 7 | 9 | 10 | 11 | Mean |
|---|---|---|---|---|---|
| Rough | 7.43 | 8.21 | 8.53 | 8.12 | 8.07 |
| Full | 8.11 | 8.36 | 8.68 | 8.34 | 8.37 |
| | 7.77 | 8.28 | 8.60 | 8.23 | |

| | |
|---|---|
| SED (between removals) | 0.095 *** (62 df) |
| SED (between trimming treatments) | 0.067 *** |
| SED (other comparisons) | 0.134 * |

Table 18 Shelf life quality after 72 hours - CA store

| Weeks in store | Disease on shank | Turgidity | Extension of flower stalk | % wt loss |
|---|---|---|---|---|
| 7 | 8.79 | 7.73 | 6.09 | 2.19 |
| 9 | 8.62 | 7.63 | 6.20 | 2.31 |
| 10 | 8.68 | 7.70 | 6.19 | 2.15 |
| 11 | 8.42 | 7.10 | 5.85 | 3.34 |
| SED 62 df | 0.067 *** | 0.076 *** | 0.146 * | 0.079 *** |

Effect of fungicide treatments

The use of a fungicide drench pre-storage did improve the quality of leeks out of store by a small but significant amount.

The marketable yield out of store was slightly increased (Table 19). Although the use of a fungicide did not reduce the percentage of totally rotten leeks (Table 20), the amount of trimming required on treated leeks was reduced (Table 21) and as a result, the number of undersized leeks reduced also. Weight loss on treated leeks was also reduced. This is probably attributable to the addition of the drench rather than the act ingredient but the result is a slight reduction in the numbers of floppy or unacceptably limp leeks.

Table 19 Percentage marketable leeks (by number). Mean 2 stores

| Fungicide | Removal (weeks in store) 7 | 9 | 10 | Mean |
|---|---|---|---|---|
| None | 88 (69.8) | 80 (64.1) | 69 (57.0) | 79 (63.6) |
| Benlate | 89 (70.6) | 84 (66.4) | 74 (60.0) | 82 (65.7) |
| Mean | 89 (70.2) | 82 (65.2) | 72 (58.5) | |

| | | |
|---|---|---|
| SED (between fungicide treatments) | 0.80 * | (94 df) |
| SED (between removals) | 0.98 *** | |
| SED (other comparisons) | 1.39 ns | |

Figures in brackets are angular transformations.

Table 20 Effect of fungicide treatments on quality of leeks out of store. (Mean 2 stores, 3 removals)

| Fungicide | % unmkt rots | % unmkt undersized | % unmkt floppy | % wt loss |
|---|---|---|---|---|
| None | 6 (12.9) | 6 (11.1) | 3 (5.4) | 2.55 |
| Benlate | 6 (12.8) | 4 ( 8.5) | 2 (3.5) | 7.30 |
| SED (94 df) | 0.75 ns | 0.76 *** | 0.86 * | 0.46 *** |

Figures in brackets are angular transformations.

Table 21 Effect of fungicide and store on percentage trimming required

| Fungicide /store | Removal (weeks in store) 7 | 9 | 10 |
|---|---|---|---|
| Air | | | |
| None | 41.4 | 42.0 | 46.2 |
| Benlate | 43.5 | 41.6 | 42.3 |
| CA | | | |
| None | 40.3 | 37.7 | 41.2 |
| Benlate | 37.3 | 38.6 | 40.1 |

SED (any comparison) 1.42 * (94 df)

The effect of a fungicide treatment on the shelf life of pre-packed Class I leeks was not widespread. The use of Benlate did reduce the development of disease on the leek flags (Table 22), particularly on the fully trimmed leeks. Disease levels on leek shanks were not significantly affected by the use of a fungicide treatment.

Similarly other shelf life characteristics did not respond consistently to fungicide treatment.

Table 22 Disease scores on flag of leeks after 72 hours shelf life. Mean 2 stores, 3 removals

| Fungicide treatment | Trimming treatment Full | Rough | Mean |
|---|---|---|---|
| Benlate | 8.47 | 8.18 | 8.32 |
| None | 8.11 | 8.00 | 8.05 |
| Mean | 8.29 | 8.09 | |

SED (between fungicide treatments) 0.060 *** (94 df)
SED (between trimming treatments) 0.060 **
SED (other comparisons) 0.085 ns

Response to trimming treatments

Although labour saving at the time of store loading, the minimal (rough) trimming treatment did lead to a significant reduction in the percentage of marketable leeks out of store (Table 23). Leaving the outer damaged leaves on the rough trimmed treatments led to an increase in the level of rots over fully trimmed ones (Table 24) and in addition, a larger number of undersized leeks (Table 25). Some responses were restricted to one variety only.

Obviously trimming levels were higher on rough trimmed leeks but the percentages of small leeks suggest that excessive trimming was required beyond that needed for the fully trimmed plots.

Overall the response to trimming treatments did not interact with either fungicide treatment or store environment, although the effect was less marked in the earlier removals from the CA store.

Table 23 Percentage marketable leeks (by number) out of store. (Mean CA and Air stores)

| Trimming | Removal (weeks in store) 7 | 9 | 10 | Mean |
|---|---|---|---|---|
| Rough | 87 (69.0) | 79 (63.1) | 66 (54.7) | 77 (62.3) |
| Full | 89 (71.3) | 85 (67.4) | 77 (62.2) | 84 (67.0) |
| Mean | 88 (70.2) | 82 (65.2) | 72 (58.5) | |

SED (between trimming treatments) 0.80 *** (94 df)

SED (between removals) 0.98 ***

SED (other comparisons) 1.97 *

Figures in brackets are angular transformations.

Table 24 Percentage unmarketable leeks - number of rots. Air store only

| Trimming | Removal (weeks in store) 6 | 7 | 9 | 10 | Mean |
|---|---|---|---|---|---|
| Vincent | | | | | |
| Rough | 4 (11.0) | 4 ( 8.9) | 4 (11.8) | 15 (22.0) | 7 (13.4) |
| Full | 4 ( 9.6) | 2 ( 7.6) | 6 (13.8) | 15 (22.4) | 7 (13.4) |
| Porino | | | | | |
| Rough | 3 (10.3) | 4 (10.6) | 8 (15.9) | 24 (29.2) | 10 (16.5) |
| Full | 2 ( 6.1) | 1 ( 3.8) | 3 (10.0) | 16 (23.2) | 6 (10.8) |

SED (trimming treatment x variety means) 1.48 ** (62 df)

SED (other comparisons) 2.96 ns

Figures in brackets are angular transformations.

Table 25 Percentage unmarketable leeks - number undersized. (Mean 2 stores, 3 removals)

| Trimming | Variety Vincent | Porino | Mean |
|---|---|---|---|
| Rough | 7 (14.2) | 8 (15.4) | 7 (14.8) |
| Full | 2 ( 5.1) | 1 ( 4.3) | 2 ( 4.7) |

SED (between trimming treatments) 0.76 *** (94 df)

SED (other comparisons) 1.07 ns

Figures in brackets are angular transformations.

Although all leeks were pre-packed to Class I standards before entry into the shelf life room, the effect of trimming treatments was evident in the quality at the end of shelf life. Fully trimmed leeks consistently developed less disease on the leek flag (Table 26) and shank. Turgidity and extension growth of the flower stalk did not show a consistent response but levels of internal rotting were higher on the rough trimmed samples of leeks, particularly from the later removals from the air store. There was no difference between the treatments in weight loss during shelf life. Overall, quality was still high at the end of the shelf life period.

Table 26 Shelf life quality after 72 hours. Mean 2 stores, 3 removals

| Trimming treatment | Disease on flag | Disease on shank | Turgidity | Extension of flower stalk | Internal rotting | % wt loss |
|---|---|---|---|---|---|---|
| Rough | 8.09 | 8.60 | 7.61 | 5.87 | 8.90 | 2.20 |
| Full | 8.29 | 8.69 | 7.71 | 5.74 | 8.94 | 2.14 |
| SED (between trimming trts) 94 df | 0.060 ** | 0.041 * | 0.040 * | 0.092 ns | 0.020 (p=0.07) | 0.042 ns |
| Significant interactions | TxS<br>TxR<br>VxFxTxS | -<br>- | VxT<br>TxS<br>VxTxR<br>VxFxTxS | | | |

Variety responses

The two varieties Vincent and Porino were chosen for their winter hardy characteristics. As such they do not represent a detailed evaluation to determine the best varieties available but results do indicate the type of performance which might be expected from different varieties. Both Vincent and Porino are short shafted leeks of a similar type.

Overall, Porino yielded a slightly lower percentage of marketable leeks out of store than Vincent, particularly in the air store (Table 27). The level of rots in Vincent was lower than Porino at later removals (Table 28). Weight loss was also reduced in the variety Vincent compared to Porino (Table 29).

The levels of bolting, undersized leeks and the percentage of leeks in the size grade 20-28 mm were all significantly affected by variety but no consistent trend emerged from either store.

Table 27 Percentage marketable leeks out of store. (Mean 4 store removals)

| Variety | Store type Air | CA |
|---|---|---|
| Vincent | 81 (65.5) | 82 (65.6) |
| Porino | 79 (63.5) | 81 (64.5) |

SED (varieties Air store) 0.82 * (62 df)

SED (varieties CA store) 1.07 ns

Figures in brackets are angular transformations.

Table 28 Percentage unmarketable leeks - number of rots. (Mean 2 stores)

| Variety | Weeks in store 7 | 9 | 10 | Mean |
|---|---|---|---|---|
| Vincent | 3 (9.1) | 4 (10.6) | 9 (16.2) | 5 (12.0) |
| Porino | 2 (8.0) | 5 (12.7) | 14 (20.4) | 7 (13.7) |

SED (between varieties) 0.75 * (94 df)

SED (other comparisons) 1.30 *

Figures in brackets are angular transformations.

Table 29 Percentage weight loss out of store. Mean 2 stores

| Variety | Weeks in store 7 | 9 | 10 | Mean |
|---|---|---|---|---|
| Vincent | 2.40 | 5.03 | 4.33 | 3.92 |
| Porino | 3.68 | 7.35 | 6.71 | 5.93 |

SED (between varieties) 0.535 *** (93 df)

SED (other comparisons) 0.797 ns

Figures in brackets are angular transformations.

The response of the two varieties in shelf life is very complicated with interactions between several treatments for most assessments. As a result there are few clear responses excepting that the variety Vincent consistently developed slightly more disease on the leaf flag than the variety Porino (Table 30).

Table 30 Disease on leek flags scored after 72 hours shelf life. Mean 2 stores

| Variety | Weeks in store 7 | 9 | 10 | Mean |
|---|---|---|---|---|
| Vincent | 7.59 | 7.98 | 8.36 | 7.98 |
| Porino | 8.17 | 8.40 | 8.63 | 8.40 |

SED (between varieties) 0.060 *** (94 df)

SED (other comparisons) 0.104 ns

## Discussion

This trial report represents the third and final report of the project investigating cold storage of leeks to supply the market in May and June. Over the three years, two of the overwintered crops (1988 and 1989) grew through relatively mild winters, whilst the first (1987) was exposed to lower and more normal temperatures. Advanced crop maturity in the later two trials necessitated earlier lifting for storage in early April, as opposed to mid-late April. In all three years a minimum of 6-7 weeks storage in air at 0 to minus 1°C yielded over 80 per cent (by number) of marketable leeks out of store.

The work has also shown the period of storage can be successfully extended to 9-10 weeks by the use of controlled atmospheres (9% $CO_2$; 3% $O_2$) in addition to store temperatures of 0 to minus 1°C. The beneficial effect of CA storage was apparent not only in the yield out of store but also in the subsequent shelf life quality of the leeks.

The use of a fungicide treatment pre-storage did not produce such a marked effect. There is evidence to suggest that the use of a Benlate spray pre-storage does increase the marketable yield by reducing the degree of rotting on most leeks. However the effect on subsequent shelf life is minimal. Benomyl is not currently approved for use in this way and will require extensive residue testing if approval is to be given. The current pressure of public opinion against the use of chemicals post harvest, together with the magnitude of benefit it derived from its application on leeks, require that careful consideration needs to be given to the necessity of its use. CA storage is likely to produce better results.

Over the three years of the project the work has mostly been carried out on the variety Porino. This was originally chosen for its proven winter hardy characteristics and for its quality in early-mid April. The varieties Cortina and Vincent have also been assessed, in one year only, and both gave an adequate performance (although were not tested for winter hardiness). Cortina in particular is a long shanked variety and produced an attractive pre-pack leek in comparison to the shorter shanked Porino.

Results from one year only suggest that minimal trimming before storage will reduce the labour requirement at store loading but will also sacrifice marketable quality out of store. Reports from Holland suggest that some sort of reduced trimming system is feasible (Brakeboer 1989), but it needs further evaluation in the UK.

**Conclusions**

1. Storing leeks in air at 0 to minus 1°C, 95% RH will yield over 80 per cent marketable leeks (by number) out of store after 6-7 weeks. Yield and shelf life quality start to deteriorate beyond this storage period.

2. The use of Controlled Atmosphere storage (9% $CO_2$; 3% $O_2$) significantly improves quality both in store and during subsequent shelf life. A storage period of 8-9 weeks is feasible in CA without a significant loss of yield. In 1989 even after 11 weeks 77 per cent of the leeks in store (by number) were still marketable but the level of trimming was increasing.

3. The use of a Benlate spray pre-storage is beneficial to the marketable yield of leeks out of store but the effect is not large.

4. The variety Porino has consistently performed well in storage trials. The longer shanked leek variety Cortina trialled in 1988 produced a more attractive pre-pack but was also prone to lack turgidity and to become too small when trimmed out of store. Vincent was trialled in 1989 and gave a performance similar to Porino.

5. The use of a reduced trimming technique before storage led to a reduction in marketable yield (by number) out of store and to subsequent reduction in shelf life quality. This technique required further evaluation.

**Recommendations for future action**

This project is now complete and with the closure of Luddington EHS, CA storage facilities are no longer available.

Reference

Brakeboer, T (1989). Rapid cooling of leeks gives best results.
Weekblad Groenten en Fruit 20-1-89

HDC CONTRACT R & D - EXPERIMENT REPORT

HDC FV2/C/87/0354

# LEEKS. EXTENSION OF MARKETING SEASON THROUGH STORAGE AND EARLY PRODUCTION TECHNIQUES (EARLY PRODUCTION SECTION)

## EFFECT OF CROP COVER MATERIALS AND DURATION OF COVER ON YIELD

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Status of work: last year of trial completed

Year of experiment: 3

Report Number: 3

Period covered: September 1988 to August 1989

## Abstract

Leeks are now required for sale over as long a season as possible, with some outlets willing to sell them all the year round. At present there is a gap in production from mid May to late July. This trial was initiated to determine whether crop covers could bring forward the harvest of the earliest spring planting into the first half of July.

Seed of cv. Tilina was sown on 18 January into 27 mm peat blocks. The planting was carried out on 30 March and the covering done on the following day. Open ground plants were compared to those covered with perforated plastic 500 holes/$m^2$ and perforated plastic 10 holes/$m^2$. Both of these materials were left on the crop for 4, 6 and 8 weeks. A double cover was also used. This comprised a perforated plastic 500 holes/$m^2$ cover over fleece. The removal dates for these were 4, 4 and 6 weeks for the perforated plastic and 6, 8 and 8 weeks for the fleece cover. Assessments for marketable yield and size were made at two harvests, 29 June and 17 July.

At the first harvest, the 10 holes/$m^2$ perforated cover removed after 6 weeks produced a yield of 26 tonnes/ha, a yield increase over open ground plants of 7.6 tonnes/ha, equivalent to 15 days growth. However the yield was reduced to just below that of the open ground plants if the cover was left on for 8 weeks. The 500 holes/$m^2$ perforated cover gave a yield increase of 1.9 tonnes/ha, equivalent to 4 days growth. The double cover came between the two perforated covers, a yield increase of 3.8 tonnes/ha, equivalent to 8 days advancement.

## Objective

To determine the effect of crop covers on the yield and quality of early leeks.

## Introduction

There is a gap in normal commercial leek production from mid May to late July. In mid May the overwintered crop will bolt in the field and the first spring plantings will not mature until the end of July. The life of the overwintered crop can be extended by storage into the May and June period, but quality declines with prolonged periods in store. Crop covers have been used in this country to advance the early spring plantings of many crops by one to three weeks, depending on season. From work done on the continent it appears that the same could be true for leeks. However no work has previously been undertaken in the UK to determine the ideal cover material or the duration of the covering period. Perforated plastic with 500 holes/$m^2$ is the standard cover material for many vegetable crops. Trials on the continent have shown that 10 holes/$m^2$ perforation density clear plastic covers are beneficial to early yield. Double covering is also practiced on the continent to give early protection for bolt sensitive crops. With this system a fleece cover is placed immediately over the crop and a perforated plastic 500 holes/$m^2$ put on top. The top cover is removed early in the growth of the crop before 'overheating' can occur and the fleece cover left on longer. For these reasons two perforated plastic covers (500 holes/$m^2$ and 10 holes/$m^2$) and a double cover system were compared.

## Materials and methods

### Treatments

Following last year's trial the treatments were modified in 1989. As both the perforated plastic 500 holes/$m^2$ and fleece materials performed similarly in 1988, it was decided that the more expensive fleece material should be replaced by the double cover system. In other trials work plants raised in peat blocks have given larger transplants than for those raised in 308 cell trays. Therefore single seeded 27 mm peat blocks were used. This allowed the sowing date to be delayed until mid January to improve the standability of the crop.

The other changes made for the 1988 trial proved successful and thus the perforated plastic 10 holes/$m^2$ and different cover removal times were continued in 1989.

Treatments for 1989

Treatments:

| | |
|---|---|
| 3 cover materials: | Perforated plastic 500 holes/$m^2$ |
| | Perforated plastic 10 holes/$m^2$ |
| | Double cover (fleece under perforated plastic 500 holes/$m^2$) |

3 cover removal treatments:

| | Single covers | Double cover | |
|---|---|---|---|
| Removal time | | Perforated plastic | Fleece |
| First | 2 May | 2 May | 11 May |
| Second | 11 May | 2 May | 25 May |
| Third | 25 May | 11 May | 25 May |

Statistical design

The treatments were laid out in a randomised block design, with the two harvest dates as sub-plots. There were three replicates. In each plot there were 100 recorded plants with guard plants at the ends of each plot and at the sides of the trial. Burying of the crop cover affected several plants in each row. Therefore extra plants were used to minimise any crushing of recorded plants as the cover became tighter with the growth of the crop.

Crop diary

| Date | Operation |
|---|---|
| 18 January | Seeds sown |
| 10 March | Base fertiliser applied (150 N, 70 $P_2O_5$, 210 $K_2O$ kg/ha) |
| 29 March | Trial planted |
| 31 March | Covers put on |
| 12 May | 9 mm irrigation |
| 19 May | 9 mm irrigation |
| 13 June | 25 mm irrigation |
| 23 June | 13 mm irrigation |
| 27 June | 25 mm irrigation |
| 29 June | Harvest 1 |
| 3 July | Topdressed all 50 kg/ha N |
| 6 July | 25 mm irrigation |
| 14 July | 25 mm irrigation |
| 17 July | Harvest 2 |

Top dressing dates of individual treatments

(All applications 50 kg/ha N as nitrochalk)

| Cover removal treatment | Open ground | Single covers | Double cover |
|---|---|---|---|
| First | 2 May, 26 May | 2 May, 26 May | 11 May, 5 June |
| Second | 12 May, 5 June | 12 May, 5 June | 26 May |
| Third | 26 May | 26 May | 26 May |

Management

A quick bulking variety, Tilina, was single seeded into 27 mm peat blocks. These were germinated at 18°C under glass. This temperature was gradually reduced to 10°C by planting time. In the field, planting was done in five rows, 300 mm apart, on a 1.83 m bed, with an intra-row spacing of 90 mm. This gave 300,000 plants/ha.

The transplants were placed into holes made by a dibbing machine so that the last major leaf break was at soil level. Covers were put on the relevant treatments after planting.

Assessments

At planting the fresh weight of the transplants (without roots) was recorded to give an objective size comparison with related trials. The rest of the assessments were made at harvest. At this time a full quality and size breakdown of the crop was recorded.

The leeks were trimmed to a 'supermarket prepack' specification, with 50 mm of flag left on the shank. They were quality graded into the following categories:

- Marketable
- Too short (less than 150 mm long)
- Too small (less than 20 mm in diameter)
- Split
- Rotten
- Bolted

Marketable leeks were graded into the following size bands:

- 20-27 mm
- 28-34 mm
- 35-44 mm
- greater than 45 mm.

As well as recording the visually bolted plants, a sample of the marketable leeks was assessed for flower stalk initiation. All plants that showed a flower stem when trimmed came into the former category and were considered unmarketable. Flower initiation was assessed by cutting open ten leeks from each plot and counting the number of plants where the apices were not vegetative. An overall assessment was also made of the degree of bulbing and length of blanch on a 0 to 9 scale.

Statistical analysis

The data was subjected to analysis of variance with angular transformation of results expressed in percentage form.

## Results

Temperatures under the cover materials

Air and soil temperatures were taken under each of the covering treatments and also from the open ground plots. A data logger was used with a temperature range of -10 to 40$^{\circ}$C. The air temperature was measured using a probe mounted in a radiation screen made from a stack of slightly separated plant pot saucers that had been painted white. Air movement around the probe was maintained by drilling holes in all but the top saucer. These probes were arranged so that they were a few inches above soil level, but were placed in the wheeling between the two harvest sub-plots.

The soil probes were placed within the planted beds and readings were taken at 5 cm below soil level.

The weekly mean, air and soil temperatures for each treatment are set out in Table 1. The data logger malfunctioned in the final week before the last cover removal and the data for this week was lost.

In general the average weekly air temperatures under the double cover and low perforation plastic cover were similar. They were on average 80 per cent higher than the open ground with the high perforation plastic cover halfway between. The order was the same for the soil temperatures but increases over the open ground plots were less marked, averaging 60 per cent and 35 per cent higher respectively. Once the top cover on the double cover treatment was removed the temperature under this cover was similar to that under the high perforation plastic.

The maximum air temperature recorded was well over 40°C for both the double and low perforation plastic. Temperatures under the high perforation plastic rose to 38°C, with an open ground maximum of 27°C.

The minimum air temperatures of open ground plots was around -2°C. The high perforation plastic fell to just below zero. For the other two covers the minimum was about 2°C.

Table 1 Mean air and soil temperatures under different cover materials (Probes placed under third removal date treatments)

| Week commencing | Covering material None | Perforated plastic 500 holes/$m^2$ | Perforated plastic 10 holes/$m^2$ | Double cover |
|---|---|---|---|---|
| Air | | | | |
| 6 April | 5.6 | 7.6 | 10.1 | 10.0 |
| 13 April | 6.7 | 8.8 | 11.4 | 11.5 |
| 20 April | 7.2 | 10.3 | 13.4 | 14.1 |
| 27 April | 5.7 | 9.2 | 12.1 | 12.6 |
| 4 May | 10.2 | 13.8 | 16.9 | 16.7 |
| 11 May | 13.2 | 18.1 | 22.3 | 21.3 |
| 18 May | 11.2 | 14.0 | 18.5 | 13.4 |
| Soil (50 mm) | | | | |
| 6 April | 7.1 | 9.2 | 10.9 | 10.5 |
| 13 April | 7.4 | 9.5 | 11.8 | 12.4 |
| 20 April | 8.9 | 12.2 | 14.9 | 15.2 |
| 27 April | 7.9 | 11.8 | 14.2 | 14.5 |
| 4 May | 11.5 | 15.8 | 18.3 | 17.9 |
| 11 May | 17.0 | 21.2 | 24.4 | 22.7 |
| 18 May | 12.5 | 16.8 | 19.6 | 15.1 |

The covers were removed when favourable conditions were expected for a few days afterwards. The crop was irrigated, if necessary, soon after uncovering to minimise any adverse effects. As a result, no stress symptoms were noticed in this period.

Table 2 Effect of crop cover materials and removal time on marketable yield of leeks over 20 mm (t/ha)

| | No cover | Removal treatment 1 | 2 | 3 |
|---|---|---|---|---|
| a) Harvested 29 June | | | | |
| Open ground | 18.8 | | | |
| Perforated plastic (500 holes/$m^2$) | | 20.7 | 20.1 | 17.8 |
| Perforated plastic ( 10 holes/$m^2$) | | 21.5 | 26.4 | 14.2 |
| Double cover | | 20.2 | 21.0 | 22.6 |
| SED (18 df) | | | 1.67 | |
| CV | | | 10.0% | |
| b) Harvested 19 July | | | | |
| Open ground | 27.8 | | | |
| Perforated plastic (500 holes/$m^2$) | | 29.4 | 35.0 | 31.0 |
| Perforated plastic ( 10 holes/$m^2$) | | 33.4 | 34.6 | 26.5 |
| Double cover | | 30.6 | 29.5 | 33.5 |
| SED (18 df) | | | 2.25 | |
| CV | | | 8.8% | |

<u>Length of stem</u> (Table 3)

At the first harvest, plants covered in low perforation plastic for the shortest period were shorter than for those covered for longer. There were no differences at the second harvest between treatments.

Condition of plants at cover removal

The condition of the plants that had been covered in high perforation plastic was similar to those not covered, although they were more advanced. However they were slightly pale in colour at the last cover removal time.

The low perforation cover gave paler, taller plants with greater tip dieback than open ground plants. The plants also showed twisted growth. These effects became greater as the cover removal was delayed. At the last removal date the plants did not fully recover their colour fully by harvest.

The double cover also produced taller plants than the open ground. The colour of the plants was similar to that of plants under the high perforation plastic cover.

Fresh weight of transplants

The plants weighed an average of 1.08g each at transplanting.

Total marketable yield (Table 2)

At both harvests the second removal of the low perforation cover and the final removal of the double cover gave higher yields than the control. At the second harvest the first removal of the low perforation cover and the second removal of the high perforation cover were also high yielding. Leaving the low perforation cover on for the longest period gave lower yields than the earlier removal times at both harvests.

Table 3 Trimmed leek length (mm)

| | No cover | Removal treatment 1 | 2 | 3 |
|---|---|---|---|---|
| a) Harvested 29 June | | | | |
| Open ground | 208 | | | |
| Perforated plastic (500 holes/$m^2$) | | 208 | 192 | 208 |
| Perforated plastic ( 10 holes/$m^2$) | | 197 | 223 | 215 |
| Double cover | | 200 | 207 | 216 |
| SED (18 df) | | | 7.9 | |
| CV | | | 4.7% | |
| b) Harvested 19 July | | | | |
| Open ground | 252 | | | |
| Perforated plastic (500 holes/$m^2$) | | 251 | 253 | 236 |
| Perforated plastic ( 10 holes/$m^2$) | | 233 | 237 | 259 |
| Double cover | | 229 | 237 | 246 |
| SED (18 df) | | | NS | |

Blanching and degree of bulbing

All treatments gave a similar proportion of blanched stem with 20 to 25 per cent of the shank pure white at each harvest. There were also no differences between treatments in degree of bulbing at each harvest. Although the plants were slightly more bulby at the second harvest than the first, this did not detract from stem quality.

Marketable leeks (Table 4)

At the first harvest there was a particularly high percentage of marketable leeks from plants covered with low perforation plastic and when this had been removed at the second date. However, leaving this cover on to the last removal date gave a low percentage of marketable leeks. The other covering treatments gave similar results to the control plants. At the second harvest all treatments gave a similar proportion of marketable leeks.

Table 4 Percentage of marketable leeks using Angular transformation

| | No cover | Removal treatments 1 | 2 | 3 |
|---|---|---|---|---|
| a) Harvested 29 June | | | | |
| Open ground | 64.8(81) | | | |
| Perforated plastic (500 holes/$m^2$) | | 64.2(81) | 62.6(79) | 61.2(76) |
| Perforated plastic ( 10 holes/$m^2$) | | 64.0(81) | 75.4(94) | 53.7(65) |
| Double cover | | 62.8(78) | 66.2(84) | 68.4(86) |
| SED (18 df) | | | 3.70 | |
| CV | | | 7.0% | |
| b) Harvested 19 July | | | | |
| Open ground | 63.5(80) | | | |
| Perforated plastic (500 holes/$m^2$) | | 64.5(81) | 73.4(91) | 69.5(88) |
| Perforated plastic ( 10 holes/$m^2$) | | 70.9(89) | 68.3(85) | 61.5(77) |
| Double cover | | 69.3(87) | 68.4(86) | 70.8(89) |
| SED (18 df) | | | NS | |

Note: Figures in brackets are actual percentages.

NS = Not significant

Unmarketable

i) Undersized (Table 5)

At the first harvest poor size was the major reason for the leeks being considered unmarketable. Therefore treatments with a low percentage of marketable leeks had higher numbers of small and short leeks. At the second harvest no differences were found.

Table 5 Percentage of leeks too small (<20 mm diameter) or too short (<150 mm long), using Angular transformation

| | No cover | Removal treatment 1 | 2 | 3 |
|---|---|---|---|---|
| a) Harvested 29 June | | | | |
| Open ground | 24.8(18) | | | |
| Perforated plastic (500 holes/$m^2$) | | 25.5(19) | 25.3(18) | 27.9(22) |
| Perforated plastic ( 10 holes/$m^2$) | | 24.5(17) | 14.2( 6) | 34.5(32) |
| Double cover | | 25.8(20) | 23.0(15) | 20.5(13) |
| SED (18 df) | | | 3.80 | |
| CV | | | 18.9% | |
| b) Harvested 19 July | | | | |
| Open ground | 16.2( 8) | | | |
| Perforated plastic (500 holes/$m^2$) | | 15.6( 7) | 11.4( 4) | 11.9( 5) |
| Perforated plastic ( 10 holes/$m^2$) | | 13.9( 6) | 13.3( 7) | 18.0(10) |
| Double cover | | 16.2( 8) | 16.5( 9) | 15.4( 7) |
| SED (18 df) | | | NS | |

Note: figures in brackets are actual percentages.

ii) Bolted (Table 6)

At the first harvest very few plants had bolted. By the second harvest six per cent of plants had bolted. Here, all removal dates of the double cover, the second removal of the high perforation plastic and earliest removal of the low perforation plastic gave a low incidence of bolters. From the second harvest the low perforation plastic cover increased the number of bolters as the covering period was increased.

Table 6 Percentage of plants visibly bolted once trimmed using Angular transformation

| | No cover | Removal treatment 1 | 2 | 3 |
|---|---|---|---|---|
| a) Harvested 29 June | | | | |
| Open ground | 0.0( 0) | | | |
| Perforated plastic (500 holes/$m^2$) | | 0.0(0) | 0.0(0) | 0.0( 0) |
| Perforated plastic ( 10 holes/$m^2$) | | 0.0(0) | 0.0(0) | 2.0(<1) |
| Double cover | | 4.6(1) | 0.0(0) | 0.0( 0) |
| SED (18 df) | | | 1.38 | |
| CV | | | 255.3% | |
| b) Harvested 19 July | | | | |
| Open ground | 18.9(11) | | | |
| Perforated plastic (500 holes/$m^2$) | | 17.7(9) | 11.8(5) | 14.4( 6) |
| Perforated plastic ( 10 holes/$m^2$) | | 9.5(3) | 14.4(6) | 19.3(11) |
| Double cover | | 10.6(3) | 11.3(4) | 9.7( 3) |
| SED (18 df) | | | 2.25 | |
| CV | | | 20.0% | |

Note: figures in brackets actual percentages.

**Discussion**

This year's results confirm that the management of the low perforation cover is critical to achieve the best result. Too early a removal gives reduced advancement, whilst late removal will quickly remove any advantage already gained over open ground plants. However the two later cover removal dates did not give the reduction in bolting seen last season, instead increasing the period of cover increased bolting.

The low perforation cover was 'home-made' and, in this season on a more exposed site, was more prone to disturbance in windy conditions than the other materials tested. However it gave the greatest advancement, with a yield increase of 7.6 tonnes/ha over open ground plants, when the cover was removed at the optimum time. The double cover system gave a reduction in bolting from all three treatments at the second harvest. Otherwise it was inferior to the best result from using the low perforation cover. The double cover is also more expensive to buy, and manage, than single covers. In 1989 the high perforation cover only gave a few days earlier cropping than the open ground, less than has been achieved in other years. On average only about half the advancement of the low perforation cover can be expected. Although the removal date was not critical for this material, it would still be prudent to remove the cover by the middle of May as there was no yield advantage in leaving the cover on for longer.

The lowest perforation density available commercially for 10 m wide sheets is 200 holes/$m^2$. Although this has not been evaluated it would appear from the materials trialled that this would give an advantage in earliness over the high perforation plastic.

## Conclusions

This year's trial confirmed that maximum advancement was given by covering in low perforation plastic at planting and removing the cover in early May. But results also confirmed that the time of cover removal is critical as late removal depresses yields.

From a single season's results the double cover system did not perform as well as the low perforation plastic cover.

For a late March planting the low perforation plastic cover gave 15 days advancement, whilst the high perforation cover only 4 days. Taking into account previous results, it seems that about two weeks can be expected from the low perforation plastic and about a week from the high perforation cover.

## Recommendations for future action

### Future R & D

Evaluation of cover materials over early March plantings to determine the effect of double covers and single covers on earliness and standability.

### Exploitation of findings

Recommendations on cover materials and duration of cover can now be made. However, as with covering of any field vegetable crop, the precise timing in a given season will still be as much an art as a science.

HDC CONTRACT R & D - EXPERIMENT REPORT

HDC FV2/C/87/0354

# LEEKS. EXTENSION OF MARKETING SEASON THROUGH STORAGE AND EARLY PRODUCTION TECHNIQUES (EARLY PRODUCTION SECTION)

## EFFECT OF SOWING DATE AND MODULE TYPE ON YIELD FOR THE COVERED CROP


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Status of work: last year of trial completed

Year of experiment: 3

Report Number: 3

Period covered: September 1988 to August 1989

## Abstract

Leeks are now required for sale over as long a season as possible, with some outlets willing to sell them all the year round. At present there is a gap in production from mid May to late July. This trial was initiated to determine the effect of sowing date and propagation system on production in this period.

Seed of cv. Tilina was single seeded into 15 ml cell trays and 27 mm peat blocks on 3 and 24 January. Superseedlings and BRT's were also sown on 24 January. All these were planted out on 19 April. The complete trial was then covered in perforated plastic 500 holes/$m^2$ on 21 April, which was removed on 11 May. Assessments for marketable yield and size were made at two harvests, 4 July and 19 July.

The highest early marketable yields were obtained from the two sowings of block raised plants. These were followed by plants from the earlier sowing of 15 ml cell tray plants. The other treatments had similar, lower, yields.

These differences were correlated with the size of transplants from each of the treatments at planting. The Superseedlings did not grow well under the standard propagation conditions of the trial and were pale in colour at planting. The BRT's were sown at the density of 'seed sheets', which was much greater than for the other treatments. Therefore at transplanting the plant size of these was small.

The earlier sown block and cell tray raised plants had a significant proportion of bolters at the second harvest and these crops would not have stood any longer in the field.

**Objective**

To determine the effect of sowing date, propagation system and covering on the yield of early leeks.

**Introduction**

In last year's trial on early leeks, differences in average plant size were found between transplants raised in 15 ml cell trays and 27 mm peat blocks and these were carried forward to early yields. In commerce a wider range of raising systems are used for early leeks, including compressed peat plugs in cell trays (e.g. Superseedlings) and BRT's raised in seed trays. Propagation systems use different plant densities and make different volumes of compost available to the roots of individual plants. Also the BRT's are planted without any compost attached to the roots. For the latter it was thought that establishment time in the field may be extended. Therefore in 1989 an assessment was made of four propagation systems.

The earliest maturing leek crops are quick to bolt and their standability in the field is short. Sowing date is an important factor in the time of bolting and so this factor was evaluated for the plant raising systems already used in trials work at Luddington.

**Materials and methods**

Treatments

All the propagation treatments are listed in Table 1. These were covered in perforated plastic with 500 holes/$m^2$. For each of these treatments there were two harvest dates:

4 July

19 July

Table 1 Summary of propagation method and sowing dates

| Propagation treatment | | Sown | Transplant density/$m^2$ |
|---|---|---|---|
| SCS308 | (early sowing) | 3 January | 1160 |
| SCS308 | (later sowing) | 24 January | 1160 |
| Block | (early sowing) | 3 January | 950 |
| Block | (later sowing) | 24 January | 950 |
| Superseedling | (later sowing) | 24 January | 720 |
| BRT | (later sowing) | 24 January | 2500 |

Statistical design

The treatments were laid out in a randomised block design, with the two harvest dates as sub-plots. There were three replicates. In each plot there were 100 recorded plants with guard plants at the ends of each plot and at the sides of the trial. Burying of the crop cover would affect several outer plants in each row. Therefore extra plants were used to minimise any crushing of recorded plants as the cover became tighter with the growth of the crop.

Crop diary

| Date | Operation |
|---|---|
| 3 January | First sowing (SCS308 and 27 mm peat blocks) |
| 24 January | Second sowing (All modules) |
| 10 March | Base fertiliser applied (150 N, 70 $P_2O_5$, 210 $K_2O$ kg/ha) |
| 18 April | Extra base fertiliser applied (75 kg/ha N as Nitrochalk) |
| 19 April | Crop planted |
| 21 April | Covered trial (perforated plastic 500 holes/$m^2$) |
| 11 May | Cover removed |
| 12 May | 9 mm irrigation. |
| 19 May | 9 mm irrigation |
| 5 June | Topdressed with 50 kg/ha N as Nitrochalk |
| 13 June | 25 mm irrigation |
| 23 June | 13 mm irrigation |
| 26 June | 25 mm irrigation |
| 6 July | 25 mm irrigation |

| | |
|---|---|
| 11 July | Topdressed 50 kg/ha N |
| 18 July | 25 mm irrigation. |

Management

A quick bulking variety, Tilina, was single seeded into each of the modules, with the BRT's raised in seed trays. The density of the latter was comparable to that of seed sheets. The seeds were germinated at 18°C under glass. This temperature was gradually reduced to 10°C by planting time. In the field, all treatments were planted out five rows, 300 mm apart, on a 1.83 m bed, with an intra-row spacing of 90 mm. This gave 300,000 plants/ha.

The transplants were placed into holes made by a dibbing machine so that the last major leaf break was at soil level. Thus the different size transplants were at slightly different depths. The BRT's were planted without any compost, whereas the other propagation systems were planted with the module included. Covers were put on after planting. As planting was delayed due to adverse weather conditions the plants were larger than intended. The block raised transplants were particularly large.

The covers were removed when favourable conditions were expected for a few days afterwards. The crop was irrigated, as necessary, soon after uncovering to minimise any adverse effects. As a result, no stress symptoms were noticed in this period. The larger the transplant at planting the larger the plants were at cover removal .

Assessments

At planting the fresh weight of the transplants (without roots) was recorded to give an objective size comparison with related trials. The rest of the assessments were made at harvest. At this time a full quality and size breakdown of the crop was recorded.

The leeks were trimmed to a 'supermarket prepack' specification, with 50 mm of flag left on the shank. They were quality graded into the following categories:

- Marketable
- Too short (less than 150 mm long)
- Too small (less than 20 mm in diameter)
- Split
- Rotten
- Bolted

Marketable leeks were graded into the following size bands:

- 20-27 mm
- 28-34 mm
- 35-44 mm
- greater than 45 mm.

As well as recording the visually bolted plants, a sample of the marketable leeks was assessed for flower stalk initiation. All plants that showed a flower stem, when trimmed, came into the former category and were considered unmarketable. Flower initiation was assessed by cutting open ten leeks from each plot and counting the number of plants where the apices were not vegetative. An overall assessment was also made of the degree of bulbing and length of blanch on a 0 to 9 scale.

Statistical analysis

The data was subjected to analysis of variance with angular transformation of results expressed in percentage form.

## Results

Fresh weight of transplants (Table 2)

The blocks produced heavier transplants than SCS308's from both sowings. The Superseedling plants were a similar weight to the later sown SCS308's with the BRT plants being the lightest.

Table 2 Fresh weight of transplants (without roots), g

| Propagation treatment | | Transplant weight (g) |
|---|---|---|
| SCS308 | (early sowing) | 2.9 |
| SCS308 | (later sowing) | 2.2 |
| Block | (early sowing) | 4.9 |
| Block | (later sowing) | 3.8 |
| Superseedling | (later sowing) | 2.4 |
| BRT | (later sowing) | 1.8 |

Total marketable yield (Table 3)

At the first harvest the early sowing of the block raised plants gave the highest yield with the later block sowing and earlier SCS308 sowing also performing well. At the second harvest the two block raised treatments outyielded all but the second sowing of SCS308's.

Table 3 Effect of propagation module and planting date on marketable yield of leeks over 20 mm (t/ha)

| Propagation treatment | | Harvested 4 July | Harvested 19 July |
|---|---|---|---|
| SCS308 | (early sowing) | 19.3 | 25.4 |
| SCS308 | (later sowing) | 15.4 | 28.2 |
| Block | (early sowing) | 23.3 | 29.2 |
| Block | (later sowing) | 21.2 | 28.9 |
| Superseedling | (later sowing) | 16.1 | 25.7 |
| BRT | (later sowing) | 14.4 | 25.7 |
| SED (15 df) | | 1.00 | 1.41 |
| CV | | 7.7% | 7.3% |

Length of stem (Table 4)

In general the earlier block raised plants had the longest shank lengths.

Table 4 Trimmed leek length (mm)

| Propagation treatment | | Harvested 4 July | Harvested 19 July |
|---|---|---|---|
| SCS308 | (early sowing) | 217 | 235 |
| SCS308 | (later sowing) | 203 | 232 |
| Block | (early sowing) | 227 | 255 |
| Block | (later sowing) | 215 | 233 |
| Superseedling | (later sowing) | 202 | 240 |
| BRT | (later sowing) | 216 | 234 |
| SED (15 df) | | 6.4 | 8.3 |
| CV | | 4.3% | 4.9% |

Blanching and degree of bulbing

All treatments gave a similar proportion of blanched stem with 20 to 25 per cent of the shank pure white at each harvest. There were also no differences between treatments in degree of bulbing at each harvest. Despite the plants becoming slightly more bulby by the second harvest the quality was still good in this respect.

Marketable leeks (Table 5)

At the first harvest the three highest yielding treatments had the greatest number of marketable leeks. At the second harvest the two treatments that were sown earlier had the lowest proportion of leeks that were marketable. This was due to bolting of these treatments. The second sowing of SCS308 had a particular high percentage of plants marketable at this harvest.

Table 5 Percentage of marketable leeks using Angular transformation

| Propagation treatment | | Harvested 4 July | Harvested 19 July |
|---|---|---|---|
| SCS308 | (early sowing) | 67.8 (86) | 62.9 (79) |
| SCS308 | (later sowing) | 60.8 (76) | 74.4 (93) |
| Block | (early sowing) | 71.3 (90) | 62.7 (79) |
| Block | (later sowing) | 69.4 (88) | 66.9 (84) |
| Superseeding | (later sowing) | 62.2 (78) | 68.2 (86) |
| BRT | (later sowing) | 58.8 (73) | 69.9 (88) |
| SED (15 df) | | 2.22 | 2.54 |
| CV | | 4.8% | 5.3% |

Note: figures in brackets are actual percentages

Unmarketable

i) Undersize (Table 6)

At the first harvest most leeks that were not marketable were small or short. Therefore treatments with high marketable yields had the lowest proportion of leeks that were undersized. At the second harvest differences were not as marked.

Table 6 Percentage of leeks too small (less than 20 mm diameter) or too short (less than 150 mm long) using Angular transformation

| Propagation treatment | | Harvested 4 July | Harvested 19 July |
|---|---|---|---|
| SCS308 | (early sowing) | 21.4 (14) | 15.0 ( 7) |
| SCS308 | (later sowing) | 29.2 (24) | 12.4 ( 5) |
| Block | (early sowing) | 18.0 (10) | 12.0 ( 4) |
| Block | (later sowing) | 20.4 (12) | 18.7 (11) |
| Superseeding | (later sowing) | 27.3 (21) | 17.3 ( 9) |
| BRT | (later sowing) | 31.1 (27) | 18.2 (10) |
| SED (15 df) | | 2.26 | 2.74 |
| CV | | 13.0% | 24.9% |

Note: figures in brackets are actual percentages.

ii) Bolted (Table 7)

At the first harvest there was only a single bolter. By the second harvest the earlier sown treatments had a higher incidence of bolters than the other treatments. The BRT's gave the lowest incidence of bolters.

Table 7 Percentage of plants visibly bolted once trimmed using Angular transformation

| Propagation treatment | | Harvested 4 July | Harvested 19 July |
|---|---|---|---|
| SCS308 | (early sowing) | 1.5 (<1) | 21.4 (13) |
| SCS308 | (later sowing) | 0.0 ( 0) | 7.7 ( 2) |
| Block | (early sowing) | 0.0 ( 0) | 23.4 (16) |
| Block | (later sowing) | 0.0 ( 0) | 11.5 ( 4) |
| Superseeding | (later sowing) | 0.0 ( 0) | 11.7 ( 5) |
| BRT | (later sowing) | 0.0 ( 0) | 4.0 ( 1) |
| SED (15 df) | | NS | 2.56 |
| CV | | - | 27.3% |

Note: figures in brackets are actual percentages

Internal flower stalk at harvest

At both harvests about 10 per cent of the marketable trimmed leeks had internal flower stalks.

## Discussion

At both harvests the two block raised treatments were amongst the highest yielding. For the first harvest the earlier sown SCS308's also gave good yields but by the second harvest the yields were comparatively poor because of bolting. Also, by the second harvest, the later sown SCS308's had caught up with the block treatments.

Although both the earlier sown treatments gave a similar incidence of bolting at the second harvest, the yield of the block raised plants was greater. It appears that the better growth of these in propagation allowed a larger plant to be produced before bolting occurred in the field.

The Superseedlings did not perform as well as expected. The plant density in propagation was low but the plants did not grow as well as the block raised plants. They were also paler in colour at the time of planting.

The BRT raised transplants were seeded at a higher density than the other treatments and thus gave smaller transplants. For early production a lower density is required.

## Conclusions

The better growth during the propagation phase with block raised transplants resulted in greater yields at both harvests. However the earlier sown plants did not stand so well in the field and a significant proportion had bolted by the mid July harvest.

**Recommendations for future action**

Future R & D

1. A further evaluation of the effect of planting date is required as it was not possible to conduct a late March planting in 1989. This would determine the importance of transplant size at planting. Past work has indicated that small transplants have not established as well from March plantings.

2. Re-evaluation of BRT's and Superseedings is needed to determine seasonal effect, especially given the latters' poor result in 1989. The optimum density of BRT's in propagation also needs to be evaluated as the density used this year was too high.

Exploitation of findings

The information gained on block and SCS308's will make up part of the 'blueprint' to early leek growing when used in conjunction with other early leek trials work.

HDC CONTRACT R & D - EXPERIMENT REPORT

HDC FV/2/C/87/0354

# LEEKS. EXTENSION OF MARKETING SEASON THROUGH STORAGE AND EARLY PRODUCTION TECHNIQUES (EARLY PRODUCTION SECTION)

## EFFECT OF PLANT DENSITY AND YIELD UNDER PLASTIC COVERS

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Status of work: last year of trial completed

Year of experiment: 3

Report Number: 3

Period covered: September 1988 to August 1989.

**Abstract**

Although experiments comparing the effect of crop density have been carried out in the past, they have primarily been concerned with achieving maximum yields of marketable leeks in the main cropping period. This present trial was initiated to evaluate the effect of crop density on marketable yield under crop covers to produce very early high yielding crops. Three densities; 180,000, 270,000 and 360,000 plants/ha, were compared.

Seed of the cv. Verina, was sown into 15 ml cell trays (SCS 308) on 13 January and planting done on 30 March. The trial was covered on the following day and the cover removed on 11 May. The crop was harvested on three occasions between late June and late July.

A yield of over 17 tonnes/ha was obtained on 30 June and by 24 July this had increased to over 30 tonnes/ha. The trend was towards greater yields as plant density increased. The lowest density gave the greatest yields of large (35 to 45 mm diameter) leeks.

**Objective**

To determine the optimum plant population under plastic covers for producing the maximum yield of leeks over 20 mm diameter in July.

**Introduction**

Little is known about the effect of density on the bulking rate of leeks grown for early summer production under crop covers. The plant populations used on the Continent (11 plants/$m^2$) are lower than for main season production here (30 to 45 plants/$m^2$). However, higher densities may reduce the individual plant bulking rate as the crop approaches harvest. In the first year of this trial (1987) the highest density (27 plants/$m^2$) gave the greatest marketable yield. Therefore the plant densities chosen for the 1988 trial were 18, 27 and 36 plants/$m^2$. The 18 plants/$m^2$ treatment was retained as large leeks are produced earlier at lower plant densities. These same treatments were used for this year's trial to determine any seasonal effect.

There have been reports in the past that another alliaceous crop, salad onions, is easily damaged by a perforated plastic cover in windy conditions. For this reason a non-woven cover, which is less damaging than perforated plastic, was used.

Treatments

Plant densities: 18 plants/$m^2$
27 plants/$m^2$
36 plants/$m^2$

Harvest dates: 30 June
12 July
24 July

Crop diary

| Date | Operation |
|---|---|
| 13 January | Seeds sown |
| 10 March | Base fertiliser applied (150 N, 70 $P_2O_5$, 210 $K_2O$ kg/ha) |
| 30 March | Crop planted |
| 31 March | Covered trial (fleece) |
| 27 April | Topdressed and re-covered (50 kg/ha N as Nitrochalk) |
| 11 May | Cover removed |
| 12 May | 9 mm irrigation. |
| 19 May | 9 mm irrigation |
| 26 May | Topdressed (50 kg/ha N as Nitrochalk) |
| 13 June | 25 mm irrigation |
| 23 June | 13 mm irrigation |
| 26 June | 25 mm irrigation |
| 3 July | Topdressed (50 kg/ha N as Nitrochalk) |
| 6 July | 25 mm irrigation |
| 18 July | 25 mm irrigation |
| 23 July | 25 mm irrigation |

**Materials and methods**

Statistical design

The trial was a full factorial design with three plant densities and three harvest dates. This was laid out using a randomised block design of three replicates. In each plot there were 100 recorded plants with guard plants at the ends and sides of each plot. Since burying the crop cover affects several plants in each row, extra plants were used to minimise the crushing of recorded plants as the cover became tighter due to the growth of the crop.

Management

A quick bulking variety, Verina (Blue green autumn type), was single seeded into SCS308 modules and germinated at 18°C under glass, This temperature was gradually reduced to 10°C by planting time. In the field planting out was done in five rows, 300 mm apart, on a 1.83 m wide bed. The required densities were obtained by varying the intra-row plant distance.

The beds were cross marked and the transplants planted using a trowel to give the last major leaf break at soil level.

The cover was removed when favourable conditions were expected for a few days afterwards. The crop was irrigated soon after uncovering to minimise any adverse effects. No stress symptoms were seen in this period.

Assessments

At planting the fresh weight of the transplants (without roots) was taken to give an objective size comparison with plants from other trials. The average leek weight was 1.0g. The rest of the assessments on the crop were at harvest. At this time full records of the crop were taken covering both leek quality and size.

The leeks were trimmed to a 'supermarket prepack' specification, with 50 mm of flag left on the shank. They were quality graded into the following categories:

- Marketable
- Too short (less than 150 mm long)
- Too small (less than 20 mm in diameter)
- Split
- Rotten
- Bolted

The marketable leeks were graded into the following size bands:

- 20-27 mm
- 28-34 mm
- 35-44 mm
- greater than 45 mm.

Plants that had visually bolted were considered unmarketable. To assess internal bolting a sample of 10 leeks from each plot was cut in half and the number that had initiated a flower stalk was recorded. An overall assessment was also made of the degree of bulbing and length of blanch on a 0 to 9 scale.

Statistical analysis

The date was subjected to analysis of variance with angular transformation of results expressed in percentage form.

**Results**

Total marketable yield (Table 1)

This is expressed as the yield of leeks over 20 mm in diameter, greater than 150 mm long and showing no obvious defects. In general the higher the plant density the greater the yield. Delaying harvest also increased yields.

Table 1 Total marketable yield of leeks over 20 mm (tonnes/ha)

| Plants/ha | Harvest date<br>30 June | <br>12 July | <br>24 July |
|---|---|---|---|
| 180,000 | 13.8 | 19.8 | 23.0 |
| 270,000 | 15.4 | 23.5 | 25.3 |
| 360,000 | 16.9 | 27.6 | 30.3 |
| SED (12 df) | | 1.72*+ | |
| CV | | 11.2% | |

Notes: *To compare two harvest dates at one density only.

+To compare two densities at one harvest date use SED (12 df) = 2.00

Marketable yield by size grade, 20-27 mm (Table 2)

Overall the higher the plant density the greater the yield in this grade.

Table 2 Yield of 20-27 mm leeks (tonnes/ha)

| Plants/ha | Harvest date 30 June | 12 July | 24 July |
|---|---|---|---|
| 180,000 | 3.7 | 1.8 | 1.9 |
| 270,000 | 7.8 | 5.4 | 4.6 |
| 360,000 | 10.8 | 10.9 | 10.6 |
| SED (12 df) | | 1.31* | |
| CV | | 25.2% | |

Note: *To compare two densities at one harvest date only

Marketable yield by size grade, 28-34 mm (Table 3)

At the first harvest a similar yield was obtained from all of the plant densities. At the lowest plant density the yield of this grade did not increase with late harvesting. The other two densities at the two later harvests gave higher yields.

Table 3 Yield of 28-34 mm leeks (tonnes/ha)

| Plants/ha | Harvest date 30 June | 12 July | 24 July |
|---|---|---|---|
| 180,000 | 8.0 | 8.8 | 6.1 |
| 270,000 | 6.8 | 13.7 | 11.3 |
| 360,000 | 5.9 | 14.5 | 11.9 |
| SED (12 df) | | 1.62* | |
| CV | | 19.9% | |

Note: *Except when comparing two densities at one harvest date then SED (12 df) = 1.57

Marketable yield by size grade, 35-45 mm (Table 4)

In general the higher the plant density the lower the yield in this size grade. Delaying harvest also increased the yield in this size grade for each density treatment.

Table 4 Yield of 35-45 mm leeks (tonnes/ha)

| Plants/ha | Harvest date 30 June | 12 July | 24 July |
|---|---|---|---|
| 180,000 | 2.1 | 9.1 | 13.3 |
| 270,000 | 0.8 | 4.4 | 9.4 |
| 360,000 | 0.1 | 2.3 | 7.7 |
| SED (12 df) | | 1.73*+ | |
| CV | | 39.4% | |

Notes: *To compare two harvest dates at one density only.
+To compare two densities at one harvest date use SED (12 df) = 1.76

Marketable yield by size grade, greater than 45 mm

The lowest density produced a negligible proportion of leeks over 45 mm at the second harvest. By the last harvest this had increased to 8 per cent of the total marketable yield. The higher densities did not produce any leeks in this grade.

Length of stem (Table 5)

The total length of the trimmed leeks was increased by delaying the harvest.

Table 5 Trimmed leek length (mm)

| Plants/ha | Harvest date 30 June | 12 July | 24 July |
|---|---|---|---|
| 180,000 | 19.6 | 21.7 | 23.6 |
| 270,000 | 18.9 | 22.5 | 22.7 |
| 360,000 | 18.9 | 21.7 | 24.3 |
| SED (12 df) | | 0.98* | |
| CV | | 5.7% | |

Note: *To compare two harvest dates at one density only.

<u>Stem quality - degree of bulbing and length of blanch</u>

The proportion of the stem blanched was similar from all treatments with 20 per cent of the stem pure white. The degree of bulbing was acceptable from all treatments.

<u>Marketable leeks</u> (Table 6)

In general the percentage of marketable leeks was greater when the crop density was reduced and was greatest at the second harvest.

Table 6 Total percentage of marketable leeks, using Angular transformation

| Plants/ha | Harvest date 30 June | 12 July | 24 July |
|---|---|---|---|
| 180,000 | 64.9 (82) | 68.7 (87) | 65.7 (83) |
| 270,000 | 57.5 (71) | 66.8 (84) | 61.3 (77) |
| 360,000 | 53.5 (65) | 65.3 (82) | 58.9 (73) |
| SED (12 df) | | 2.88*+ | |
| CV | | 14.5% | |

Notes: Actual percentages in brackets

*To compare two harvest dates at one density only.

+To compare two densities at one harvest date use SED (12 df) = 3.26

Unmarketable

i) Unmarketable - under size (Table 7)

In general the lowest density had the fewest small leeks, with the two other densities having a similar number. Delaying the harvest also decreased these, especially between the first and second harvests.

Table 7 Percentage of leeks that were too small for market (<150 mm in length), or too small (<20 mm in diameter) using Angular transformation

| Plants/ha | Harvest date 30 June | 12 July | 24 July |
|---|---|---|---|
| 180,000 | 24.6 (18) | 17.9 ( 9) | 12.8 ( 5) |
| 270,000 | 32.3 (29) | 18.8 (11) | 17.0 ( 9) |
| 360,000 | 36.1 (35) | 22.4 (15) | 19.8 (12) |
| SED (12 df) | | 2.69*+ | |
| CV | | 16.8% | |

Notes: Actual percentages in brackets

*To compare two harvest dates at one density only.

+To compare two densities at one harvest date use SED (12 df) = 3.07

ii) Unmarketable due to bolting (Table 8)

At the first harvest there was only a single bolted plant. Bolting had increased to over 10 per cent of the crop by the third harvest.

Table 8 Number of leeks that were discarded due to bolting, using Angular transformation

| | Harvest date 30 June | 12 July | 24 July |
|---|---|---|---|
| % bolted | 0.6 (<1) | 9.2 (3) | 19.4 (11) |
| SED (12 df) | | 1.24 | |
| CV | | 27.1% | |

Note: Actual percentages in brackets

## Discussion

### Marketable yield

The marketable yield of leeks increased greatly during July. At the same time the number of both small and short leeks was reduced. The highest density gave the greatest marketable yield at each harvest.

Increasing the plant density gave the higher marketable yields but the average size of the leeks was reduced. Thus the lower density gave a greater quantity of large leeks in the second half of July. Handling costs at harvest would increase for the higher densities as there are more leeks for a given weight.

### Unmarketable leeks

At the first harvest the majority of unmarketable leeks were beneath the minimum size specification. The numbers of these dropped with later harvesting and by the last harvest there was a similar number of both undersized and bolted leeks from treatments.

### Quality assessments

Although this was a transplanted crop, overall the amount of blanch was typical of commercially drilled crops. In the assessments all leeks that were not visibly bolted when trimmed were considered marketable. This may not be the case for the more demanding outlets.

## Conclusions

Over 17 tonnes/ha of leeks, greater than 20 mm in diameter, were obtained from a late June lift. It was achieved by planting out 360,000 leeks/ha on 30 March and covering for seven weeks with a non-woven (Agril) material. To produce larger leeks, a density of about 180,000 plants per ha would give higher yields in the second half of July.

## Recommendations for future action

Future R & D

The effect of density on the production of early prepacked leeks has been determined in this series of trials. No further work is required at present.

Exploitation of findings

The information obtained on plant size distribution and yield for the different densities will be of benefit to producers planning to market leeks from late June to early August.