Carrots - Ice Bank Storage

and Shelf Life Trials

HDC FV27/C/88/0249/2
FV27/C/87/0355/2

HDC CONTRACT R & D - EXPERIMENT REPORT Date: 6.10.89

HDC FV/27/C/88/0249/1

FV/21/C/87/0355/1

CARROTS - ICE BANK STORAGE AND SHELF LIFE TRIAL

Experiment Leaders: Mrs H Airdrie, Luddington Experimental Horticulture Station, Stratford-on-Avon, Warwickshire CV37 9SJ. Tel: 0789 750601
Fax: 0789 750957

Mr J Davies. Arthur Rickwood Experimental Husbandry Farm, Mepal, Ely, Cambridgeshire CB6 2BA. Tel: 03543 2531
Fax: 03543 4488

Project Leader: Dr M R Shipway, Luddington Experimental Horticulture Station, Stratford-on-Avon, Warwickshire CV37 9SJ. Tel: 0789 750601
Fax: 0789 750957

Status of work: completed

Year of experiment: 2

Report Number: 2

Period covered: November 1988 to June 1989

FV 27 year 2

Abstract

Carrots from peat, sand and silt sites were overwintered and stored through to June under a number of different systems: lifted in November and held in a high humidity cold store; overwintered in the field under straw; lifted in March and held in a cold store; field stored under straw; field stored under straw and polythene.

Quality both in the field and in the cold store was monitored through to May/June and, in addition, samples from each treatment were assessed for shelf life quality, sugar levels and sensory value throughout the storage period.

The levels of rotting in cold storage varied considerably between crops and tended to be linked to a site. The skin finish of cold stored carrots was always worse than that of freshly dug roots. The difference was particularly marked on sand-grown crops and was more pronounced after longer periods in store.

In contrast, during May and June cold stored carrots deteriorated less (rotting) than field stored samples during a period of shelf life and were perceived in sensory appraisals as being sweeter. Sugar levels were also higher, particularly so on those roots lifted in November and cold stored for 27-30 weeks, although in this trial these carrots did not produce acceptable yields out of store. A March lifted crop developed less marked flavour improvements over field stored samples but also produced a more acceptable skin finish and yield out of store.

Objective

To provide good quality carrots from UK sources in the period from March to June using the best field and cool storage techniques. To provide quality carrots not only as lifted or out of store but also after a period of shelf life.

Introduction

Growers store carrots from November onwards in two ways. Crops grown on deep peat can be insulated against extreme cold weather by ridging up the soil. This method holds the crop in reasonable condition until April at the latest, but is an unreliable system. The peat covering may not provide sufficient insulation in cold weather especially where the sides of the ridge have eroded. In addition the black soil absorbs heat in the spring encouraging the crop to grow again, which leads to loss of root sugars and to development of woodiness. Those crops grown on mineral soils are covered with straw - a system which potentially can keep carrots frost free, but light and heat may still penetrate the cover and encourage the crop to regrow thus reducing quality.

Since 1982 ADAS has encouraged growers to improve their field storage system. Trials at Arthur Rickwood Experimental Husbandry Farm have determined the best varieties, sowing dates, covering materials and covering dates to give a reliable field storage system. Now the system is being evaluated against the standard commercial practice and against high quality cool storage. This will determine which system offers the best economic alternative for each month from March to June to ensure a supply a excellent quality carrots.

In addition to assessing the quality of carrots out of store or as lifted, the condition during subsequent shelf life is of increasing importance to many market outlets. The storage technique used can have a marked effect on this shelf life quality but requires detailed assessment to determine these effects.

Results from the first year of this project identified the need to assess crops from different soil types as completely different systems. Silvering and skin finish was always worse from cold stored carrots in comparison to field stored samples. In May, however, sensory analysis indicated that differences between field and cold stored samples were emerging and that the cold stored carrots, particularly those lifted in November, were sweeter than field stored treatments.

The 1988/89 trial was designed to verify these results and to extend assessments to three sites covering a wider range of soil types.

Materials and methods

Comparisons were made between the following storage systems:

1. Cool stored from November onwards
2. Field stored until March, cool stored March onwards
3. Field stored throughout (straw covering at 30 t/ha)
4. Field stored throughout (straw and black polythene).

Sites

A. Arthur Rickwood EHF (fen peat)

B. Tuddenham (sand)

C. Sedge Fen (silty/loam).

Crops of well grown carrots at each of these three sites were selected in October 1988. Samples for storage were lifted, by hand, on 8 November and 28 February.

Storage technique

Cool store environment: 95% RH, 0-1°C.

Carrots were lifted from each site, transported to Luddington and loaded into bulk bins. The bins of carrots were drenched with Benlate 1g/litre (50% a.i. benomyl). Carrots were not washed before storage.

Field storage treatments (straw or straw and black polythene) were applied on 31 October. A crop diary of the crop at the peat site is given in Appendix I.

Assessments

Field assessments

Marketable yield, plant population and percentages of unmarketable carrots were assessed from each of the field storage treatments on 7 November, 28 February, 29 March and 8 May. The sand and silty/loam sites were commercial crops and early harvesting meant that complete records for field treatments from these sites could not be obtained through to early June.

Cool store

Four 15 kg nets of carrots were selected from each bin at loading, weighed and buried in the bin. At each store removal one bag was removed, reweighed, and the carrots washed and graded. The number and weight of marketable carrots in a range of size grades, together with unmarketable roots were recorded. Samples removed from store were assessed on 1 March ('March'), 28 March ('April'), 9 May ('May')and 31 May ('June').

Shelf life

At each store removal a sample of Class I carrots from each treatment was selected, bagged into 5 x 1 lb polythene bags and assessed over a 6 day period in shelf life conditions of 20°C, 50% RH.

Skin finish, disease incidence, shoot regrowth and overall quality were assessed after 0, 24, 48, 72 hours and 6 days using a 0-9 scale, where 9 = excellent, 6 = just unmarketable. Weight loss during shelf life was also recorded over this period.

Sensory and sugar analysis

A sample of carrots from each treatment was sent to the Campden Food and Drink Research Association (CFDRA) for an initial assessment in November after 2 days shelf life. Samples from each cool store and field storage treatment available were also sent for sensory analysis and assessment of sugar levels at each shelf life assessment. Full details of the methods of analysis are given in Appendix II.

Results

Effect of storage treatment on marketable quality

The main factor causing the deterioration of carrots in cold storage was the development of fungal and bacterial rots. The percentage of rotten and diseased carrots out of cold storage varied considerably between the three soil types.

Levels of rotting in the crop were very low at lifting in November. All treatments both in store and in the field deteriorated over the winter period (Table 1). In almost all treatments levels of rotting in May and June were higher than in the March and early April assessments.

Patterns of rotting were specific to individual sites. On the peat site <u>Rhizoctonia carotae</u> was the major pathogen and on November lifted treatments in particular, caused extensive deterioration. Levels of rotting from this treatment were the highest in the trial and were considerably higher than those on the same crop which had overwintered in the field and been lifted for cold storage in March.

Table 1 Percentage of rotten/diseased carrots (by weight)

Site	Treatment	Nov	March	April	May	June	Mean
Peat	Cold store Nov	0.3	18.4	45.7	49.6	77.2	47.7
	Cold store March		27.2	25.1	32.9	32.5	29.4
Sand	Cold store Nov	0.0	7.3	21.1	37.9	37.5	26.0
	Cold store March		8.0	8.8	25.8	36.8	19.8
Silt*	Cold store Nov	1.1	7.0	7.7	10.1	7.6	8.1
	Cold store March		31.0	0.8	52.8	45.0	32.4
Mean			16.5	18.2	34.8	39.5	

SED (comparison between treatment means) = 5.77 *** (65 df)
SED (comparison between removal means) = 4.72 *** (65 df)
*Limited material reduced the replication on the treatment and results should be treated with caution.

On the sandy site <u>Botrytis cinerea</u> was the main pathogen isolated. Overall levels of rotting were lower than on the peat site, and there was no significant difference between November and March lifted treatments.

Limited material from the silt site also suggested that overall levels of rotting were lower than the peat, in particular the November lifted treatment developed very low levels of rot (Table 1).

The total percentage of marketable carrots out of cold store reflects the patterns of rotting and is illustrated in graph 1.

The deterioration in yield of marketable carrots was not limited to cold stored treatments. Yields from field stored treatments also declined throughout the assessment period (Table 2).

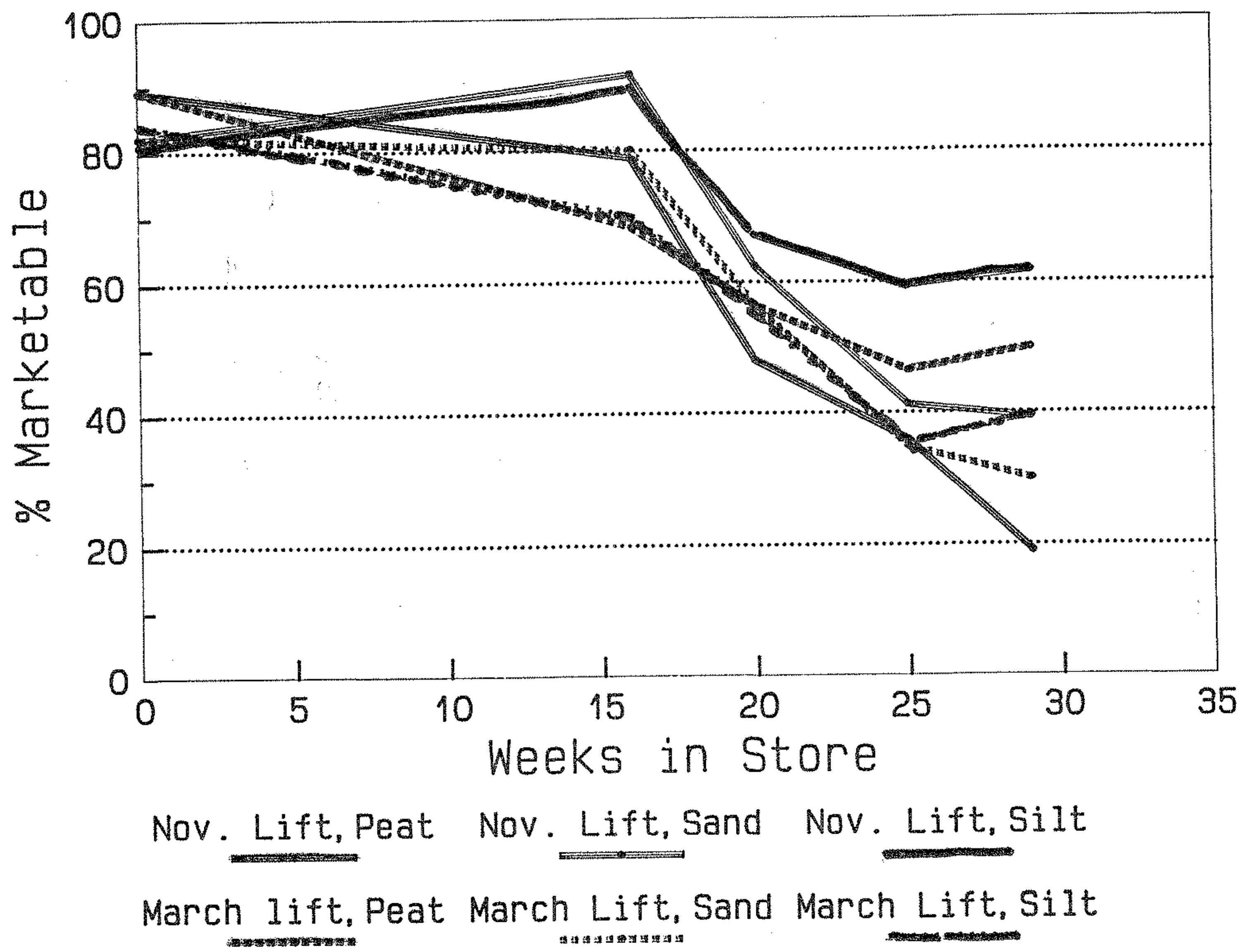
Table 2 % unmarketable from field storage treatments (includes all unmarketable grades)

Storage treatment	Field assessment 7.11.88	28.2.89	29.3.89	8.5.89
Peat				
Straw only	3.0	21.0	33.4	29.9
Straw + polythene	-	-	46.8	37.3
Sand				
Straw only	6.0	11.0	11.7	N/A
Straw + polythene	-	-	15.0	N/A
Silt				
Straw only	12.0	29.0	N/A	N/A
Straw + polythene	-	-	N/A	N/A

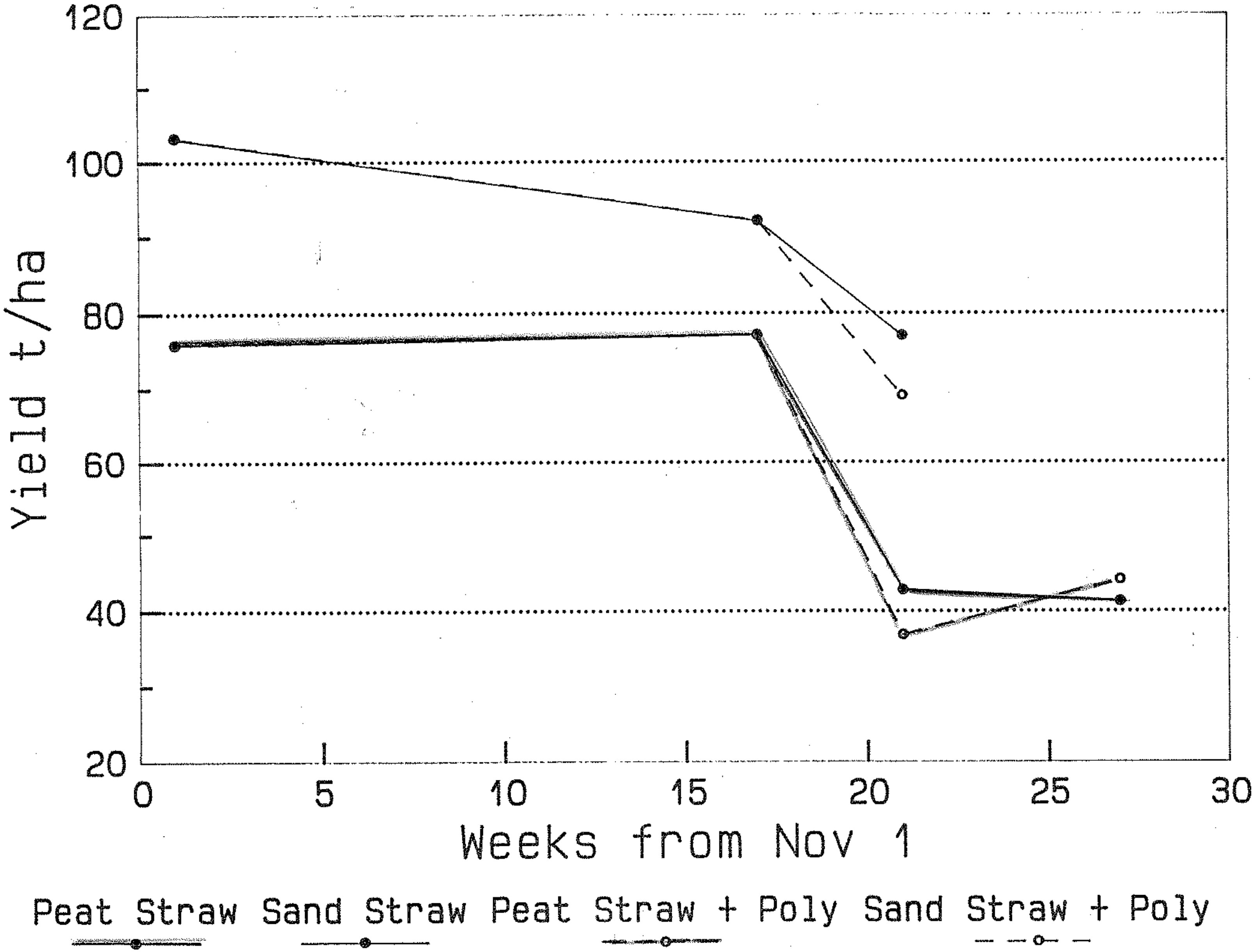
On the peat site the increase in rotten/diseased carrots was attributable to increased levels of carrot rootfly. The straw and polythene treatment was worse affected than the straw only covering. Higher temperatures under the polythene may have contributed to increased rootfly activity. There was also a small increase in the levels of cavity spot.

On the sand site deterioration in the field was less marked. Carrot rootfly and cavity spot both played a part. No one factor was largely responsible for the losses.

Graph 1 Percentage of marketable carrots out of cold store



Graph 2 Yield of carrots (tonnes/ha) from field stored treatments



On the silt site the cavity spot was largely responsible for the loss of quality in the field.

Yields of field stored treatments are illustrated in graph 2.

Effect of storage treatment on shelf life quality

Pre-storage

Carrots from the three sites were assessed for shelf life quality, sensory value and sugar levels at the start of the trial in November. There were few differences between the crops. Carrots from the silt site lost more weight in shelf life than the peat site (Table 3).

Table 3 Pre-storage shelf life quality after 72 hrs

Site	Scored 0-9, 9 = excellent Skin finish	Disease	Re-growth	% weight loss
Peat	6.25	8.65	7.90	0.82
Sand	6.30	8.15	7.75	1.22
Silt	6.10	8.40	7.60	1.43
SED (6 df)	0.315 ns	0.222 ns	0.127 ns	0.236 *** (5 df)

Sensory analysis indicated the peat grown carrots were paler and duller than the other two and less uniform in colour. All sites had a similar texture and flavour and all had a similar sugar level (Tables A3 and B1).

Post storage

Shelf life assessments of cold stored and freshly lifted samples in March indicated that at all times throughout shelf life the skin finish on freshly lifted roots was better than those from cold storage (Table 4) and that for cold stored treatments the sand site had a significantly poorer finish than the peat site. Grazes and abrasions at lifting and during washing had suberised and given the carrots a poor, 'dirty' appearance.

The amount of disease which developed during shelf life was worse on November lifted, cold stored treatments and was particularly high on the sand treatments (Table 5).

Table 4 Skin finish (scored 0-9, where 9 = excellent) after 72 hours shelf life - March assessment

Storage treatment	Site Peat	Sand	Silt	Mean
Lifted November	6.90	5.70	6.05	6.22
Lifted March (field stored)	7.80	7.70	7.65	7.72
Mean	7.35	6.70	6.85	
SED (between site means)		0.130	(15 df) ***	
SED (between storage treatment means)		0.106	(15 df) ***	
SED (other comparisons)		0.183	(15 df) **	

Table 5 Disease (scored 0-9, where 9 = excellent) after 72 hours shelf life - March assessment

Storage treatment	Site Peat	Sand	Silt	Mean
Lifted November	7.85	7.25	7.65	7.58
Lifted March (field stored)	8.75	7.70	8.30	8.25
Mean	8.30	7.48	7.98	
SED (between site means)		0.234	(15 df) *	
SED (between storage treatment means)		0.191	(15 df) **	
SED (other comparisons)		0.331	(15 df) ns	

Any existing shoots are knocked off the carrots during washing and packing but a small amount of regrowth inside the packs does tend to develop. This is undesirable since it is seen as a sign of age and will also lead to a reduction in sugar levels in the roots.

In the March assessment shoot growth was most developed on the silt grown treatments and was more developed on the November lifted, cold stored samples (Table 6).

Table 6 Shoot growth (scored 0-9, where 9 = excellent) after 6 days storage shelf life - March assessment

Storage treatment	Site Peat	Sand	Silt	Mean
Cold store November	6.80	6.20	5.75	6.25
Cold store March (field stored)	6.60	6.75	6.35	6.57
Mean	6.70	6.48	6.05	

SED (between site means)	0.168 ** (15 df)
SED (between storage means)	0.137 * (15 df)
SED (other comparisons)	0.238 ns (p = 0.05) (15 df)

Sensory appraisal of storage treatments in early March indicated all samples rated well for colour. The silt carrots were deepest orange and November lifted samples particularly dark. This was true at all later assessments. There were significant, but very slight, differences in strength of flavour and sweetness of the cold stored carrots (Table A4).

Analysis of sugar levels indicated the sugar content of most treatments was approximately 3 per cent (Table B1).

Shelf life assessments in early April included two field storage systems;

straw, and straw and black polythene. The silt grown crop had been completely harvested by this time so further samples were not available.

Weight loss in 'April' shelf life assessments was higher (peat site only) from the freshly lifted field stored treatments. This may be because cold stored samples had already transpired the free water from the skin surface during cold storage (Table 7).

Table 7 Percentage weight loss after 72 hours shelf life - April assessment

Storage treatment	Site Peat	Sand	Silt
Cold store November	0.75	0.72	0.82
Cold store March	0.81	1.03	0.84
Field, straw	2.29	1.48	N/A
Field, straw + polythene	2.78	1.75	N/A
SED (all comparisons)		0.638 * (19 df)	

As in March, skin finish was better on the field stored treatments (both coverings) than on the November lifted cold stored sample for both peat and sand sites. There was no difference between field treatments although for both sand and silt sites the March lifted, cold stored sample which had only been in cold store for one month at this time had a better skin finish than the November lift (Table 8). As indicated in the previous assessment, the sand grown crop overall had worse skin finish than the peat and silt grown crops.

Table 8 Skin finish (scored 0-9, where 9 = excellent) after 72 hours shelf life - April assessment

Storage treatment	Site Peat	Sand	Silt
Cold store November	6.71	4.55	5.40
Cold store March	6.85	6.00	7.21
Field, straw	7.13	7.05	N/A
Field, straw + polythene	7.40	6.90	N/A
SED (all comparisons)		0.230 *** (20 df)	

The disease scores during shelf life reflect the quality of the crop in store or in the field (Tables 1 and 2). The silt grown, November lifted cold stored crop showed very little rotting during shelf life, whilst its peat grown counterpart had developed considerably higher levels. As in March, the fresh lifted peat grown field treatments developed less disease than cold stored ones (Table 9).

Table 9 Disease (scored 0-9, where 9 = excellent) after 6 days shelf life - April assessment

Storage treatment	Site Peat	Sand	Silt
Cold store November	7.85	8.35	8.70
Cold store March	7.40	7.68	8.17
Field, straw	8.61	8.60	N/A
Field, straw + polythene	8.28	7.95	N/A
SED (all comparisons)		0.337* (20 df)	

Sensory analysis of shelf life samples indicated that the field stored sand grown carrots gained the highest scores for brightness and were significantly brighter than all cold stored samples (Table A5). Peat field stored samples were generally similar to their cold stored equivalents.

There were no significant differences in the flavour of samples in April. The flavour of field stored carrots was as good as those from cold store.

Total sugar percentages in April were similar for all treatments (excepting aberrant values) (Table B1).

'May' assessments (made week beginning 9 May) included field treatments from the peat site only.

Shelf life assessments on skin finish at this time follow the pattern previously illustrated. On the peat site, field stored samples had a better skin finish than cold stored treatments. The March lifted, cold stored treatment was intermediate between the November lift and field treatments. Stored samples from the sand site similarly confirm March lifted treatments to be better quality than the November lift (Table 10).

Table 10 Skin finish (scored 0-9, where 9 = excellent) after 72 hours shelf life - May assessment

Storage treatment	Site Peat	Sand	Silt
Cold store November	6.65	5.50	6.30
Cold store March	7.38	6.73	6.74
Field, straw	8.04	N/A	N/A
Field, straw + polythene	8.04	N/A	N/A
SED (all comparisons)		0.209*** (16 df)	

In contrast to earlier shelf life assessments, disease scores on field stored treatments were worse than cold stored ones (Table 11). This suggests quality in the field is rapidly deteriorating, possibly because carrots are losing their natural resistance, together with increased pathogenic activity in the warmer climate. All carrots were sound upon entry into shelf life. Most deterioration was due to soft rots developing around the crown or at the root tip.

Table 11 Disease (scored 0-9, where 9 = excellent) after 6 days shelf life - May assessment

Storage treatment	Site Peat	Sand	Silt
Cold store November	7.11	7.20	7.50
Cold store March	6.63	5.76	6.01
Field, straw	5.38	N/A	N/A
Field, straw + polythene	5.18	N/A	N/A
SED (all comparisons)		0.683 * (16 df)	

Shoot regrowth was again worse on the silt grown samples and for the peat grown crop was more developed on the cold stored samples (Table 12). Note this is secondary shoot growth and does not include the primary shoot growth which may have developed in field or cold store. For silt and sand sites in particular regrowth was most developed on the November lifted sample.

Table 12 Shoot growth (scored 0-9, where 9 = none present) after 6 days shelf life - May assessment

Storage treatment	Site Peat	Sand	Silt
Cold store November	6.33	5.95	6.05
Cold store March	6.95	7.04	6.88
Field, straw	8.14	N/A	N/A
Field, straw + polythene	8.14	N/A	N/A
SED (all comparisons)		0.332 *** (16 df)	

In May, sensory assessments showed the field stored peat grown samples were the palest in colour. The March lifted silt grown samples were the most fibrous. There was a suggestion that some of the cold stored samples were slightly sweeter than field stored ones. Chemical, musty and earthy off-flavours were, however, also noted in the November lift, cold stored samples although stale, earthy or musty off-flavours were noted in the field stored treatments as well (Tables A6 and A8).

In addition to the suggestion from sensory analysis that field stored samples were less sweet than cold stored ones, measured sugar levels were also slightly lower (Table B1).

The last assessment was made in very early June. There were no differences in weight loss during this period. The pattern in skin finish was similar to that in May. On the peat site the field stored treatments were always significantly better than the November lift and sometimes significantly better than the March lift. For silt and sand sites March lifted treatments were less silvered than November lifted. The sand grown crop had a worse finish than the other two (Table 13).

The most significant differences in disease levels is the deterioration of the field stored samples compared to the cold stored samples (peat site) (Table 14).

Disease scores are also reflected in the internal quality assessments (Table 15).

Shoot growth followed a pattern similar to that seen in the May assessments.

Table 13 Skin finish (scored 0-9, where 9 = excellent) after 6 days shelf life - June assessment

Storage treatment	Site Peat	Sand	Silt
Cold store November	6.21	4.05	4.65
Cold store March	6.20	5.05	5.84
Field, straw	7.19	N/A	N/A
Field, straw + polythene	7.32	N/A	N/A
SED (all comparisons)		0.362 *** (15 df)	

Table 14 Disease (scored 0-9, where 9 = excellent) after 6 days shelf life - June assessment

Storage treatment	Site Peat	Sand	Silt
Cold store November	7.53	7.40	8.10
Cold store March	7.45	7.30	7.95
Field, straw	5.82	N/A	N/A
Field, straw + polythene	6.02	N/A	N/A
SED (all comparisons)		0.535 ** (15 df)	

Table 15 Internal quality

Storage treatment	Site Peat	Sand	Silt
Cold store November	6.86	5.28	4.65
Cold store March	5.93	5.35	6.57
Field, straw	5.11	N/A	N/A
Field, straw + polythene	5.04	N/A	N/A
SED (all comparisons)		0.305 *** (15 df)	

Sensory assessments in June confirmed the pale colour of the field stored peat samples and the tendency for these samples to be firmer and more fibrous than cold stored samples.

As in May, cold stored carrots had a slightly stronger and sweeter flavour than field stored samples. In particular the November lift scored especially well. Off-flavours were again noted from both field treatments and the November lift cold stored samples (Table A7 and A8).

Sugar analysis of samples in May confirm the findings of the sensory taste panel that cold stored samples, in particular the November lifted samples, had a higher total sugar level than the field stored samples (Table B1).

Discussion

The levels of rotting which developed during cold storage of the five crops assessed (1988-89) varies considerably between sites. Under ideal storage conditions disease development is largely dependent on the levels of inoculum present on the crop at loading and on the maturity, natural resistance and handling damage in the crop. Results here suggest crops for storage should be chosen carefully if marketable yield is to be maximised.

The longer the storage period the greater the risk of rotting. Careful monitoring of crops in store is essential if losses are to be minimised.

Losses in a cold store should be balanced against expected losses in the field stored crop. Continued pest activity, rotting and shoot growth are the major problems and over a long period can also lead to an extensive reduction in marketable yield.

Two year's results confirm that even under ideal storage conditions the skin finish of cold stored crops is always worse than that of freshly lifted roots. The deterioration in skin finish appears to be directly related to the period of cold storage but crops grown on sandy soils will be worse affected by silvering than those on peat or silt soils.

In 1989 field stored crops developed less disease and rotting during shelf life in early assessments (up to April). In contrast, at later assessments the quality of field stored crops deteriorated and rotting during shelf life became a problem.

In addition to the improved shelf life of cold stored crops in May and early June, results from two years of sensory and sugar analysis also suggest that there are also flavour advantages over the field stored crop at this time. In particular, in 1989 the early November lifted crop retained a very sweet flavour. Analysis to date had only been possible on peat grown field stored crops at this late stage of the season. Other soil grown crops would, however, be expected to respond in a similar manner.

It would therefore appear that long term cold storage (lifted November) can improve flavour retention and early quality of the overwintered carrot crop in May and early June but this technique will produce a poor skin finish compared to field stored crops and may, on some crops, result in relatively high levels of rotting after the necessary 27-30 weeks storage. Overwintering the crop in the field and lifting in March for cold storage reduces the deterioration in skin finish but also reduces the benefits in flavour. Levels of rotting in this short term cold stored crop are, however, more likely to be acceptable and the off-flavours which developed in 1989 on the November lifted, cold stored crop and on the field stored crops were absent.

If carrots are required to supply the market only up until early April results from this project suggest that cold storage offers few advantages over a good field storage system. However, cold storage for short periods to alleviate problems during heavy frosts is still recommended.

Conclusions

1. The site and soil type in which carrots are grown has a marked effect on storage quality and on the subsequent skin finish out of store.

2. The level and pattern of rotting in store is specific to a crop but generally increases with length of storage.

3. Silvering and skin finish are always worse on cold stored carrots when directly compared to those lifted straight from the field.

4. In May and June, cold stored carrots showed less deterioration (rotting) in shelf life than field stored ones.

5. In May and June, cold stored carrots were slightly sweeter than field stored samples.

6. There was no noticeable deterioration in the texture of cold stored carrots. Field stored samples tended to be firmer and more fibrous.

7. A March lifted crop held in cold store until June compromises skin finish problems although still shows some slightly better flavour over field stored treatments. In addition the decision to store can be made when more knowledge on the quality of the crop and the market are available.

Recommendations for future action

Sensory appraisal and sugar analysis comparing field and cold storage systems from sand and silt sites in May and June is needed to confirm the trend established here for peat grown crops. The use of waxes and/or surface coatings should be given a preliminary investigation to see whether they might improve skin finish out of store, although the current consumer opinion does not encourage the use of any chemical post harvest.

Appendix 1

Crop diary

Site		Arthur Rickwood EHF
Cultivations	4 January 26 April 27 May	Plough and furrow press Cultirateau to make beds Trial drilled cv Nandor
Herbicides	27 May	600g/ha a.i. paraquat as 3 l/ha cp Gramoxone in 210 l/ha water
	16 June	2.52 kg/ha a.i. pentanochlor and chlorpropham as 5.6 l/ha cp Herbon Brown in 500 l/ha water
	8 July	1.5 kg/ha a.i. metoxuron as 3 l/ha cp Dosaflo and 1.35 kg/ha a.i. pentanochlor and chlorpropham as 3 l/ha cp Herbon Brown in 500 l/ha water
	19 July	3.25 kg/ha a.i. metoxuron as 6.5 l/ha cp Dosaflo in 500 l/ha water
Insecticides	27 May	2.8 kg/ha a.i. phorate as 28 kg/ha cp BASF Phorate
	15 June + 18 July	140 g/ha a.i. pirimicarb as 280 g/ha cp Aphox in 400 l/ha water
	4 + 26 August, 21 September + 24 October	1.05 kg/ha a.i. triazophos as 2.5 l/ha cp Hostathion in 1000 l/ha water
Irrigation	18 August 23 August	25 mm 25 mm
Fungicide	2 June	1.2 kg/ha a.i. metalaxyl and 5.76 kg/ha a.i. mancozeb as 12 kg/ha cp Fubol 58WP in 1000 l/ha water
Covering	31 October	Straw or straw + black polythene (30 t/ha straw)
Harvest dates	7 November 28 February 29 March 8 May	

CFDRA

Sensory appraisal and sugar analysis of stored carrots for Luddington EHS 1988/89

Introduction

Storage trials at Luddington EHS compared cold storage and field storage of carrots grown on sand, peat and silt soil types. Campden Food and Drink Research Association taste panels carried out sensory appraisal of samples at intervals during the storage period and an analysis of types and amounts of sugars was also carried out on each occasion.

Methods

Times when samples were assessed and the treatments sent at each time are recorded in Table 1.

Sensory appraisal

Carrot samples were hand peeled, cut into 6 mm slices and cooked for 10 minutes in boiling salted water. Three samples of each treatment were tasted (3 replicates) by a trained panel of at least three people. Colour, flavour and texture of the samples was rated using the QAV method of sensory appraisal and the scoring system in Table 2. Results for each assessment date were analysed using the Mann Whitney 'U' test for non-parametric comparisons. Carrots tasted on different dates cannot be compared.

Analysis of sugars

The Boehringer enzyme test kit was used for analysis of sugars. A sub-sample from each treatment was prepared and duplicate samples of macerate were analysed.

Table A1 Samples assessed

Treatment	Date of assessment November (control samples)	March	April*	May	June
<u>Cold stored - November</u>					
Sand	/	/	/	/	/
Peat	/	/	/	/	/
Silt	/	/	/	/	/
<u>Cold stored - March</u>					
Sand		/	/	/	/
Peat		/	/	/	/
Silt		/	/	/	/
<u>Field treatments</u>					
<u>Sand</u>					
Straw			/		
Straw + polythene			/		
<u>Peat</u>					
Straw			/	/	/
Straw + polythene			/	/	/

*actually assessed end of March

Table A2 Scoring systems for quality appraisal of processed carrots

Attribute		Score 1	2	3	4	5
Colour	Tint	Very pale	Slightly pale	Medium orange	Slightly dark	Very dark
	Brightness	Dull	Slightly dull	Moderately bright	Bright	Very bright
	Uniformity	Extremely non-uniform	Very non-uniform	Moderately non-uniform	Slightly non-uniform	Very uniform
	Prominence of cambium	Not at all	Slightly	Moderately	Very	Extremely
Flavour	Sweetness	Not at all	Slightly	Moderately	Very	Extremely
	Bitterness	Not at all	Slightly	Moderately	Very	Extremely
	Strength of carrot	Moderately weak	Fairly weak	Slightly weak	Slightly strong	Moderately strong
Texture	Softness	Very soft	Moderately soft	Slightly soft	Slightly firm	Very firm
	Fibrous cores	Not at all	Slightly	Moderately	Very	Extremely

Table A3 Sensory appraisal November 1988

Soil types	Orange	Bright	Uniform
Sand	3.3B**	3.7B***	3.3B*
Peat	2.3A	2.3A	2.4A
Silt	3.2B**	3.3B**	3.0
Overall mean	3.0	3.1	2.9

	Range	Mean
Prominence of CA	1.9 - 2.4	2.2
Soft	2.2 - 2.3	2.3
Fibrousness	1.0 - 1.0	1.0
Sweet	1.9 - 2.3	2.0
Bitter	1.9 - 2.0	2.0
Strength of flavour	2.6 - 3.2	2.8

Confidences of differences from control.

(Confidences are per column of 3 soil types based on Fisher's Modified LSD procedure).

* 95 per cent

** 99 per cent

*** 99.9 per cent

Treatments marked A are significantly different from those marked B.

Table A4 Sensory appraisal March 1989

Treatment	Orange	Promi	Soft/	Sweet	Strength
Cold stored November					
Sand	3.1A	2.3B	2.9B	2.4B	3.4A
Peat	3.3C	2.3B	2.8	2.3	3.0B
Silt	3.7B	2.4B	2.5A	2.4B	3.1
Cold stored March					
Sand	3.0A	2.3B	2.9B	2.1	3.1
Peat	3.3C	3.0A	2.6	2.3	3.1
Silt	3.8BD	2.4B	3.0B	2.0A	2.8B
Overall mean	3.4	2.5	2.8	2.3	3.1

	Range	Mean
Brightness	3.2 - 3.6	3.4
Uniformity	3.5 - 3.7	3.5
Fibrous cores	1.0 - 1.3	1.2
Bitter	1.7 - 2.0	1.9

Confidences of differences from control.

(Confidences are per column of 6 treatments based on Fishers's Modified LSD procedure).

* 95 per cent

** 99 per cent

*** 99.9 per cent.

Treatments marked A are significantly different from those marked B.

Treatments marked C are significantly different from those marked D.

Table A5 Sensory appraisal April 1989

Treatment	Orange	Bright	Promi	Soft/
Cold stored November				
Sand	3.5BC	3.0B	2.2B	2.9
Peat	3.3B	2.8BD	2.4	2.8
Silt	4.0AC	2.6BD	2.2B	2.6A
Cold stored March				
Sand	2.9B	2.6BF	2.2B	2.8
Peat	3.0BD	3.1B	2.3	2.9
Silt	3.8C	2.8B	1.8B	3.0
Field treatments				
Sand				
Straw	3.3B	3.9A	2.0B	3.1
Straw and polythene	3.4B	3.6CE	2.3B	2.9
Peat				
Straw	3.3B	3.5C	2.7	3.3B
Straw and polythene	3.2B	3.3B	3.1A	3.1
Overall mean	3.3	3.1	2.3	2.9

	Range	Mean
Uniformity	3.2 - 4.0	3.5
Fibrous cores	1.0 - 1.3	1.1
Sweet	1.8 - 2.3	2.0
Bitter	1.8 - 2.1	2.0
Strength of flavour	2.7 - 3.3	2.9

Confidences of differences from control.
(Confidences are per column of 10 treatments based on Fisher's Modified LSD procedure).

* 95 per cent
** 99 per cent
*** 99.9 per cent

Treatments marked A are significantly different from those marked B.
Treatments marked C are significantly different from those marked D.

Table A6 Sensory assessments May 1989

Treatment	Orange	Bright	Unifo	Promi	Soft/	Fibro	Sweet	Bitter	Stren
<u>Cold stored November</u>									
Sand	3.4BCG	3.1	3.2	2.1BD	2.6B	1.2C	2.1	1.9	2.7
Peat	3.2BC	2.9	3.4	2.6E	2.7	1.1A	2.2D	1.9	2.5
Silt	4.1AC	3.0	3.6A	2.2B	2.7	1.3	2.5AD	1.8A	2.9A
<u>Cold stored March</u>									
Sand	3.2BC	2.6A	3.1B	1.9BDF	2.6B	1.3	2.0	2.1	2.4B
Peat	2.6BD	3.0	3.0B	2.7C	3.1A	1.4	2.0BD	1.9	2.7
Silt	3.7CF	2.7	3.2	1.8BD	2.8	1.7B	2.5D	1.7	2.7
<u>Field treatments</u>									
<u>Peat</u>									
Straw	2.9BEH	3.3B	3.3	2.8A	3.0	1.6BD	1.6BC	2.2B	2.4B
Straw & P	2.9BE	3.0	2.9B	2.8A	2.9	1.6B	1.8B	2.2	2.6
Overall	3.2	3.0	3.2	2.4	2.8	1.4	2.0	2.0	2.6

Confidences of differences from control.

(Confidences are per column of 8 treatments based on Fisher's Modified LSD procedure).

* 95 per cent

** 99 per cent

*** 99.9 per cent.

Treatments marked A are significantly different from those marked B

Treatments marked C are significantly different from those marked D

Treatments marked E are significantly different from those marked F

Treatments marked G are significantly different from those marked H.

Table A7 Sensory appraisal June 1989

Treatment	Orange	Bright	Uniform	Promi	Soft/	Fibrous	Sweet	Stren
Cold stored November								
Sand	3.1BD	3.5A	3.2B	2.1E	2.7B	1.3	2.3D	2.6
Peat	3.0BF	3.1	3.4C	2.9BDF	2.0A	1.0A	2.8A	2.6
Silt	4.0A	3.2	3.7A	1.9A	2.4	1.1C	2.4D	2.7A
Cold stored March								
Sand	3.1BD	2.8B	2.7BD	2.1C	2.9B	1.4	2.2B	2.3B
Peat	2.3BCE	3.0	3.0B	2.4B	2.6B	1.3	2.0B	2.6
Silt	3.4BF	3.0	3.2	2.4	2.2	1.2	2.0B	2.6
Field treatments								
Peat								
Straw	2.6BC	2.8B	2.9BD	2.7BD	2.9B	1.7BD	1.8BC	2.3
Straw & P	2.6BC	2.9	2.8B	2.7B	3.0B	1.5B	1.9B	2.4
Overall mean	3.0	3.0	3.1	2.4	2.6	1.3	2.2	2.5

	Range	Mean
Bitter	1.7 - 2.1	1.9

Confidences of differences from control.

(Confidences are per column of 8 treatments based on Fisher's Modified LSD procedure)

* 95 per cent

** 99 per cent

*** 99.9 per cent

Treatments marked A are significantly different from those marked B

Treatments marked C are significantly different from those marked D

Treatments marked E are significantly different from those marked F.

Table 8 Comments on other flavours noted

Treatment	Assessments November	March	April	May	June
Cold stored November					
Sand	Sl. soapy/ tangy (2 reps)	-	-	Musty/ chemical/ soapy (3 reps)	Soapy/ onion (2 comments only)
Peat	?/sl soapy/ sl. stale (3 reps)	-	Earthy (1 taster, 2 reps)	Musty/ chemical (3 reps)	Sickly/ chemical (2 reps)
Silt	?/earthy/ soapy (3 reps)	Buttery/ soapy (2 reps)	Rotten/ buttery (2 tasters, 1 rep)	Salty/ soapy/sl buttery (2 reps)	Earthy/ musty/ stale (2 reps)
Cold stored March					
Sand	NA	Soapy (2 reps)	-	Piney/ soapy (1 taster each rep)	Soapy and buttery (3 reps) Stale soapy (2 reps)
Peat	NA	-	-	-	-
Silt	NA	Soapy (1 taster, 2 reps)	-	-	-
Field treatments					
Sand					
Straw	NA	NA	-	Na	NA
Straw + polythene	NA	NA	Soapy/pine (2 tasters, 1 rep)	NA	NA

Table A8 (continued) Comments on other flavours noted

Treatment	Assessments November	March	April	May	June
Peat					
Straw	NA	NA	Soapy/sl earthy/pine (1 taster, 3 reps)	Soapy (1 taster, 3 reps)	Soapy and stale (3 reps)
Straw +	NA	NA	-	Soapy (1 taster, 3 reps)	Soapy/ stale/ earthy/ musty (2 reps)

NA = Not applicable - no samples sent.

A dash can indicate that there were no other flavours noted.

Table B1 Total sugars (%)

Treatment	Assessments November	March	April	May	June
Cold stored November					
Sand	6.4	3.4	4.7	5.2	7.8
Peat	6.3	2.9	4.6	5.4	7.2
Silt	5.9	3.2	4.9	4.9	6.6
Cold stored March					
Sand		2.9	4.9	5.3	6.6
Peat		3.0	4.3	2.6	5.2
Silt		5.2	-	-	5.2
Field treatments					
Sand					
Straw			4.5		
Straw + polythene			5.0		
Peat					
Straw			5.7	3.7	4.6
Straw + polythene			3.7	3.2	4.0