Project Report

Agronomy and storage of crops for processing

Ref: 807/196

Interim Report

Cambridge University Farm
ADAS
BPC Sutton Bridge Experimental Unit

2001

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Preface

This report provides an analysis of the agronomy and storage trial on processing crops, which was carried out on a collaborative basis by Cambridge University Farm, ADAS Gleadthorpe and Sutton Bridge Experimental Unit.

Varieties Lady Rosetta and Russet Burbank were grown at the two field sites and material stored at SBEU. The trial results are from one year only and as such, should be treated with caution. However, there are some specific points of potential interest and commercial value.

In the trial year 1998-1999, the intended range of planting dates could not be achieved because of extremely wet conditions during late March and April. Consequently the two planting dates were only 14 days apart in May. The information from this trial about the subsequent performance of the crops is of value in similar seasons.

Data is available on the effects on tuber numbers, yield, dry matter and fry colours at harvest and during storage.

The delayed planting at CUF increased numbers of mainstems in both varieties but this did not increase tuber number as number of tubers per stem was reduced.

There was little effect of delay in planting on yields at CUF, but the two varieties differed considerably in yield. The relatively short growth pattern of Lady Rosetta resulted in modest yields, which were increased by the delay in harvesting. In contrast yields of Russet Burbank were large and increased more with the delay in harvest as extensive ground cover allowed bulking to continue. At Gleadthorpe delay in planting reduced yield in both varieties, but especially in Russet Burbank.

Despite the short season dry matter contents were acceptable at first harvest and remained so throughout harvesting and even the late planted early defoliated crops provided acceptable fry colour at intake and during early storage. Generally fry colours of such short season crops decrease more rapidly in store than for longer season crops. This suggests in seasons where planting is delayed, the later planted crops should be processed first.

There were large and commercially significant differences in weight loss of the two varieties between the two sites and the report suggests that crop senescence at defoliation has a considerable effect on weight loss in store and effort should be directed towards managing the extent of the canopy more directly.

Dr Ewen Brierley, British Potato Council

Introduction

This report covers the results of the first field and storage year of a three year programme of research. There were two separate parts to the research programme. First, the effects of field treatments on the processing quality of two varieties, Lady Rosetta and Russet Burbank grown on two sites was studied during field growth and throughout storage. The field treatments included dates of planting and harvesting, timing of defoliation and extent of irrigation while curing and holding temperature were varied during storage. These treatments were based on previous experience and were designed to produce crops across a broad spectrum of storage potential. Secondly, the effects of planting and harvesting dates and contrasting seed stocks on the packing quality of Estima was studied on two sites. The seed stocks were chosen to contrast in disease loading and detailed analyses of disease transmission and its consequences for tuber appearance (skin finish) were carries out.

The sites used were Cambridge University Farm (CUF) and Gleadthorpe Experimental Husbandry Farm (GLE) for the processing experiments and CUF and Terrington Experimental Husbandry Farm (TERR) for the packing experiments. The soil type at CUF is a gravelling loam over clay and would not be considered ideal for high quality skin finish while Terrington has a silt soil which would be expected to produce high quality table potatoes. Both CUF and GLE have light soils which are typical of many soils used for producing potatoes for processing.

In order to produce sufficient tubers for an extensive sampling programme during storage in both programmes the plots were large and harvested by elevator diggers and hand picking.

Materials and methods

Field details

Main experiments

Similar experiments were grown at two sites, Cambridge University Farm (CUF) and Gleadthorpe (GLE), using two processing varieties, Lady Rosetta and Russet Burbank. At CUF, there were three replicates of all combinations of two dates of planting (7 or 21 May), two dates of defoliation (three weeks prior to harvest or defoliated just prior to harvest) and three dates of harvest (7, 28 September and 19 October). At GLE, there were three replicates of all combinations of two dates of planting (7 or 21 May), two irrigation regimes (no irrigation after 20 July or fully irrigated) and three dates of harvest (2, 21 September and 12 October). The experiments were randomized split plot designs, with three replicates. All the plots at CUF were fully irrigated and at both sites irrigation was scheduled using CUF irrigation scheduling programme (Stalham & Allen unpublished) according to on-site rainfall and crop cover data. At GLE, all plots were defoliated two weeks prior to harvest.

At both sites, plots were hand planted with the same seed stocks (Table 1). At CUF, the seed spacings were 26 cm (Lady Rosetta) and 29 cm (Russet Burbank) and the plots were 8 rows wide and 10 m long. At GLE, the plots were 6 rows wide and 9 m long and planted at 25 cm (Russet Burbank) and 23 cm (Lady Rosetta) spacings. Row widths were 76 cm at CUF and 86 cm at GLE.

Table 1. Summary of seed class, size and disease (% tubers affected)

	Lady Rosetta	Russet Burbank
Class	A	SE2
Size (mm)	28-35	28-35
Mean weight (g)	23	28
Erwinia	no colonies	no colonies
Silver scurf	53	63
severe*	16	5
Black scurf	29	21
Common scab	3	1
Skin spot	0	37
Black dot	2	0
Powdery scab	0	9

* >12.5 % surface area affected

At CUF, 150 kg N/ha was applied pre-planting and no P or K fertilizers were used. Whilst at GLE 126 kg/ha N, 201 kg/ha P_2O_5 and 251 kg/ha K_2O was applied on 24 February and then a further 80 kg/ha N (Lady Rosetta) and 50 kg/ha N (Russet Burbank) was applied on 12 June.

Fertilizer requirements were determined according to soil type, previous cropping and the length of growing season. The determinacy of the varieties was taken into account in establishing N requirements. At GLE, application of N was split pre and post planting, with the N applied at the later application taking account of N that may have leached following spring rainfall. Indices for P, K and Mg at CUF and GLE were 4, 2, 2 and 3, 1, 2 respectively.

At CUF, plant emergence was recorded every 2-3 days following planting until emergence was complete. At GLE, emergence was recorded weekly. At both sites, ground cover was assessed weekly. At each harvest, eight plants from each plot were harvested by hand and the number of main and secondary stems, planting depth and total weight of tubers >10 mm were recorded. All tubers >10 mm were dispatched to Sutton Bridge Experimental Unit (SBEU) on the day of harvest. The remainder of each plot was machine harvested and all undamaged tubers >40 mm transported to SBEU on the day of harvest.

Curing experiment

Additional blocks of Lady Rosetta and Russet Burbank were grown at both sites, to provide material for storage work at SBEU. The blocks comprised 6 rows, each 40 m in length. The experiments were hand planted at both sites on 7 May, at the same spacings as the main processing experiments. There was a single harvest on 28 September at CUF and 21 September at GLE. The experiments were fully irrigated and defoliated three weeks (CUF) and two weeks (GLE) prior to harvest. The blocks were harvested by machine and all undamaged tubers >40 mm were transported to SBEU on the day of harvest. At each site the total weight of each variety was recorded.

Storage details at SBEU

Main experiment

At SBEU, the tubers harvested by hand from each plot were assessed for graded yield (<30, 30-40, 40-50, 50-60, 60-70 and >70 mm grades) bruising and scuffing.

Scuffing assessment

Following each harvest, a sub-sample of 10 tubers (50-80 mm tubers) from each plot were assessed for percent surface area (SA) scuffed after 10 revolutions in a scuffing barrel and scored on a scale of: 0-2, 2-10, 10-25 or >25 % SA scuffed.

Bruising assessment

Following each harvest, a sub-sample of 10 tubers (50-80 mm tubers) from each plot was assessed for susceptibility to bruising. The tubers were subjected to 10 revolutions in bruising barrel and incubated for 4 days at 20 ^{o}C and 96 % relative humidity. Bruising was scored on a scale of: unbruised, slight (bruise removed by 2 stokes of peeler) or severe (bruise not removed by 2 strokes of the peeler). If there were sufficient tubers in a sample, a further two sub-samples of 10 tubers were assessed for bruising from each replicate.

Storage assessments

The total weight of the tubers harvested by machine from each plot was recorded and then the tubers >40 mm were split into 23 (harvest 1), 21 (harvest 2) or 19 (harvest 3) samples of at least 5 kg (*c*. 30 tubers of Lady Rosetta and *c*. 20 tubers Russet Burbank >40 mm) and weighed. With the exception of the sample required for assessment at intake (dry matter and fry colour assessment) the samples were cured at 15 °C for two weeks. After curing, store temperatures were reduced by 1 °C per day to the required holding temperature. There were two holding temperatures for each variety (Lady Rosetta 10 °C and 8 °C, Russet Burbank 10 °C and 7 °C).

Following curing, one sample from each plot was weighed and assessed for fry colour (storage sample 1). Successive samples from each replicate were then weighed and assessed for fry colour, initially at three week intervals (storage samples 2 and 3) and then at four week intervals (storage samples 4 to 11) until mid-June. On two occasions, all replicates from storage samples 7 (CUF, 22 February; GLE, 15 February) and 11 (CUF, 14 June; GLE, 7 June) were assessed for disease and internal defects.

Tuber dry-matter assessment

The dry matter of tubers >40 mm from each plot was assessed at intake following each harvest. A sub-sample of 3.628 kg of peeled tubers from each replicate was assessed for tuber dry matter (%) using a Zeal hydrometer.

Fry colour – crisps (Lady Rosetta)

The fry colour of tubers >40 mm from each plot of Lady Rosetta was assessed at intake, after each harvest and at each successive sampling occasion. Approximately 30 peeled tubers from each sub-sample were cut along the longitudinal axis and sliced. No more than three slices were taken per tuber. A total of 300 g of slices (0.053±0.001 in. thickness) were washed in cold water for 45 seconds and then fried at 170 ^{o}C for 180 seconds. Fry colours ('L', 'a', and 'b' values) were assessed by Hunterlab.

Fry colour – chips (Russet Burbank)

The fry colour of tubers >40 mm from each plot of Russet Burbank was assessed at intake after each harvest and at each successive sampling occasion. Ten tubers from each sub-sample were assessed for fry colour. A minimum of 15 chips (3/8 in. slices) were fried for 210 seconds at 185 ^{o}C. The fry colours ('L', 'a', and 'b' values) were assessed by Hunterlab. In addition, USDA fry colour was assessed at SBEU. The USDA fry colour was assessed in the light cabinet using the 'artificial daylight' source. The fry colour was evaluated by comparing individual chips with the USDA standard colour chart. The number of chips in a sample matching the standard colours (scoring between 1 (USDA, 000) and 7 (USDA 4)) was recorded as well as the range in scores.

Internal defects assessment

On two occasions (storage samples 7 and 11) a sub-sample of 25 washed tubers >40 mm from each replicate was assessed for presence or absence of the following external defects: mechanical damage, pest damage, greening, mis-shapen, growth cracks, frost damage, enzymic browning, russetting, lenticel discolouration and lenticel out growth. Tubers were then cut and assessed for internal defects: bruising, softness, compression, internal sprouts, internal rust spot, vascular discoloration, hollow heart and spraing, on a scale of: <10 % or ≥10 % tissue affected. In addition, presence or absence of glassiness was recorded.

Disease assessment

On two occasions (storage samples 7 and 11) a sub-sample of 25 washed tubers >40 mm from each replicate was assessed for percent SA affected by skin diseases (silver scurf, black dot, skin spot, common scab, powdery scab and black scurf), on a scale of: 0, 1, 2, 3, 4, 5, 10, 20, 30, 40, 50, 60, 70, 80, 90, 95, 96, 97, 98, 99 or 100 % SA affected. The tubers were then cut and assessed for rots and internal diseases (blackleg, gangrene, dry rot, soft rot, watery wound rot, violet root rot and rubbery rot) on the same scale as the skin diseases. Late blight, pink rot and spraing were assessed as: <10 % or ≥10 % tissue affected.

Curing experiment

At SBEU, the total weight of each variety from each site was recorded and then the tubers were divided into 58 samples of at least 5 kg (*c*. 30 tubers of Lady Rosetta and *c*. 20 tubers Russet Burbank >40 mm) and the sample weights recorded. With the exception of the two replicate samples required for assessment at intake (fry colour), the samples were cured for two weeks. There were four different curing regimes common to both sites and varieties:

1. Two weeks at 15 °C then cooled 1 °C / day to holding temperature
2. Two weeks at 15 °C then transferred straight to holding temperature
3. Two weeks at 12 °C then cooled 1 °C /day to holding temperature
4. Two weeks at 12 °C then transferred straight to holding temperature

Initially after harvest, two samples from each variety, site and curing regime were weighed and assessed weekly for fry colours (storage samples 1 to 5). Storage samples were then assessed at two week intervals (storage samples 6 to 7) and at four week intervals (storage samples 8 to 14) until mid-June. On two occasions, all replicates from storage samples 10 (CUF, 22 February; GLE, 15 February) and 14 (37 weeks after harvest: CUF, 14 June; GLE, 7 June) were assessed for disease and internal defects.

Missing data

In some of the storage samples there were insufficient numbers of tubers to fulfil the assessment protocols. Therefore, where there were missing replicates, the analysis of the data was carried out as described below:

Main Experiment

- CUF Lady Rosetta: Storage samples 4, 6 and 9 restricted to harvests 2 and 3 only, owing to missing data from harvest 1. Storage samples 8 and 10 not included owing to missing data from all harvests
- GLE Lady Rosetta: Storage samples 5 and 11 restricted to harvests 2 and 3 only. Storage sample 9 at holding temperature 10 ^{o}C restricted to harvest 3 only, owing to missing data from harvests 1 and 2. Storage samples 4, 6, 8, 9 and 10 not included
- CUF Russet Burbank: Storage samples 8 and 10 restricted to harvests 2 and 3 only
- GLE Russet Burbank: Storage samples 5, 9 and 11 restricted to harvests 2 and 3 only. Storage samples 4 and 6 restricted to harvest 3 only. Storage samples 8 and 10 not included

Curing Experiment

- CUF Lady Rosetta: Storage samples 5, 7, 9, 11 and 13 not included
- GLE Lady Rosetta: Storage samples 11, 12 and 13 not included
- CUF Russet Burbank: Storage sample 5 not included
- GLE Russet Burbank: All samples analysed

Meteorological data

The meteorological data for the growing season at the two sites are shown in Table 2 and Table 3. CUF was generally slightly warmer, brighter and in the spring, wetter than GLE but the lack of complete data from GLE does not allow a complete comparison to be made. The timing and amounts of irrigation used at GLE are shown in Figure 1 and Figure 2. The SMD's in both varieties increased substantially after the cessation of irrigation in July,

although the SMD's did not reach the levels which might have been expected because of the rainfall in August and September. Nonetheless, the fully irrigated crops grew throughout the season at small SMD's which should not have been limiting, in contrast to the partially-irrigated crops.

Table 2. Monthly meteorological data at Cambridge University Farm 1998

Month	Total rainfall (mm)	Mean daily air temp. (^oC)	Mean daily soil temp. (^oC)	Mean daily radiation (MJ/m^2)	Mean daily ET0 (mm)
April	123	7.9	9.0	11.0	1.70
May	10	12.8	15.9	16.8	2.81
June	114	14.6	16.0	14.5	2.65
July	26	16.0	18.2	14.8	3.04
August	17	16.7	19.5	15.3	3.17
September	97	15.0	15.6	8.9	2.36
October	93	10.7	10.4	5.0	2.30

Table 3. Monthly meteorological data at Gleadthorpe 1998

Month	Total rainfall* (mm)	Mean daily air temp.** (^oC)	Mean daily soil temp.** (^oC)	Mean daily radiation*** (MJ/m^2)	Mean daily ET0 (mm)
April	111.6	n/a	n/a	n/a	n/a
May	15.9	12.3	15.7	n/a	n/a
June	58.3	14.0	15.1	13.4	2.30
July	34.9	15.6	15.7	14.6	2.62
August	34.2	15.9	16.1	13.4	2.44
September	11.8	16.5	15.0	9.2	1.67

* data ends 11/09/98
** data starts on 28/05/98
*** data starts on 02/06/98 and ends 09/09/99

Figure 1. Effect of irrigation on SMD of Lady Rosetta at GLE. Planted 7 May (■), Planted 21 May (●), irrigation stopped 20 July (solid), fully irrigated (open). Irrigation application, numbers in squares (mm)

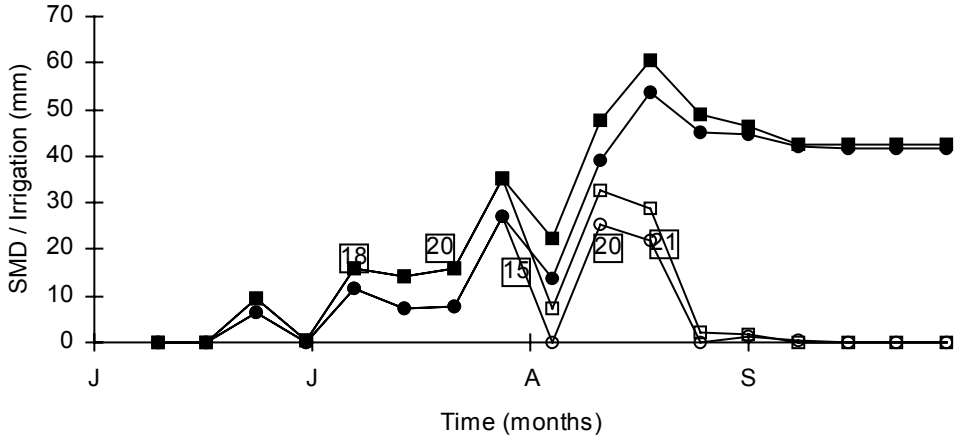
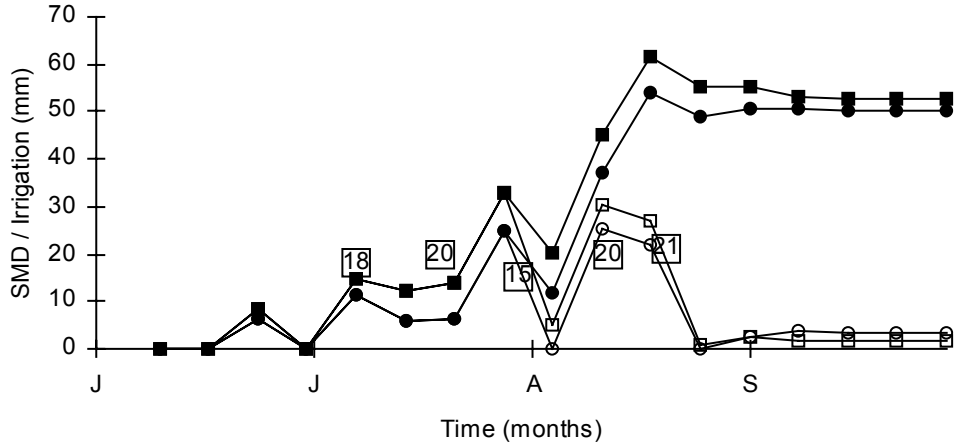


Figure 2. Effect of irrigation on SMD of Russet Burbank at GLE. Planted 7 May (■), Planted 21 May (●), irrigation stopped 20 July (solid), fully irrigated (open). Irrigation application, numbers in squares (mm)



Results

Field details

Main experiments

Emergence

Date of planting had little effect on time to 50 % emergence for Russet Burbank at CUF but emergence of Lady Rosetta was delayed slightly by planting later (Table 4). For both varieties at CUF, planting later reduced the final proportion of plants that emerged (Table 4). Only limited emergence data were recorded at GLE (Table 5).

Table 4. Effect of planting date on emergence of Lady Rosetta and Russet Burbank at CUF

Planting date	Lady Rosetta		Russet Burbank	
	50 % emergence (DAP)	Final emergence (%)	50 % emergence (DAP)	Final emergence (%)
7 May	21.8	99.9	23.3	99.8
21 May	23.2	90.3	23.8	95.6
S.E.	0.16	1.10	0.12	0.68

Table 5. Effect of date of planting on emergence (%) of Lady Rosetta and Russet Burbank at GLE

Date of measurement	Lady Rosetta		Russet Burbank	
planting date	7 May	21 May	7 May	21 May
1 June	90	-	70	-
4 June	98	-	95	-
12 June	-	5	-	5
15 June	-	75	-	60
17 June	-	100	-	98

Ground cover

At both sites, later planting delayed ground cover development of Lady Rosetta (Figure 3 and Figure 4). Complete ground cover was reached in Lady Rosetta in all treatments but was very short lived at GLE even from the later planting. Particularly at CUF, later planting delayed canopy senescence, whilst irrigation had no effect on the duration of ground cover of Lady Rosetta at GLE (Figure 4). This was surprising and no convincing explanation can be given. This unexpected pattern of growth must be born in mind when considering any effects of irrigation which occurred during storage.

Later planting also delayed ground cover development of Russet Burbank at both sites (Figure 5 and Figure 6). Complete cover was reached in all treatments and, at CUF, persisted until final harvest. In contrast, at GLE complete canopy cover of Russet Burbank was very short lived and again irrigation had no effect on canopy persistence (Figure 6). In view of the indeterminate nature of the canopy of this variety, this result was even more surprising than for Lady Rosetta and suggests factors other than water supply were affecting canopy senescence at GLE.

Figure 3. Effect of date of planting on ground cover of Lady Rosetta at CUF. Planted 7 May (■), planted 21 May (●)

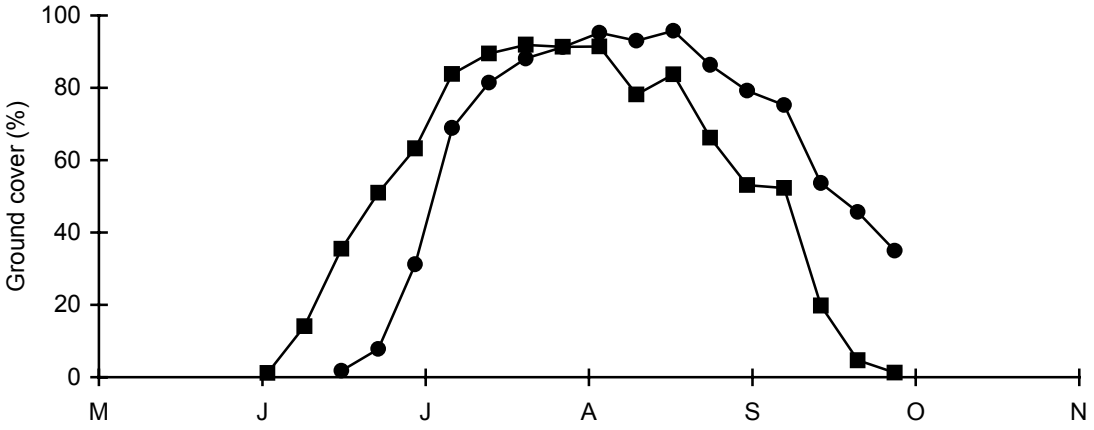


Figure 4. Effect of date of planting and irrigation on ground cover of Lady Rosetta at GLE. Planted 7 May (■), planted 21 May (●), irrigation stopped 20 July (solid), fully irrigated (open). Irrigation stopped at ↑

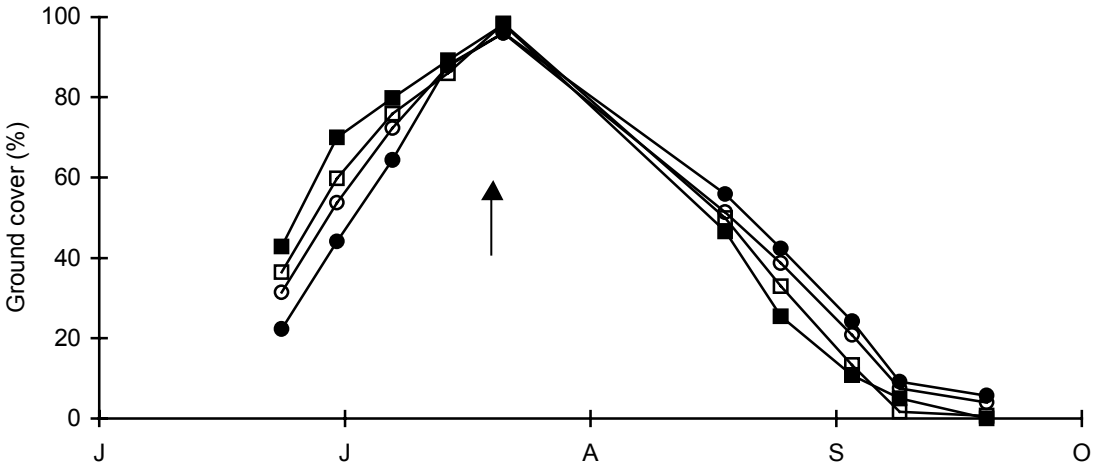


Figure 5. Effect of date of planting on ground cover of Russet Burbank at CUF. Planted 7 May (■), planted 21 May (●)

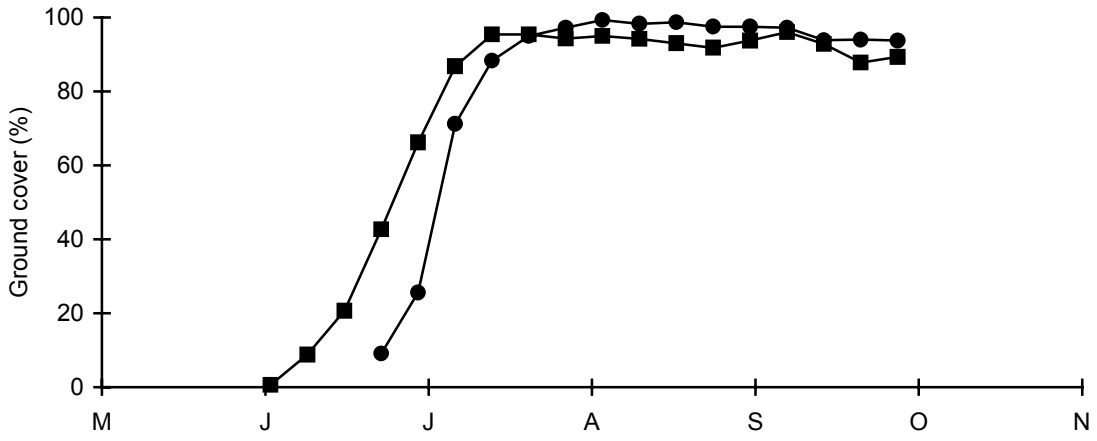
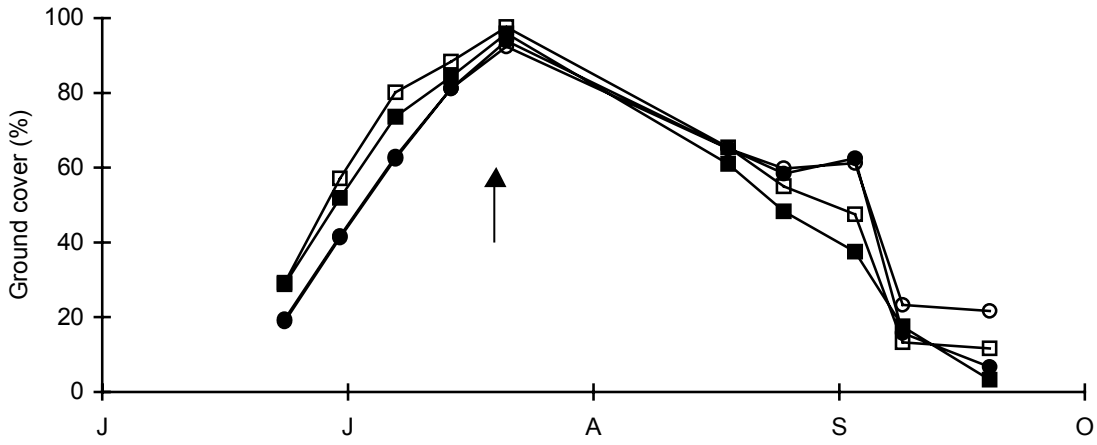


Figure 6. Effect of date of planting and irrigation on ground cover of Russet Burbank at GLE. Planted 7 May (■), planted 21 May (●), irrigation stopped 20 July (solid), fully irrigated (open). Irrigation stopped at ↑



Number of stems

Data analysis of the number of stems was restricted to harvests 1 and 2 only, as a result of difficulties in accurately counting stems at the final harvest.

Mainstems

At CUF, both varieties produced more mainstems from the later planting (Lady Rosetta 191 000 ± 6 100, Russet Burbank 108 000 ± 5 000/ha) than earlier planting (Lady Rosetta 153 000, Russet Burbank 85 000/ha). Only the number of above-ground stems was measured at GLE.

Secondary stems

At CUF, both varieties produced relatively few secondary stems (Lady Rosetta, *c*. 300 and Russet Burbank *c*. 1 900/ha), which were not affected by any of the treatments.

Above-ground stems

Lady Rosetta produced more above-ground stems than Russet Burbank but the range between sites was relatively small (Table 6). At CUF, both varieties produced more above-ground stems from the later planting (Table 6) as a result of an increase in the number of mainstems. At GLE, the number of above-ground stems was not affected by date of planting.

Table 6. Effect of planting date on total number of above-ground stems (000/ha)

Variety	Site	Planting date		
		7 May	21 May	S.E.
Lady Rosetta	CUF	153	191	6.1
Lady Rosetta	GLE	177	168	10.9
Russet Burbank	CUF	88	108	5.8
Russet Burbank	GLE	120	114	7.0

Number of tubers

Lady Rosetta produced similar numbers of tubers at CUF and GLE (Table 7). At CUF, there were fewer tubers at the final harvest than at earlier harvests (Table 7). The difference in number of tubers was the result of more small tubers at the early harvests, since the number of tubers >40 mm did not differ significantly between harvests (mean, *c*. 390 000/ha). The small tubers may have been less effectively recovered from the final harvest in wet soil conditions. At GLE, the total number of tubers did not differ significantly between dates of harvest (Table 7), although at the final harvest there were more tubers >40 mm (478 000 ± 23 900/ha) than at earlier harvests (2 September, 337 000; 21 September, 371 000/ha). Date of planting, defoliation and irrigation had no affect on the total number of tubers produced by Lady Rosetta (Table 7).

Russet Burbank produced more tubers at GLE than CUF (Table 7). At CUF, the total number of tubers produced by Russet Burbank was greater at the first harvest than at later harvests (Table 7) and this was the result of more small tubers, as there was no difference in the number of tubers >40 mm between harvests (mean, *c*. 279 000/ha). At GLE, date of harvest did not significantly affect the total number of tubers produced by Russet Burbank (Table 7) or the number of tubers >40 mm (mean, *c*. 300 000/ha). At CUF, the total number of tubers produced by Russet Burbank was not altered by date of planting but there were more tubers >40 mm from planting late (299 000 ± 6 300/ha) than planting early (259 000/ha). At GLE, the total number of tubers produced by planting late was greater than from planting early (Table 7). This was the result of more small tubers as there were fewer tubers >40 mm from

planting late (281 000 ± 7 700/ha) than planting early (319 000/ha). Irrigation and defoliation did not significantly affect the number of tubers produced by Russet Burbank (Table 7).

Table 7. Effect of irrigation, date of planting, harvest and defoliation on the total number of tubers (000/ha) produced by Lady Rosetta and Russet Burbank

	Lady Rosetta		Russet Burbank	
	CUF	GLE	CUF	GLE
Date of planting, 7 May	817	802	442	506
21 May	746	823	484	566
S.E.	25.6	16.5	17.6	18.7
Date of harvest, 2 (7) Sept	831	835	505	578
21 (28) Sept	840	782	449	512
12 (19) Oct	674	821	435	519
S.E.	22.2	17.6	7.9	22.3
Defoliated, just prior to harvest	781	-	464	-
3 weeks prior to harvest	781	-	462	-
S.E.	18.2		6.4	
Irrigation stopped 20 July	-	815	-	506
Fully irrigated	-	811	-	566
S.E.		14.4		18.2

Harvest dates for GLE outside brackets, CUF inside brackets

Total yield

Russet Burbank produced larger yields than Lady Rosetta and for both varieties, yields at CUF were greater than at GLE (Table 8). Total and ware yields generally increased with delay in harvest, although the effect of date of harvest on yields of Russet Burbank at GLE was not significant (Table 8 and Table 9). Date of planting had no effect on total or ware yields of Lady Rosetta or Russet Burbank at CUF, but at GLE total and ware yields of both varieties were greater from planting early than late (Table 8 and Table 9). At CUF, total and ware yields of Russet Burbank, were greater from defoliating just prior to harvest than when defoliated earlier, but yields of Lady Rosetta were not affected by timing of defoliation (Table 7). Irrigation treatments at GLE had no significant effect on the total or ware yields of either variety (Table 8 and Table 9).

Table 8. Effect of irrigation, date of planting, harvest and defoliation on total yield (t/ha) of Lady Rosetta and Russet Burbank

	Lady Rosetta		Russet Burbank	
	CUF	GLE	CUF	GLE
Date of planting, 7 May	42.0	38.7	51.8	44.5
21 May	39.9	34.7	49.2	36.6
S.E.	1.91	1.01	1.78	1.01
Date of harvest, 2 (7) Sept	35.3	31.5	43.4	35.6
21 (28) Sept	43.4	36.7	49.9	42.8
12 (19) Oct	44.2	41.9	58.2	43.2
S.E.	1.67	1.76	1.84	2.40
Defoliated, just prior to harvest	42.6	-	55.0	-
3 weeks prior to harvest	39.3	-	46.0	-
S.E.	1.37		1.50	
Irrigation stopped 20 July	-	35.4	-	39.3
Fully irrigated	-	38.1	-	41.8
S.E.		1.44		1.96

Harvest dates for GLE outside brackets, CUF inside brackets

Table 9. Effect of irrigation, date of planting, harvest and defoliation on ware yield >40 mm (t/ha) of Lady Rosetta and Russet Burbank

	Lady Rosetta		Russet Burbank	
	CUF	GLE	CUF	GLE
Date of planting, 7 May	34.7	29.5	47.6	39.5
21 May	33.3	24.6	45.3	27.9
S.E.	2.08	1.11	1.77	1.05
Date of harvest, 2 (7) Sept	27.4	21.1	38.8	27.8
21 (28) Sept	36.1	26.5	45.6	36.5
12 (19) Oct	38.5	33.4	55.0	36.9
S.E.	2.22	2.28	1.90	2.99
Defoliated, just prior to harvest	35.9	-	51.4	-
3 weeks prior to harvest	32.1	-	41.5	-
S.E.	1.81		1.55	
Irrigation stopped 20 July	-	24.8	-	32.0
Fully irrigated	-	29.3	-	35.4
S.E.		1.86		2.44

Harvest dates for GLE outside brackets, CUF inside brackets

Mean tuber size

Mean tuber size (mu) and coefficient of variation (CV) for Lady Rosetta was not altered by any treatment at CUF or GLE. Mean tuber size for Lady Rosetta was 49 mm at CUF and 45 mm at GLE. Coefficient of variation for Lady Rosetta was 19 at CUF and 15 at GLE. With Russet Burbank at CUF, mean tuber size increased with increasing yield from 50 ± 1.1 mm for early harvested early defoliated crops to 60 mm for late defoliated crops at the final harvest but CV was not affected (mean *c*. 15). At GLE, mean tuber size of Russet

Burbank increased with increasing yield from 42 ± 1.3 mm for early harvested, late planted tubers to 51 mm for early planted tubers at the final harvest. Coefficient of variation increased from 13 ± 0.8 at the first harvest to 16 at the final harvest.

Intake data

Bruising score

Overall bruising score was greater for Lady Rosetta than Russet Burbank but similar between sites (Table 10). With the exception of Russet Burbank at GLE, date of harvest had a significant influence on bruising score but this effect was not consistent between sites. At CUF, both varieties had greater bruising scores at the final harvest than at earlier harvests, whilst Lady Rosetta at GLE had a greater bruising score at the first harvest than at later harvests (Table 10). Date of planting did not affect the bruising score at CUF but at GLE planting early increased bruising scores of both varieties (Table 10). Timing of irrigation and defoliation did not affect bruising score.

Table 10. Effect of date of planting and harvest on bruising score at intake

	Lady Rosetta		Russet Burbank	
	CUF	GLE	CUF	GLE
Date of planting, 7 May	0.24	0.39	0.10	0.21
21 May	0.20	0.26	0.13	0.09
S.E.	0.023	0.022	0.019	0.031
Date of harvest, 2 (7) Sept	0.08	0.60	0.02	0.27
21 (28) Sept	0.05	0.24	0.00	0.06
12 (19) Oct	0.52	0.14	0.33	0.13
S.E.	0.038	0.038	0.032	0.062

Harvest dates for GLE outside brackets, CUF inside brackets

Tuber dry-matter (%)

Tuber dry-matter percentage of Lady Rosetta from CUF at intake was slightly greater from defoliation just prior to harvest than with earlier defoliation (Table 11) but was not affected by date of planting or harvest. At GLE, tuber dry-matter of Lady Rosetta was greater from planting early than late (Table 12) but date of harvest did not affect dry-matter percentage. Withholding irrigation from mid-July resulted in higher dry-matter than full irrigation (Table 12).

Tuber dry-matter percentage of Russet Burbank from CUF was greater from harvesting later than at earlier harvests, planting early than planting late and defoliating just prior to harvest rather than earlier defoliation. (Table 11). As with CUF, at GLE, dry-matter percentage was greater from planting early than planting late but the effect of delaying harvest was affected

by irrigation regime. At GLE, dry-matter percentage was greater from harvesting later than at earlier harvests only when plots were fully irrigated (Table 12). At the first harvest tuber dry-matter percentage of Russet Burbank from GLE was greater when irrigation had been withheld from mid-July than when fully irrigated but this was not observed from later harvests (Table 12).

Table 11. Effect of date of planting and harvest and timing of defoliation on tuber dry-matter (%) at intake of Lady Rosetta and Russet Burbank from CUF

	Lady Rosetta	Russet Burbank
Date of planting, 7 May	23.7	22.4
21 May	23.4	21.7
S.E.	0.11	0.11
Date of harvest, 7 Sept	23.6	21.0
28 Sept	23.8	22.6
19 Oct	23.2	22.7
S.E.	0.17	0.23
Defoliated, just prior to harvest	23.8	22.7
3 weeks prior to harvest	23.3	21.4
S.E.	0.14	0.19

Table 12. Effect of irrigation and date of planting and harvest on dry-matter (%) at intake of Lady Rosetta and Russet Burbank from GLE

	Lady Rosetta		Russet Burbank	
	Irrigation stopped 20 July	Fully irrigated	Irrigation stopped 20 July	Fully irrigated
Date of planting, 7 May	26.6	24.6	23.2	22.8
21 May	24.9	23.9	21.9	21.6
S.E.		0.16		0.31
Date of harvest, 2 Sept	26.1	24.1	22.3	20.4
21 Sept	25.4	24.4	22.6	22.7
12 Oct	25.7	24.2	22.8	23.5
S.E.		0.20		0.41

Fry characteristics at intake

At GLE, the 'L' value of Lady Rosetta at intake was less from the final harvest than earlier harvests and the 'a' value was least from the mid-harvest (Table 13). The 'L' and 'a' values of Lady Rosetta from CUF at intake were not affected by date of harvest (Table 13).
Lady Rosetta from both sites had smaller 'b' values at intake from the final harvest than earlier harvests (Table 13). Date of planting and timing of defoliation and irrigation did not affect the fry colours of Lady Rosetta at intake.

The 'L' value of Russet Burbank from CUF at intake was greater from the early harvests than the final harvest but this effect was not found at GLE (Table 13). The 'L' value of Russet

Burbank at intake was not affected by date of planting or timing of defoliation and irrigation. At both sites the fry colour scores and 'b' values for Russet Burbank tended to increase with delay in harvest (Table 13). At CUF, the fry colour scores and 'b' values were lower from defoliating just prior to harvest (fry colour score, 2.05 ± 0.053; 'b' value, 17.2 ± 0.11) than defoliating earlier (fry colour score, 2.38; 'b' value, 17.7) and from planting late (fry colour score, 2.13 ± 0.052; 'b' value, 17.3 ± 0.08) than planting early (fry colour score, 2.30; 'b' value, 17.6). The 'a' value of Russet Burbank was greater when fully irrigated (1.5 ± 0.07) than when irrigation had been withheld from mid-July (-1.7) and greater when defoliated just prior to harvest (-1.9 ± 0.20) than earlier defoliation (-1.0). The 'a' value of was not affected by date of planting or harvest.

Table 13. Effect of date of harvest on fry colour characteristics at intake

Date of harvest	Lady Rosetta		Russet Burbank	
	CUF	GLE	CUF	GLE
'L' value				
2 (7) Sept	68.2	67.9	56.9	55.1
21 (28) Sept	68.4	68.5	57.3	55.7
12 (19) Oct	68.6	66.2	55.1	55.5
S.E.	0.25	0.27	0.42	0.18
'a' value				
2 (7) Sept	-0.28	-0.33	-1.82	-1.53
21 (28) Sept	-0.20	-1.09	-1.41	-1.73
12 (19) Oct	0.07	0.08	-1.15	-1.56
S.E.	0.140	0.138	0.239	0.091
'b' value				
2 (7) Sept	26.0	24.7	16.9	15.8
21 (28) Sept	26.1	24.5	17.6	15.9
12 (19) Oct	25.3	23.7	17.9	16.6
S.E.	0.09	0.18	0.14	0.17
Fry colour score				
2 (7) Sept	-	-	1.86	1.92
21 (28) Sept	-	-	2.48	2.02
12 (19) Oct	-	-	2.30	2.30
S.E.			0.064	0.085

Harvest dates for GLE outside brackets, CUF inside brackets

Storage data

Lady Rosetta

The 'L' value

At CUF, the 'L' value of Lady Rosetta decreased progressively during storage until *c*. mid-February for 10 ^{o}C holding temperature and *c*. mid-April for 8 ^{o}C holding temperature

(Figure 7). The 'L' value remained above the desirable value of 62 until February at both holding temperatures. At 10 ^{o}C, 'L' values then decreased more rapidly than at 8 ^{o}C, although by the end of the experimental storage (June) there was no difference between temperatures and the 'L' values were still close to acceptable *c.* 60. Initially at 8 ^{o}C holding temperature, harvesting later resulted in greater 'L' values than harvesting earlier but this effect was not apparent from 12 weeks after the first harvest (30 November) (Figure 7). Such an effect of date of harvest was not found when samples were stored at 10 ^{o}C (Figure 7). From eight weeks after the first harvest (2 November) early planting resulted in greater 'L' values than planting later at both holding temperatures (Figure 8). There was little effect of timing of defoliation on 'L' value and there was no consistent effect of holding temperature on 'L' value during storage (Figure 7 and Figure 8).

Figure 7. Effect of date of harvest and holding temperature on 'L' value of Lady Rosetta from CUF. Harvested 7 Sept (■), harvested 28 Sept (●), harvested 19 Oct (▲), 8 ^{o}C holding temperature (solid line), 10 ^{o}C holding temperature (broken line)

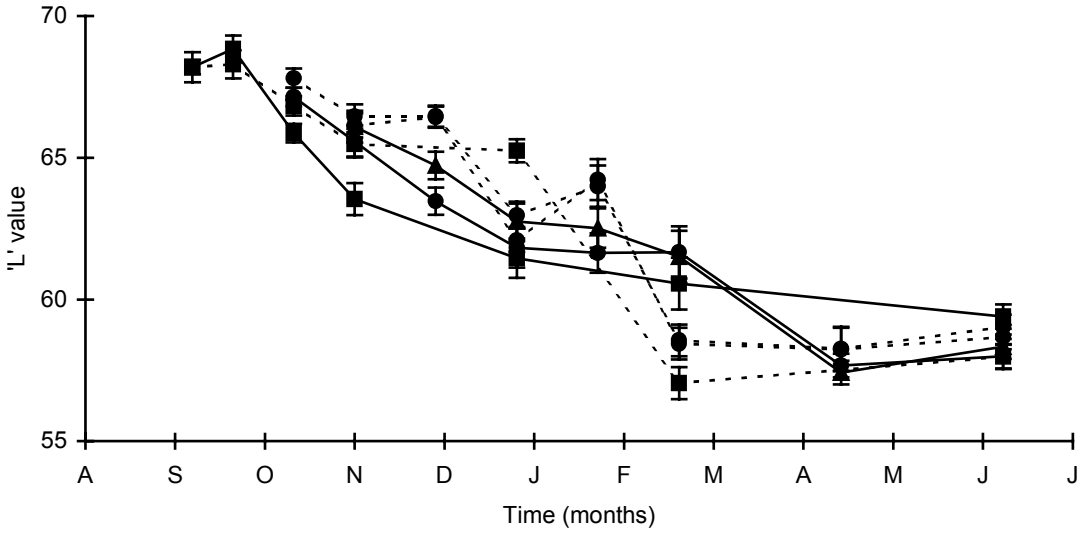
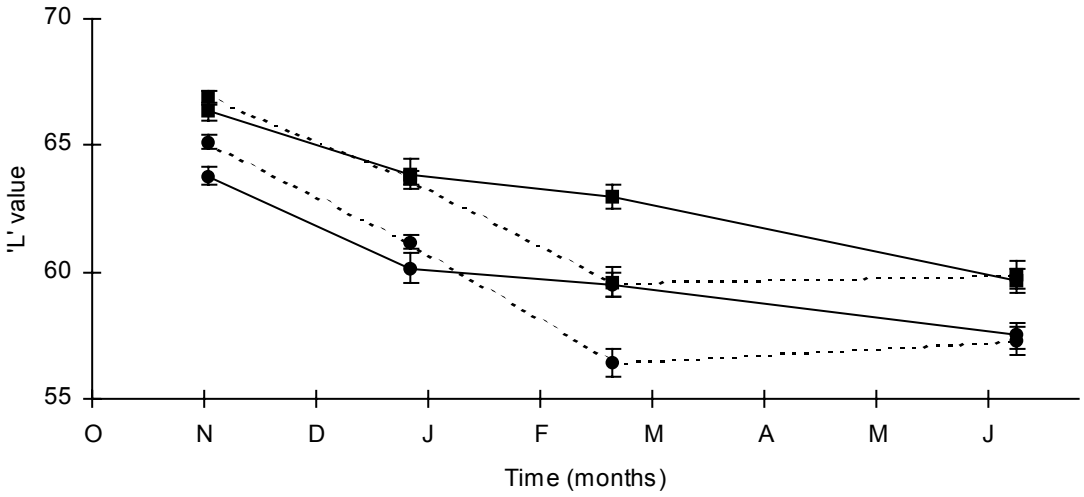


Figure 8. Effect of date of planting and holding temperature on 'L' value of Lady Rosetta from CUF. Planted 7 May (■), planted 21 May (●), 8 °C holding temperature (solid line), 10 °C holding temperature (broken line)

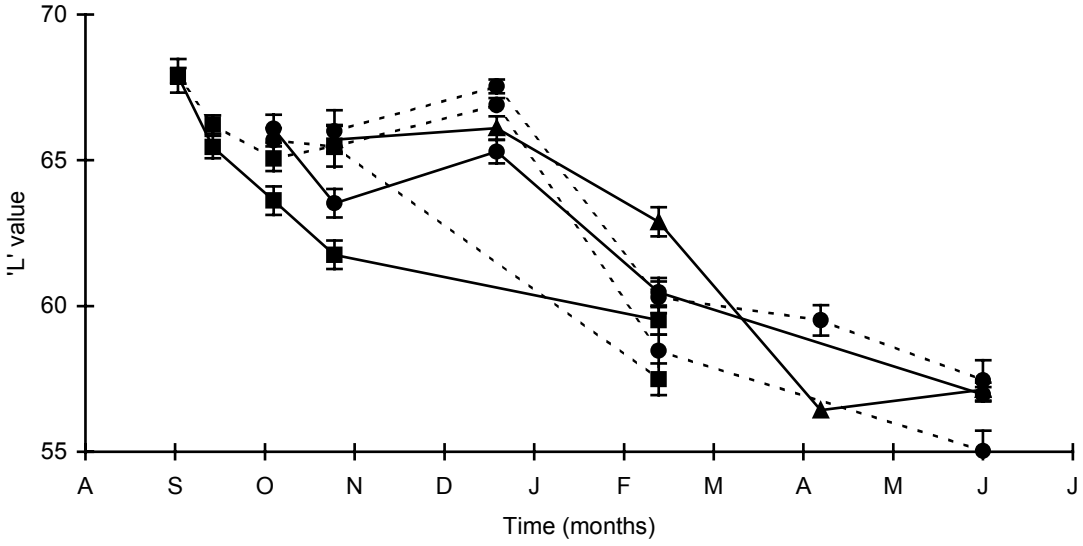


At GLE, the 'L' value of Lady Rosetta decreased during storage but the decrease was more erratic than at CUF and continued throughout storage up to June (Figure 9). The 'L' values stayed above the desirable 62 until February but at the end of the experimental period (June) the 'L' values were generally lower than from CUF. Unlike at CUF, there was no consistent effect of date of planting on the 'L' value. When stored at 8 °C, restricting irrigation generally produced greater 'L' values than full irrigation (Table 14). At 10 °C holding temperature, restricting irrigation only resulted in a greater 'L' value (60.7 ± 0.44) than full irrigation (56.8) on one sampling occasion (15 February). When stored at 8 °C, early harvesting generally had lower 'L' values than later harvesting. At 10 °C holding temperature, a significant effect of harvest date was only apparent towards the end of storage (Figure 9).

Table 14. The effect of date of harvest and irrigation on the 'L' value of Lady Rosetta from GLE from storage sample 7 (15 February)

	Date of harvest		
	2 September	21 September	12 October
Holding temperature 8 °C			
Irrigation stopped 20 July	63.1	62.3	63.7
Fully irrigated	56.0	58.6	62.1
S.E.			0.71
Holding temperature 10 °C			
Irrigation stopped 20 July	60.6	60.1	61.4
Fully irrigated	54.3	56.8	59.3
S.E.			0.77

Figure 9. Effect of date of harvest and holding temperature on 'L' value of Lady Rosetta from GLE. Harvested 2 September (■), harvested 21 September (●), harvested 12 Oct (▲), 8 °C holding temperature(solid line), 10 °C holding temperature (broken line)



Weight loss during storage

At CUF, weight loss of Lady Rosetta increased progressively throughout storage but there was little difference between storage temperatures (Figure 10). At both holding temperatures by the end of storage, weight loss was greater from the mid-harvest than other harvests, although earlier, weight loss was greatest from the first harvest (Figure 10). At 8 °C holding temperature, final weight loss was increased by defoliating just prior to harvest than defoliating earlier (Table 15). This was not apparent at the end of the storage period from the 10 °C holding temperature, although significant differences were observed from earlier assessments. Initially at both holding temperatures, later planting increased weight loss in store, however, final weight loss at 8 °C holding temperature was greatest from early planting (Table 15) and at 10 °C holding temperature there was no effect of planting date.

Figure 10. Effect of time of harvest on weight loss in store of Lady Rosetta from CUF. Harvested 7 September (■), harvested 28 September (●), harvested 19 October (▲), 8 °C holding temperature (solid line), 10 °C holding temperature (broken line)

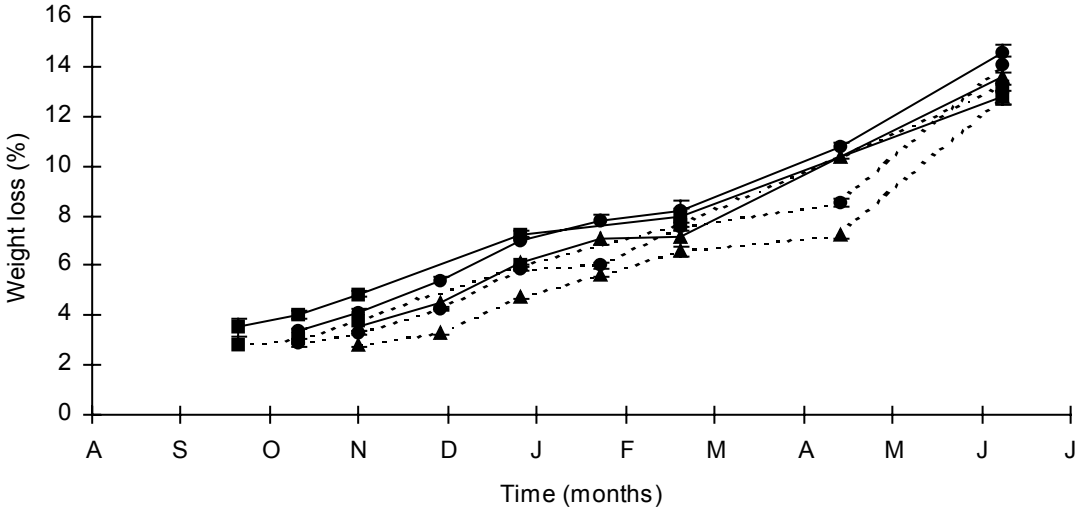


Table 15. Influence of date of planting, harvest and timing of defoliation on weight loss of Lady Rosetta from CUF in store (8 °C holding temperature, final storage sample 11 (14 June))

Date of planting	Timing of defoliation	Date of harvest		
		7 September	28 September	19 October
7 May	Just prior to harvest	14.2	15.7	13.8
7 May	3 weeks prior to harvest	11.2	14.6	13.9
21 May	Just prior to harvest	14.5	14.6	13.6
21 May	3 weeks prior to harvest	11.1	13.5	12.9
S.E.			#0.41	0.49
Mean		12.8	14.6	13.6
S.E.				0.282

#S.E. when comparing same level of defoliation and harvest

Weight loss of Lady Rosetta from GLE was considerably less than CUF (Figure 10 and Figure 11) and would be considered extremely low in practice. As at CUF, weight loss of Lady Rosetta from GLE increased progressively during storage and there was little effect of holding temperature (Figure 11). Generally, harvesting later and restricting irrigation reduced weight loss in store (Table 16). There was no consistent effect of date of planting on weight loss from GLE.

Figure 11. Effect of time of harvest on weight loss of Lady Rosetta from GLE in store. Harvested 2 September (■), harvested 21 September (●), harvested 12 October (▲), 8 °C holding temperature (solid line), 10 °C holding temperature (broken line)

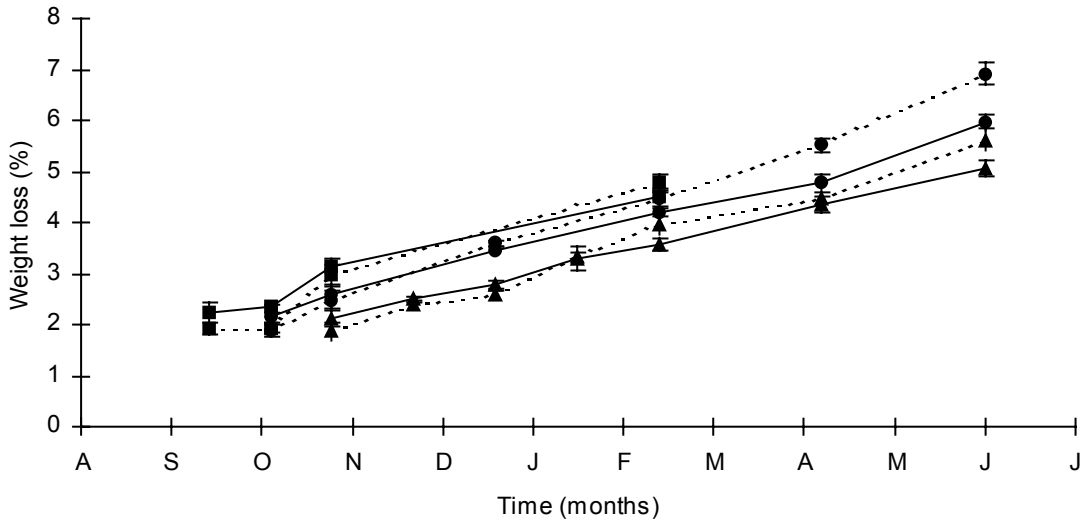


Table 16. Effect of date of planting, harvest and irrigation on weight loss of Lady Rosetta from GLE in store (8 °C holding temperature, storage sample 7 (15 February))

Date of planting	Irrigation regime	Date of harvest		
		2 September	21 September	12 October
8 °C holding temperature				
7 May	Irrigation stopped 20 July	4.8	4.1	4.3
7 May	Fully irrigated	6.6	6.2	5.5
21 May	Irrigation stopped 20 July	4.6	5.2	4.5
21 May	Fully irrigated	6.3	5.6	4.8
S.E.			#0.12	0.61
Mean		5.6	5.3	4.8
S.E.				0.10
10 °C holding temperature				
7 May	Irrigation stopped 20 July	5.2	4.4	4.8
7 May	Fully irrigated	6.7	6.8	6.5
21 May	Irrigation stopped 20 July	4.8	5.6	4.7
21 May	Fully irrigated	6.5	6.4	5.3
S.E.			#0.19	0.18
Mean		5.8	5.8	5.3
S.E.				0.09

#S.E. for same level of harvest and irrigation

Disease and defects

With the exception of silver scurf, there was little disease on Lady Rosetta tubers (Table 17). and only a low incidence of internal defects (vascular browning *c*. 2.3 %, IRS *c*. 3.6 % of tubers with <10 % SA affected and no hollow heart). The higher holding temperature increased the severity of silver scurf (Table 17). The severity of silver scurf and incidence of

Table 17. The effect of harvest, storage temperature and site on severity (% SA) and incidence (%) of disease on Lady Rosetta tubers affected during storage (storage sample 7: CUF, 22 February; GLE, 15 February. Storage sample 11: CUF, 14 June; GLE, 7 June)

	Storage	CUF, date of harvest				GLE, date of harvest			
	sample	7 Sept	28 Sept	19 Oct	S.E.	2 Sept	21 Sept	12 Oct	S.E.
8 °C holding temperature									
Severity									
Silver scurf	7	13.1	25.3	17.6	3.40	1.4	1.4	2.8	0.66
	11	20.0	43.9	25.9	5.72	-	1.7	2.9	1.37
Black dot	7	0.1	0.5	0.5	0.14	1.3	2.7	6.2	1.46
	11	0.2	0.1	0.7	0.12	-	2.6	3.6	1.68
Incidence									
Black scurf	7	17.7	18.0	19.7	3.70	30.3	45.0	51.3	5.09
	11	12.0	13.0	16.3	3.50	-	31.7	40.0	6.00
Skin spot	7	1.0	2.7	1.3	0.92	2.0	1.0	0.0	1.05
	11	15.7	21.7	17.0	4.70	-	6.3	0.7	4.09
10 °C holding temperature									
Severity									
Silver scurf	7	35.6	53.4	43.2	5.96	3.5	4.0	4.5	1.28
	11	59.4	81.9	80.0	3.87	-	12.9	18.6	3.96
Black dot	7	0.6	1.3	1.9	0.41	2.0	3.0	5.8	0.67
	11	0.1	0.2	0.3	0.08	-	2.0	2.9	0.64
Incidence									
Black scurf	7	15.7	19.7	16.3	2.93	32.7	41.4	47.7	5.45
	11	8.0	12.0	22.3	2.46	-	34.7	41.0	3.95
Skin spot	7	1.3	2.0	0.3	0.71	1.0	1.3	0.0	0.51
	11	25.3	13.0	7.7	7.09	-	0.1	0.0	0.03

skin spot generally increased during storage and this was particularly noticeable on tubers from CUF (Table 17). At 8 °C holding temperature, the severity of silver scurf on tubers from CUF was greater from the mid-harvest than the other two harvests but at 10 °C severity was lower from the first harvest than later harvests (Table 17). Date of harvest did not affect severity of silver scurf at GLE. At CUF at 10 °C holding temperature, the incidence of black scurf increased with delay in harvest whilst, from GLE the same effect of harvest was only significant at the 8 °C holding temperature (Table 17). From both sites, when stored at 8 °C, the severity of black dot, although still slight, was greater from the final harvest than earlier harvests (Table 17). There were no other effects of date of harvest on severity of disease. On the tubers from GLE, the incidence and severity of IRS increased during storage from 15 February (8 °C, *c*. 0.2 %; 10 °C, *c*. 0.4 % of tubers with >10 % SA affected) to 7 June (8 °C, *c*. 13.0 %; 10 °C 11.4 % of tubers with <10 % SA affected). The other diseases showed little change during storage. Restricting irrigation resulted in less severe silver scurf (storage sample 11, 7.7 ± 3.96 % SA affected) when stored at the higher temperature than full

irrigation (23.9 % SA affected). There was no effect of date of planting or defoliation on severity of any disease.

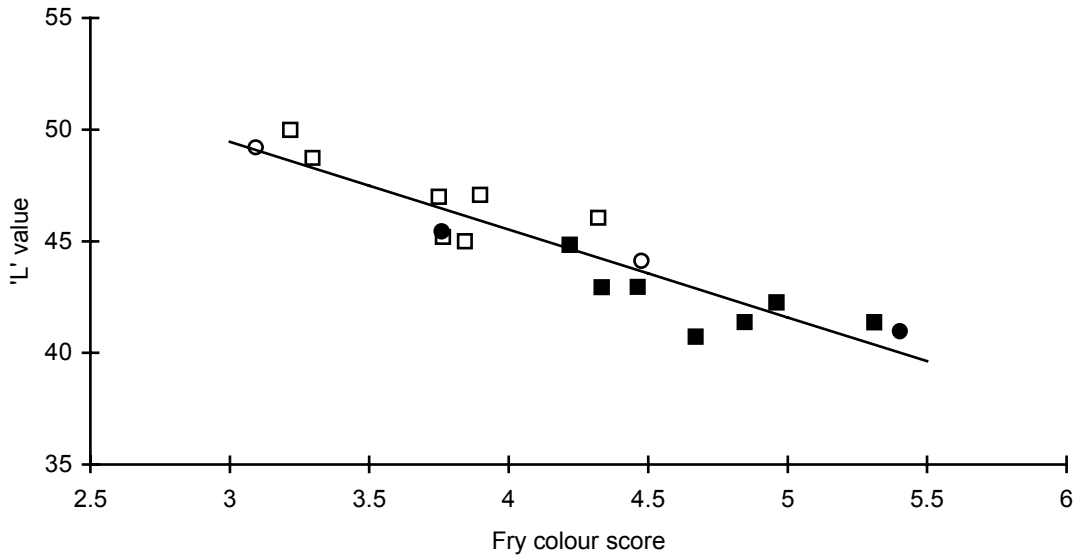
Russet Burbank

Fry colours

There was a close correlation between fry colour score and 'L' value of Russet Burbank (Figure 12), where fry colour score decreased as 'L' value increased. The regression between 'L' value and fry colour score included all data from each assessment date from CUF and GLE, expressed as mean of date of harvest. Fry colours for Russet Burbank during storage are described in terms of 'L' values since there is a degree of subjectivity in determination of USDA and fry colour score.

Fry colours of USDA 1 (score of 4) or less are normally commercially acceptable and may attract a bonus, whilst USDA >3 (score >6) are generally undesirable. The value of potatoes for chipping for some contracts is based on the proportion of chips of a particular colour so the mean fry colour does not necessarily equate to value but a standard of USDA 2, score of 5 and 'L' value of 41.6 would normally be acceptable.

Figure 12. Relationship between fry colour score and 'L' value fry characteristics of Russet Burbank. Y = -3.93X + 61.24 r^2 = 84.5 (slope ± 0.41; intercept ± 1.73). CUF (■), GLE (●), 7 ^{o}C holding temperature (solid), 10 ^{o}C holding temperature (open)



The 'L' value

The 'L' value for Russet Burbank was similar at the two sites and decreased during the first 2-3 months after intake but then was relatively stable during storage (Figure 13 and Figure 14).

Generally, storing at the lower temperature reduced the 'L' value (Figure 13 and Figure 14) although, towards the end of storage differences between storage temperatures decreased. At both sites and holding temperatures, the 'L' value from the final harvest was greater than from earlier harvests and this was found throughout the storage period (Figure 13 and Figure 14). The 'L' value from both sites remained above the acceptable value (42) throughout the experimental period when stored at 10 ^{o}C but fell below the acceptable value from November onwards when stored at the lower temperature from the first and mid harvests. With tubers from GLE, on several sampling occasions there was an interaction between harvest and irrigation regime. For example, (storage sample 7 (15 February) 10 ^{o}C) when fully irrigated the 'L' value was greater from the final harvest (46.8 ± 0.78) than first harvest (40.0) but when irrigation had been restricted there were no significant differences between the final harvest (45.5) and the first harvest (44.0). Generally, at both sites the 'L' value was greater from early planting than later planting (Table 18 and Table 19), although on several sampling occasions there was an interaction with date of harvest. For example, (GLE storage sample 7 (15 February) 7 ^{o}C) from the first harvest the 'L' value from early planting (39.9 ± 0.39) was greater than later planting (37.5) but from the final harvest the 'L' value did not differ between early planting (43.7) and later planting (44.6). The 'L' value of tubers from CUF was increased by defoliating just prior to harvest as compared to defoliating earlier (Table 18).

Figure 13. Effect of date of harvest and holding temperature on 'L' value of Russet Burbank from CUF during storage. Harvested 7 September (■), harvested 28 September (●), harvested 19 October (▲), 7 ^{o}C holding temperature (solid line), 10 ^{o}C holding temperature (broken line)

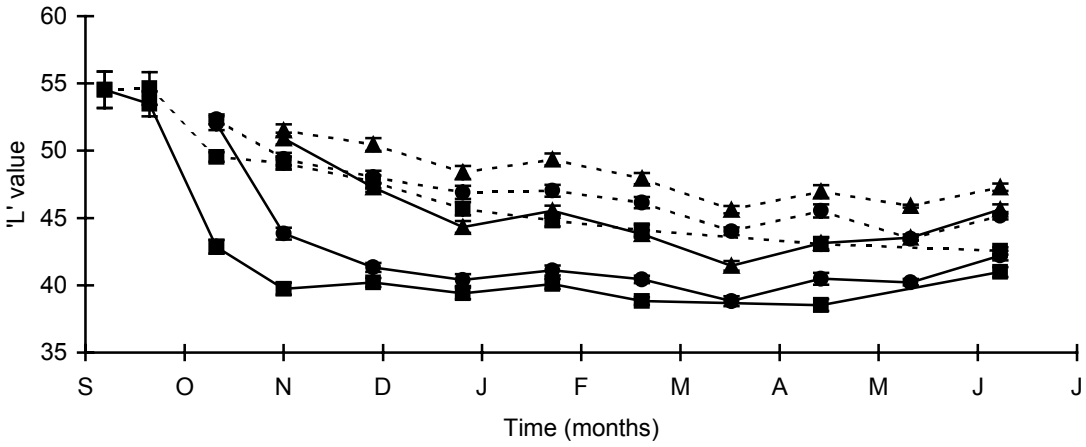


Figure 14. Effect of date of harvest and holding temperature on 'L' value of Russet Burbank from GLE during storage. Harvested 2 September (■), harvested 21 September. (●), harvested 12 October (▲), 7 °C holding temperature (solid line), 10 °C holding temperature (broken line)

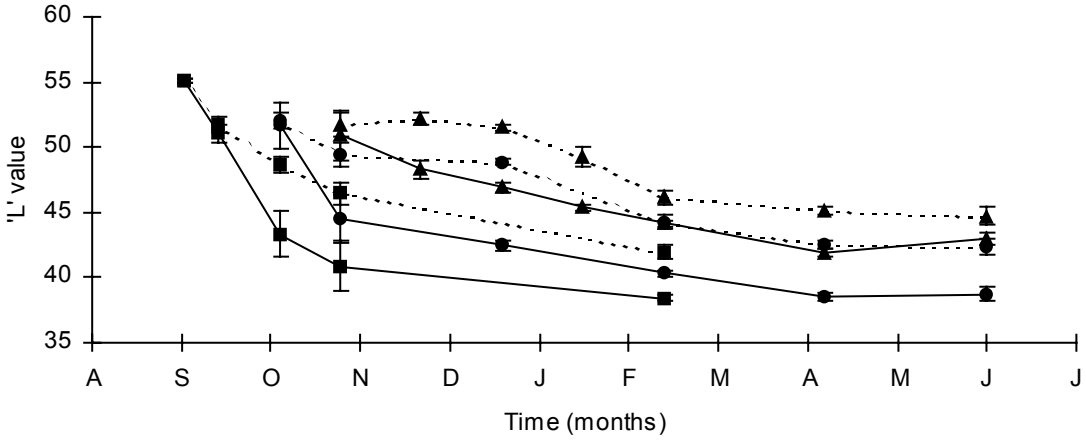


Table 18. Effect of date of planting and defoliation on 'L' value of Russet Burbank from CUF during storage

	Storage sample				
	2 Nov	28 Dec	22 Feb	19 April	14 June
7 °C holding temperature					
Defoliated, just prior to harvest	45.5	42.2	42.4	41.5	43.9
3 weeks prior to harvest	44.2	40.6	40.3	40.0	42.0
S.E.	0.36	0.35	0.23	0.36	0.30
Date of planting, 7 May	45.4	41.9	42.1	41.5	43.8
21 May	44.1	40.9	40.6	39.9	42.1
S.E.	0.35	0.28	0.29	0.29	0.35
10 °C holding temperature					
Defoliated, just prior to harvest	50.8	48.1	47.0	46.4	46.3
3 weeks prior to harvest	49.2	45.9	45.1	44.0	43.7
S.E.	0.38	0.40	0.34	0.40	0.23
Date of planting, 7 May	50.7	48.2	46.6	46.1	45.8
21 May	49.3	45.8	45.5	44.3	44.2
S.E.	0.31	0.24	0.29	0.31	0.31

Table 19. Effect of date of planting on 'L' value of Russet Burbank from GLE during storage

	Storage sample	
	26 October	15 February
7 °C holding temperature		
Date of planting, 7 May	46.4	41.6
21 May	44.5	40.3
S.E.	0.26	0.23
10 °C holding temperature		
Date of planting, 7 May	50.2	45.1
21 May	48.2	43.2
S.E.	0.30	0.23

Weight loss during storage

At both sites, weight loss of Russet Burbank increased progressively during storage and was not affected by holding temperature (Figure 15 and Figure 16). Overall, weight loss from GLE was again lower than from CUF and only *c*. 5 % by the end of 9 months of storage (Figure 15 and Figure 16). Generally, harvesting later reduced weight loss in store, although the effect was reduced or absent from early defoliated plots (Table 20) and where irrigation was restricted. For example, (GLE storage sample 7 (15 February) 7 ^{o}C) when fully irrigated weight loss was greater from the first harvest (5.1 ± 0.16 %) than the final harvest (3.7 %) but when irrigation was restricted there were no differences between the first (4.0 %) and the final harvest (3.4 %). At CUF, defoliating earlier reduced weight loss in store from the first two harvests but not from the final harvest (Table 20). Initially, earlier planting at CUF had smaller weight loss than later planting but this response decreased with time and was not significant by the end of the storage period (Table 21). At GLE, an effect of planting date on weight loss in store was only observed from the mid-harvest (Table 22), at which delaying planting increased weight loss in store.

Figure 15. Effect of time of harvest on weight loss of Russet Burbank from CUF during storage. Harvested 7 September (■), harvested 28 September (●), harvested 19 October (▲), 7 ^{o}C holding temperature (solid line), 10 ^{o}C holding temperature (broken line)

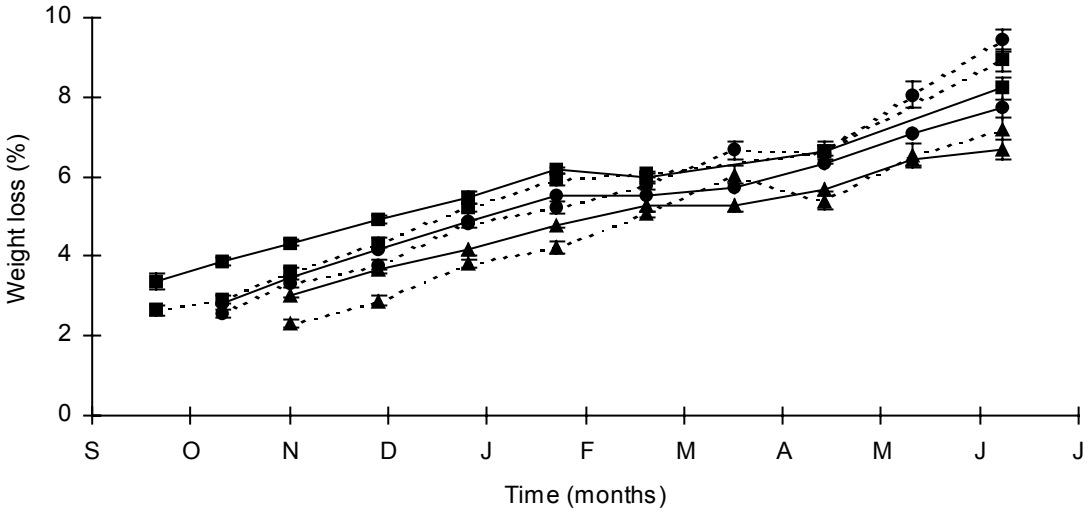


Figure 16. Effect of time of harvest on weight loss of Russet Burbank from GLE during storage. Harvested 2 September (■), harvested 21 September (●), harvested 12 October (▲), 7 °C holding temperature (solid line), 10 °C holding temperature (broken line)

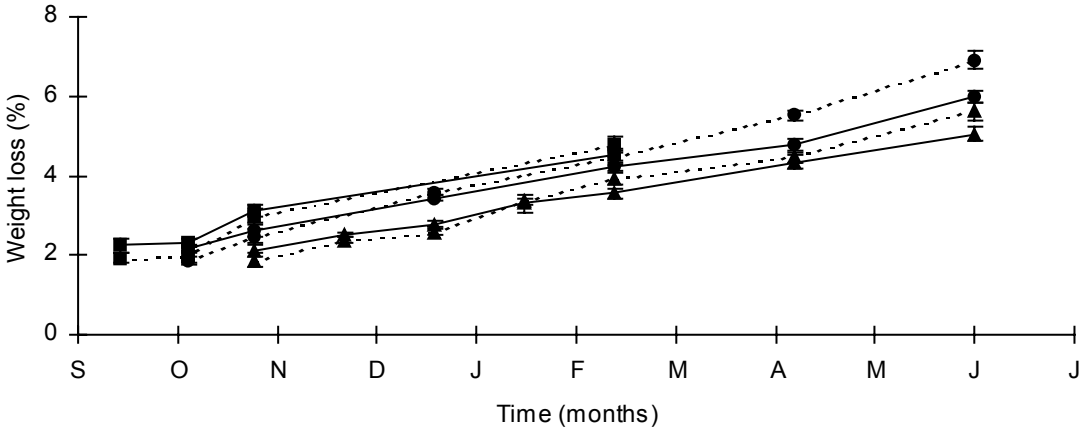


Table 20. Effect of date of defoliation and harvest on weight loss (%) of Russet Burbank from CUF during store. (storage sample 3 (2 November); Storage sample 11 (14 June))

	Storage sample 3			Storage sample 11		
Date of harvest	7 Sept	28 Sept	19 Oct	7 Sept	28 Sept	19 Oct
7 °C holding temperature						
Defoliated, just prior to harvest	5.2	3.9	3.1	9.8	8.6	6.9
3 weeks prior to harvest	3.5	3.1	2.9	6.6	6.9	6.5
S.E.			0.11			0.38
10 °C holding temperature						
Defoliated, just prior to harvest	4.1	3.7	2.3	10.1	9.8	7.3
3 weeks prior to harvest	3.2	2.9	2.3	7.8	9.1	7.1
S.E.			0.14			0.38

Table 21. Effect of date of planting on weight loss (%) of Russet Burbank from CUF in store (storage sample 3 (2 November); Storage sample 11 (14 June))

	Storage sample 3	Storage sample 11
7 °C holding temperature		
Date of planting, 7 May	3.5	7.5
21 May	3.8	7.6
S.E.	0.11	0.16
10 °C holding temperature		
Date of planting, 7 May	2.9	8.4
21 May	3.2	8.6
S.E.	0.06	0.10

Table 22. Effect of date of planting and harvest on weight loss of Russet Burbank (%) from GLE in store (storage sample 3 (26 October); Storage sample 7 (15 February))

	Storage sample 3			Storage sample 7		
Date of harvest	2 Sept	21 Sept	12 Oct	2 Sept	21 Sept	12 Oct
7 ^{o}C holding temperature						
Date of planting, 7 May	3.1	2.3	2.1	4.4	3.9	3.6
21 May	3.1	2.9	2.1	4.7	4.5	3.5
S.E.		#0.06	0.16		#0.16	0.16
10 ^{o}C holding temperature						
Date of planting, 7 May	2.9	2.3	1.8	4.8	4.2	3.9
21 May	3.1	2.7	1.9	4.8	4.7	3.9
S.E.		#0.06	0.18		#0.17	0.22

#S.E. for same date of harvest

Disease and defects

There was no severe disease (Table 23) nor internal defects on Russet Burbank tubers (vascular browning, *c*. 2.9 %; IRS, *c*. 1.2 % of tubers with <10 % SA affected; hollow heart, *c*. 0.7 % of tubers) from any treatment. Although still slight, the severity of silver scurf and incidence of skin spot at CUF was greater than at GLE and incidence of black scurf and severity of black dot at GLE was greater than at CUF (Table 23). Incidence of skin spot increased during storage but there was no change in severity or incidence of any other disease. Storage temperature only affected the severity of silver scurf, which particularly on tubers from CUF, was greater when stored at a higher temperature (Table 23). There were small effects of date of planting and harvest but these were not consistent during storage. Timing of defoliation and irrigation had no affect on severity or incidence of any disease.

Table 23. The effect of harvest, storage temperature and site on severity (mean surface area affected %) and incidence (%) of Russet Burbank tubers affected by disease during storage (storage sample 7: CUF, 22 February; GLE, 15 February; Storage sample 11: CUF, 14 June; GLE, 7 June)

	Storage	CUF date of harvest				GLE date of harvest			
	sample	7 Sept	28 Sept	19 Oct	S.E.	2 Sept	21 Sept	12 Oct	S.E.
8 °C holding temperature									
Severity									
Silver scurf	7	1.2	2.2	1.7	0.38	0.4	0.7	0.9	0.07
	11	1.0	1.3	1.8	0.13	-	0.6	0.6	0.05
Black dot	7	0.1	0.4	0.6	0.14	0.7	3.1	7.9	1.08
	11	0.4	0.8	0.9	0.19	-	3.3	5.1	0.53
Incidence									
Black scurf	7	5.4	5.0	5.4	2.05	28.5	43.3	49.6	5.97
	11	2.1	3.8	5.4	1.80	-	29.2	45.8	4.53
Skin spot	7	14.2	4.2	2.1	3.32	2.5	0.4	0.8	0.93
	11	47.1	31.3	32.9	5.63	-	6.3	2.1	2.73
10 °C holding temperature									
Severity									
Silver scurf	7	2.6	5.7	4.7	0.94	1.5	1.5	1.2	0.27
	11	3.0	10.7	4.5	2.08	-	1.2	0.8	0.15
Black dot	7	0.1	0.5	1.1	0.17	1.1	5.4	8.7	0.94
	11	0.7	0.5	1.3	0.18	-	4.0	6.6	1.64
Incidence									
Black scurf	7	3.8	11.3	5.8	2.01	35.8	40.4	41.7	8.54
	11	3.7	6.2	5.0	1.59	-	33.3	35.8	6.76
Skin spot	7	27.1	7.5	3.7	4.46	4.6	1.7	3.7	1.95
	11	53.3	36.7	43.3	7.35	-	14.6	5.2	3.92

Curing experiment

Storage data

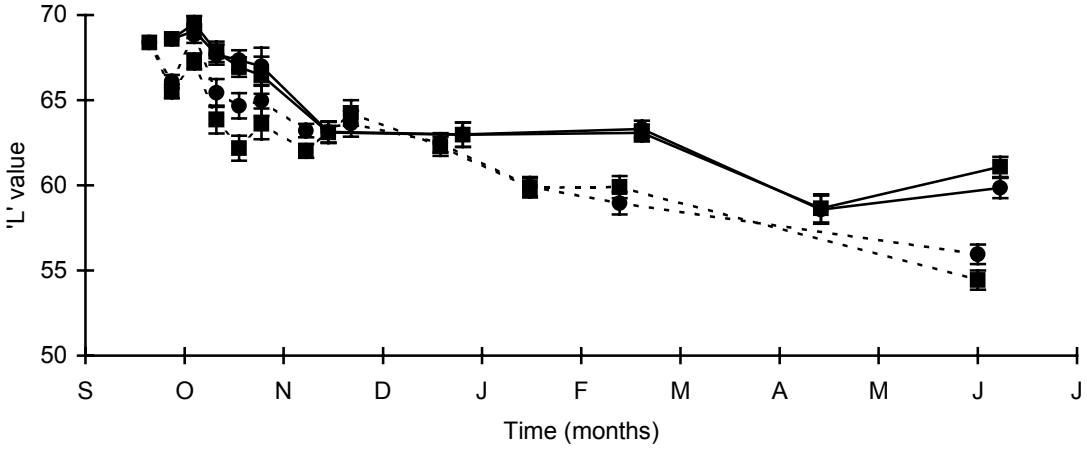
Lady Rosetta

The 'L' value

The 'L' value of Lady Rosetta decreased during storage but the rate of decrease differed between sites (Figure 17). The 'L' value from CUF decreased initially during the first 2 months after intake but was relatively stable from November to February and then decreased again slightly up to May before increasing slightly into June. The 'L' value from CUF remained close to acceptable levels even at the end of storage. The 'L' value from GLE decreased progressively to the end of storage (June). Therefore, after January the 'L' value from CUF was greater than from GLE (Figure 17) and from the end of December onwards the fry colour from GLE was unacceptably dark (<60). On 3 sampling occasions (5, 19 October and 9 November), with tubers from GLE, the 'L' value was slightly greater from curing at a

higher temperature but this was not observed after November or in tubers from CUF (Figure 17). There was no effect of rate of pull down on 'L' value from either site.

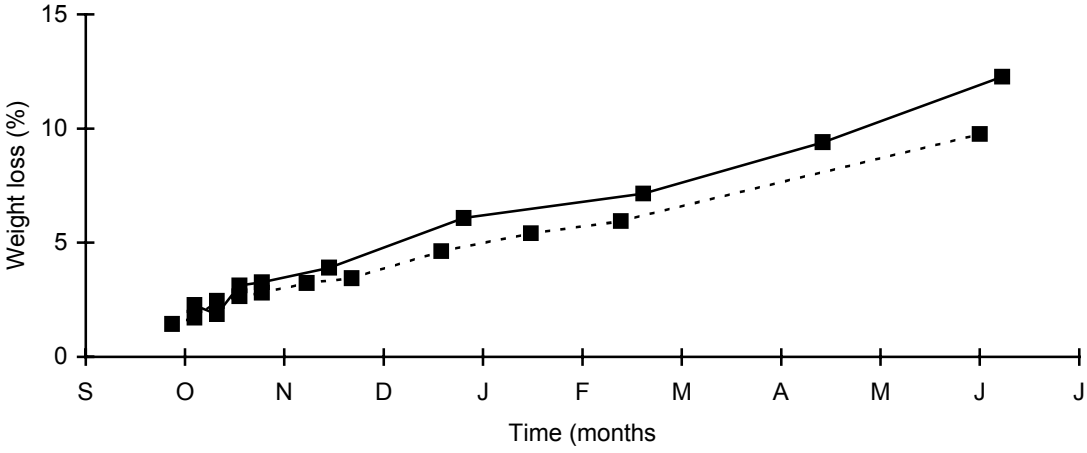
Figure 17. Effect of curing temperature on 'L' value of Lady Rosetta during storage. Cure temp. 12 °C (■), cure temp. 15 °C (●), CUF (solid line), GLE (broken line)



Weight loss during storage

Weight loss of Lady Rosetta increased progressively during storage and was generally less in tubers from GLE than CUF (Figure 18). There were no consistent effects of cure temperature or rate of pull down on weight loss.

Figure 18. Weight loss of Lady Rosetta (cure) during storage. CUF (solid line), GLE (broken line)



Disease and defects

As for the main experiment, with the exception of silver scurf at CUF, there was little disease or defects on the Lady Rosetta tubers. The severity of silver scurf at CUF was greater from curing at 15 °C (storage sample 14 (14 June), 30.4 ± 2.09 % SA affected) than 10 °C (15.2 % SA affected) and increased during storage from 22 February (*c*. 13.1 % SA affected) to 14 June (*c*. 22.8 % SA affected). At both sites the incidence of skin spot increased during

storage from 22 February (CUF 0.5, GLE 1.8 % SA affected) to 14 June (CUF 6.2, GLE 13.3 % SA affected). The incidence of IRS also increased during storage from 22 February (CUF, IRS *c*. 0.3 %; GLE, *c*. 1.3 % of tubers with <10 % SA affected) to 14 June (CUF, *c*. 2.5 %; GLE, *c*. 20.0 % of tubers with <10 % SA affected).

Russet Burbank

'L' value

From both sites, the 'L' value of Russet Burbank decreased initially for 2 months after intake. From GLE, the 'L' value was relatively stable during storage but from CUF the 'L' value increased slightly towards the end of storage (April to June) (Figure 19). The 'L' value from CUF was slightly greater than GLE initially after intake (September to November) and again towards the end of storage (May to June). Initially after intake (September to November) from both sites, curing at a higher temperature increased the 'L' value but this difference was absent after November (Figure 19). At both curing temperatures and from both sites the 'L' value fell below the acceptable value (42) from the end of November, although from CUF the 'L' value increased above the acceptable value towards the end of storage (May to June). From GLE, there was an affect of rate of pull down on the 'L' value during much of the storage period (October to March) where the 'L' value was greater when the temperature had been pulled down at 1 ^{o}C per day rather than straight to holding (Table 24). The same effect of rate of pull down on the 'L' value was only observed from CUF initially after intake (October to November) (Table 24). At neither site was the affect of pull down maintained to the end of storage.

Figure 19. Effect of curing temperature on 'L' value of Russet Burbank during storage. Cure temp. 12 ^{o}C (■), Cure temp. 15 ^{o}C (●), CUF (solid line), GLE (broken line)

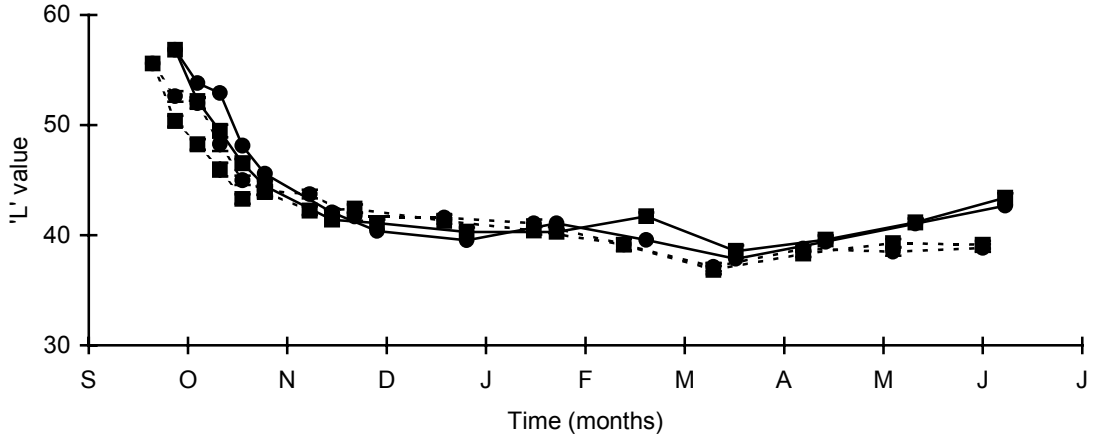


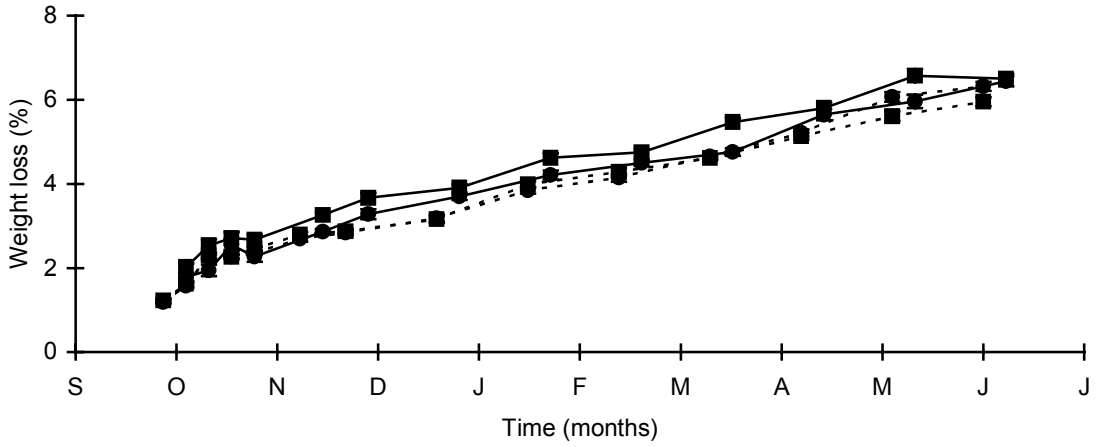
Table 24. Effect of rate of pull down on 'L' value of Russet Burbank during storage

	Storage sample					
Pull down	3	4	5	6	11	14
CUF	19 Oct	26 Oct	2 Nov	16 Nov	22 March	14 June
Straight to holding	45.8	44.0	-	41.2	38.3	43.6
1 °C per day	48.9	46.1	-	42.3	38.1	42.4
S.E.	0.38	0.50	-	0.36	0.51	0.42
GLE	12 Oct	19 Oct	26 Oct	9 Oct	15 March	7 June
Straight to holding	46.1	43.0	43.1	42.4	36.2	39.5
1 °C per day	48.1	45.2	44.8	43.6	37.7	38.5
S.E.	0.61	0.43	0.46	0.39	0.37	0.34

Weight loss during storage

Weight loss of Russet Burbank increased progressively during storage and was similar between sites (Figure 20). Curing at a higher temperature reduced weight loss of tubers from CUF throughout most of storage (October to May) but increased weight loss of tubers from GLE towards the end of the storage (May to June) (Figure 20). Rate of pull down had no effect on weight loss of Russet Burbank during storage.

Figure 20. Effect of cure temperature on weight loss of Russet Burbank during storage. Cure temp. 12 °C (■), cure temp. 15 °C (●), CUF (solid line), GLE (broken line)



Disease and defects

As for the main experiment, there was little disease or internal defects on tubers of Russet Burbank. From both sites, the incidence of skin spot was increased by curing at a higher temperature (Table 25) and increased during storage (Table 25). At the first sample, the severity of silver scurf on tubers from CUF was increased by pull down at 1 °C per day (1.2 ± 0.14 %) as compared to straight to holding (0.8 %) but the difference were not apparent at the second sampling or on tubers from GLE.

Table 25. Effect of curing temperature on incidence of skin spot on Russet Burbank. Storage samples 10 and 14

Cure temperature	CUF		GLE	
(°C)	S10, 22 February	S14, 14 June	S10, 15 February	S14, 7 June
10	0.6	8.1	1.3	15.6
15	5.0	36.2	7.5	71.2
S.E.	1.47	7.10	2.78	5.62

Discussion

In choosing the treatments for this series of experiments it was intended to generate a wide range of field growth patterns which would influence the suitability of the tubers for long-term storage. The range of planting dates which was intended, from early April to mid May, could not be achieved in the extremely wet conditions of late March and the whole of April. As a consequence, the two planting dates were only 14 days apart in May and, by commercial standards, both would be considered late. In combination with the earliest defoliation and harvest the interval from the second planting to defoliation at CUF was extremely short, only 88 days. The periods from emergence and tuber initiation to first defoliation were only 63 days and *c.* 45 days respectively. These crops were therefore somewhat more extreme then intended and would be very rare in practice. These points must be appreciated when considering the results, especially, their commercial relevance.

As the first year of an extensive three-year programme the results in themselves do not have great weight as they explored wider ranges of treatment combinations than hitherto. They should be seen as a part of a larger programme. In general, despite the difficulties of the field season, the results represent a sound data set of desirable accuracy. Some specific points of potential interest and commercial value are already clear.

The results from the field provide some information on factors affecting yield and any relationship to quality during storage. Delaying planting increased number of main stems in both varieties at CUF but this did not increase number of tubers as number of tubers per stem was reduced.

There was little affect of delay in planting on yields at CUF but the two varieties differed considerably in yield. The relatively short growth pattern of Lady Rosetta resulted in modest yields which were increased by delay in harvesting. In contrast, the yields in Russet Burbank were larger and increased more with delay in harvesting as the extensive ground cover allowed bulking to continue during the harvesting period. At GLE delay in planting reduced the yields of both varieties but especially in Russet Burbank. In both varieties yields increased with delay in harvesting. Despite the short growing season dry-matter contents were acceptable at the first harvest and remained so throughout harvesting.

Despite the extremely short season, even the late-planted, early-defoliated crops of both varieties produced very acceptable fry colours at intake and early in the storage season. Generally, the fry colours of such short-season crops decreased more rapidly in storage than from longer season crops (earlier planting or later defoliation and harvesting). This suggests

that in seasons of delayed planting (and 2001 looks like another such season) the later-planted crops should be processed first.

The two varieties differed in their response to delayed harvesting and holding temperature. In Lady Rosetta, the effect of delaying harvest was relatively small although fry colour was usually lighter (higher L value) from the later harvests throughout storage at both holding temperatures. In Russet Burbank, there was a larger and more consistent improvement in fry colour with delay in harvesting throughout storage. The effect was most clear at Gleadthorpe (Figure 14). It would appear that length of growing season may be a more significant factor in the storage programme of Russet Burbank than Lady Rosetta. The effect of holding temperature was also larger in Russet Burbank than Lady Rosetta with significantly darker chips from 7 ^{o}C than 10 ^{o}C throughout storage. At both temperatures, Russet Burbank maintained a fry colour for long periods (e.g. Figure 13) while there was considerable variation in the data for Lady Rosetta.

There were large and commercially important differences in weight loss of the two varieties between the two sites. Weight loss in tubers from CUF was substantially greater than from GLE and in commercial terms would be considered excessive. The weight loss from GLE tubers would be considered very low. The differences between the sites were much larger than any effects of treatments and in view of the standardised storage regimes it is not possible to offer any explanation. Such ranges have been found previously in experiments studying timing of defoliation and harvesting at different sites, most notably in the PMB storage work reported by Wilcockson *et al* (1985). In that extensive range of experiments at 5 sites the range in weight losses from upto 31 weeks of storage is shown in Table 26. In all cases, the range is similar to that reported here for two other varieties. In all cases, Wilcockson *et al* (1985) concluded that weight loss in store was reduced when defoliation occurred on a senescing canopy and differences between experimental treatments and sites could be explained by this association. This explanation may hold in the current experiments as the canopy of Lady Rosetta at GLE was almost senesced at the onset of defoliation and that of Russet Burbank was senescing. In contrast at CUF both varieties were close to full ground cover at the beginning of defoliation and for Russet Burbank remained so during defoliation. As no detailed recording of leaf appearance and senescence were taken it is not possible to further quantify the extent of leaf (and crop) senescence for Russet Burbank but it may be taken that leaf senescence was accelerating. These effects would suggest that crop senescence at defoliation has a considerable effect on weight loss in store and effort should be directed towards managing the extent of the canopy more directly. These differences in weight loss

between sites were also associated with generally lower and more rapidly decreasing L values at GLE. In commerce, the gross state of the canopy is generally taken to be informative about the storage potential in more direct quality terms but this may be exaggerated. The lack of any substantial effects of defoliation, also found by Wilcockson *et al* (1985) in Pentland Crown, suggests that, in general, over 2-3 weeks the tubers do not change significantly, either in processing quality or potential weight loss.

Table 26. The range of total weight loss (%) in store recorded for undamaged samples of tubers

Year	Duration of storage (weeks)	Total weight loss (%)
1976	30	5.5-16.3 (5.5-16.3)*
1977	31	6.3-16.1 (6.0-15.5)
1978	25	5.7-10.8 (6.9-13.1)
1979	25	6.1-9.7 (7.3-11.8)
1980	26	5.4-13.1 (6.2-15.1)

* Figures in parentheses are the estimated values for a 30-week storage period, assuming a constant rate of total weight loss. Wilcockson *et al* 1985.

The curing experiments did not generate large effects and only in Russet Burbank were there any indications of an effect of rate of pull-down. This was not maintained throughout storage.

There were relatively few diseases at low levels present in the stored tubers. The data can only be interpreted at the end of this whole programme.

Reference

Wilcockson, S. J., Allen, E .J., Scott, R. K. & Wurr, D. C. E. Effects of crop husbandry and growing conditions on storage losses of Pentland Crown potatoes. *Journal of Agricultural Science, Cambridge* 1985, **105**, 413-435.

