Grower Collaboration Project

Project Ref: R295

Preface

The Grower Collaboration project began in 2007. At the time, it was considered that the value of research findings for improving potato production was questioned by some levy payers. An example quoted was the uptake of the findings from research on seed physiology and crop uniformity. It was proposed that uptake would benefit from the direct involvement of researchers with the grower(s) and vice versa and taking a whole system approach, as few improvements result from a single change or addition to the existing system.

The project was established to facilitate direct interaction between researchers and groups of growers to plan the agronomic components of their production system, utilising any new information arising from research work, and to document the process and any differences from previous practice. This was applied to approx. 20% of the participating growers' production and the aim was to record the changes made and the outcomes. The host growers provided demonstration sites for field visits, to allow a larger number of growers to see the progress of the initiative. Overall, the project was a mechanism of knowledge transfer that scales-up results from small-plot research to larger scale (e.g. split-field) demonstrations of principle. It involved collaboration, between NIAB-CUF, the levy board (Potato Council which subsequently became AHDB), growers and their agronomists and other supply-chain partners.

The participating growers/groups are summarised below. The details of the crops and their agronomy are provided in the individual annual reports. Reports for 2007 to 2012 (inclusive) have been collated to produce the main body of this report. Reports for 2013 and 2014 are provided as separate pdfs.

- 2007: North Norfolk Potato Growers (NNPG), Strawson Farming, South West Agronomy Group (SWAG) and W.B. Daw.

- 2008 and 2009: North Norfolk Potato Growers (NNPG), Strawson Farming, South West Agronomy Group (SWAG), Mease Valley Potatoes and Tame Valley Potatoes (MVP/TVP) and A H Worth & Co.
- 2010: Branston Holdings Ltd, The Co-operative Farms, South West Agronomy Group (SWAG), R S Cockerill Ltd and A H Worth & Co.
- 2011: Branston Holdings Ltd, The Co-operative Farms, South West Agronomy Group (SWAG), RS Cockerill Ltd and McCain Foods Ltd.
- 2012: Branston Holdings Ltd, The Co-operative Farms, RS Cockerill Ltd and McCain Foods Ltd.
- 2013: McCain Ltd., Frederick Hiam Ltd. and Three Musketeers Ltd.
- 2014: Frederick Hiam, Ltd., Three Musketeers Ltd., Robin Baines and WB Daw and Son.

The 2014 report includes an economic analysis of the Standard and Modified agronomies (2007-2014 inclusive). Paired comparisons of N application rates were only included in the analysis if the 'standard' and 'improved' crops had similar plant populations (within 10 % of each other). Comparisons of seed rates were only included if the achieved standard and modified seed rates were within 10 % of those intended and the achieved and modified seed rates differed by more than 10 %. A paired 'T' test was then used to determine whether, on average, the Modified agronomies resulted in a statistically significant increase in crop value.

Nitrogen rates

In total, there were 22 valid comparisons that compared standard with reduced N application rates and the average reduction in N application rate was 28 kg N/ha. On average, reducing the N application rate was associated with a small, but statistically significant, increase in the tuber population > 10 mm. Analysis showed that this increase was mainly due to an increase in the number of tubers initiated and retained on each main stem rather than an effect of the reduced N applications on plant or stem population.

On average, reducing the N application rate from 196 to 168 kg N/ha was associated with a statistically significant increase in yield from 56.4 to 61.8 t/ha. The economic analysis showed that, on average, due to the reduction in N usage and the increase in marketable yield there was a statistically significant increase in crop value of £614/ha when less N had been applied. The increase in margin was partly due to the savings in N fertilizer (c. £25/ha) but a much larger component was due to the increase in marketable yield as a direct result of an increase in total yield. This increase in yield is consistent with modest reductions in N input having relatively little effect on canopy persistence, radiation absorption and total dry matter production but having significant effects on the partitioning of dry matter allocation between haulm and tubers.

Seed rates

In total there were 41 valid comparisons of standard and reduced seed rates. The most common reason for paired comparisons to be omitted from the analysis was too large a difference between achieved and intended plant populations or too small a difference between the achieved plant populations in the standard and reduced seed rate crops. For the valid comparisons, the average reduction in seed rate was from 2.34 to 1.91 t/ha. Reducing the seed rate, reduced the total tuber population from 549 000 to 493 000/ha and this effect was highly significant. However, average total tuber FW yields were almost identical when grown using the standard or reduced seed rates. Economically, crops produced using the reduced seed rates had a larger margin over seed and N costs than the standard crops, although the increase was not statistically significant. The effects of reduced seed rate on the increase in crop value were relatively small and this may have been a consequence of the dataset being dominated by processing or ware varieties (where crop value is primarily driven by yield > 40 mm and where over-size tubers have some value, albeit at stock-feed prices).

Report for 2009 and 2007-2009 summary

D M Firman & M F Allison

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Overall summary of Grower Collaboration 2007-2009

Between 2007 and 2009, data were collected for crops grown with standard practice or with modified seed or N application rates and in 31 cases valid comparisons between the standard and modified agronomy were made. Despite the inherent statistical limitations of this kind of comparison, sufficient data have now been collected so that some statistical tests can be done. These tests indicated that where crops were grown with smaller seed or N application rates than standard practice, similar yields were produced. At present, there are insufficient data to test the benefit of increased seed rates in a similar way. Whilst this project has demonstrated opportunities to reduce inputs when compared with standard agronomy, in many cases differences between the standard and modified agronomy were too small to provide worthwhile comparisons and in many cases opportunities for the collaborating growers to improve practice substantially were more limited. For several crops there was essentially no difference between the standard and modified agronomy indicating that, for these crops, growers were successfully following current recommendations.

An objective of this project was to ensure, as far as possible, that growers and agronomist were responsible for setting realistic targets for their crops and providing the initial set up data to CUF. In general, this was done well and most growers were able to supply seed crop emergence dates so that the appropriate seed rates could be calculated. In several cases, seed rate comparisons were unsatisfactory since the achieved spacings (in the standard and or modified) crops were too dissimilar from the intended. This shows that the implementation of best practice is sometimes limited by practical constraints (*e.g.* planter operation). However, more importantly, this work shows the importance of crop recording so that these problems can be identified and corrective measure implemented.

Where standard and modified N comparisons were done in the same field as replicated N response experiments, crop data suggested that the modified N application rates were *c.* 30 kg N/ha in excess of the optimum for those crops and thus the probability of yield reductions at the modified N application rates were small. Collectively, many crops (comparing both N and seed rates) were defoliated at complete or near-complete ground cover and this also implies that they were well supplied with N. Future work within the Grower Collaboration project might also include comparison of irrigation strategy, modifications to P and K application rates and investigations of the effects of modified agronomy on tuber quality (*e.g.* severity of black dot or fry colour).

Introduction

This is the third year of the project and its objectives were to collaborate with growers in planning the agronomic components of their potato production systems utilising current agronomic knowledge and documenting the process and differences from previous practice. The project

aims to examine the accuracy of the agronomic decisions in relation to crop growth, potential yield and timing of harvest, meeting irrigation requirements and other criteria. Collaboration was undertaken with the following growers and grower groups: North Norfolk Potato Growers (NNPG), Strawson Farming, South West Agronomy Group (SWAG), Mease Valley Potatoes and Tame Valley Potatoes (MVP/TVP) and A H Worth & Co.

Materials and Methods

Information on cropping plans, including varieties, seed stocks, intended planting date and yield, target tuber size, seed rates, soil data and fertilizer application rates, was obtained from collaborating growers. Fertilizer and seed rate recommendations were calculated for some of the crops using the information supplied. The dates of seed crop emergence and ware crop planting were factors accounted for in determining CUF seed rate recommendations but these were not used by growers to determine their 'standard' seed rates (except for SWAG growers already using CUF advice). Cases where the current 'standard' grower's plans differed substantially (*i.e.* by at least 10 %) from recommendations based on the best information available to CUF were identified and opportunities for making comparisons of 'standard' with 'CUF modified' recommendations discussed. In each case, generally a width of *c.* 24 m within a field received modified agronomy whilst standard agronomy was applied to the rest of the field. These unreplicated comparisons are not experiments and their limitations must be appreciated in regard to any confounding influences on the results and the variation associated with estimates of the variates recorded, particularly of crop samples from limited areas. In other cases, even where there were no substantial differences between 'standard' and 'CUFmodified' recommendations, crops were identified with a view to recording performance in relation to agronomic inputs and environmental conditions. Opportunities for additional experiments and data collection were discussed and a nitrogen fertilizer experiment was conducted at one site. A set of protocols and templates for data recording were sent to growers for recording the appropriate data on the crops so that each grower could collect data and send updates to CUF during the season. Staff from CUF visited most of the crops following establishment and some data were collected during these visits to complement data collected by growers. Emergence, ground cover and yield data were usually collected from three or four replicate areas. To complement meteorological data available for the sites, data from a calibrated pyranometer (Campbell CS300) installed at each site was collected on a logger (Tiny-Tag RE-ED) to provide daily total incident radiation data.

Results and Discussion

Sites and monitored crops

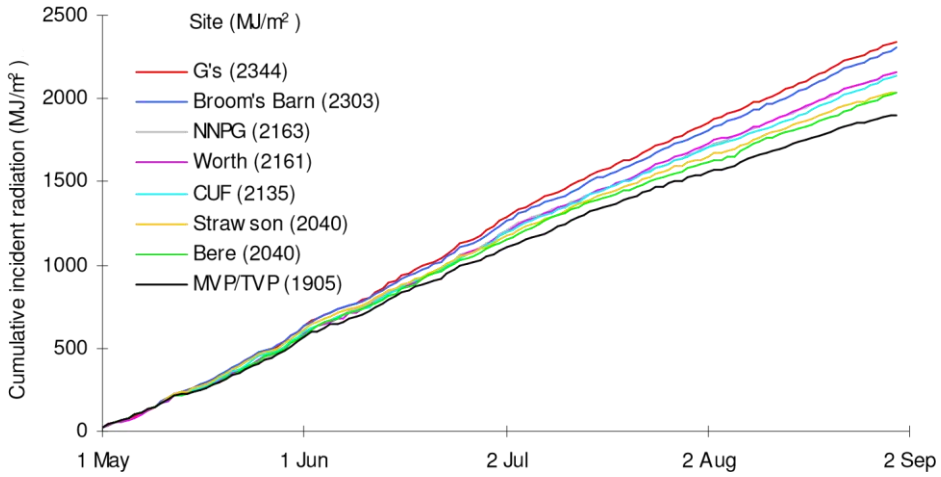
In 2009 a total 32 crops were monitored and key details for these crops are shown Table 1. For some crops the 'standard' was used for comparisons against modified seed and modified N rates.

Table 1. Summary of crops monitored as part of PCL/CUF grower collaboration program in 2009

Grower group	Sector	Varieties in program	Number of seed rate comparisons	Number of N rate comparisons
A H Worth	Fresh	Estima & Maris Piper	2	1
MVP/TVP	Processing	Lady Rosetta, Maris Piper & Markies	2	2
SWAG	Fresh	Estima, Marfona Maris Piper	No comparisons	
NNPG	Processing	Hermes & Saturna	3	2
Strawson	Processing	Hermes & Saturna	1	2

Cumulative (May to August) incident radiation for CUF, Broom's Barn (Higham, Suffolk) and the five grower collaboration sites is shown in (Figure 1). Incident radiation from an extra site, G's (Ely, Cambridgeshire) is included for reference. Missing data (caused by the logger overwriting previous records or not logging by 1 May) were replaced with data from the nearest available sites. In comparison with 2008, sites at CUF, NNPG, Strawson and Worth were slightly brighter in 2009 but the site at MVP/TVP was slightly duller. The difference between the brightest Grower Collaboration site (A H Worth) and dullest (MVP/TVP) site was 260 MJ/m^2. This difference should have had a relatively small effect on yield production as the rate of establishment and maintenance of complete ground cover generally has much larger effects.

Figure 1. Cumulative incident radiation May-August 2009 at Cambridge, Broom's Barn and collaboration sites.



A H Worth

Opportunities to compare modified and standard crops were identified from details of cropping plans for two seed sizes of Estima at one site (JEP 44) and one crop of Maris Piper (Field 38). The Estima seed crop emerged on 15 June and opportunities to compare modified crops with reduced seed rates for both seed sizes (35-45 and 45-55 mm) were identified. A smaller modified nitrogen rate in the Maris Piper was also identified for potential comparison. Thus in 2009, the plan was to compare standard and modified seed rate for two seed sizes of Estima at one site and standard and modified N applications to Maris Piper at another site.

Estima seed rate comparison

Small (35-45 mm) seed

Both the standard and modified crops of small-seed Estima achieved 50 % plant emergence on 17 May (48 days after planting). Harvest data showed that for both the standard and modified crops the achieved plant densities were less than intended and the difference in plant population between the standard and modified crops was small (Figure 2). The ground cover curve was similar for both the standard and modified crop, although there was some evidence that ground cover expansion was slower in the modified crop planted at a slightly wider spacing. At final harvest on 21 August, both total tuber FW yield and tuber yield greater than 40 mm were numerically larger in the standard area when compared with the modified area. However, these yield differences cannot be attributable to differences between the intended standard and modified plant populations as the actual achieved spacings were very similar. The target yield and mean tuber size for this crop was 65 t/ha and 65 mm, respectively. Neither the standard nor modified crop achieved the target yield but both crops achieved a mean tuber size close to the intended.

Large (45-55 mm) seed

When grown from large seed, both the standard and modified crops of Estima achieved 50 % plant emergence on 15 May (46 days after planting) and the achieved plant density was close to intended for both standard and modified crops (Figure 3). Ground cover expansion was similar in both crops, both achieved complete ground cover and the pattern of crop senescence was similar irrespective of planting density. At final harvest, total yields and yield greater than 40 mm were similar in both the standard and modified areas of crop and both crops exceeded the target yield of 65 t/ha. The mean tuber size of both crops was close to the intended (65 mm) but was greater in the modified crop than the standard consistent with a smaller tuber population.

Maris Piper N rate comparison

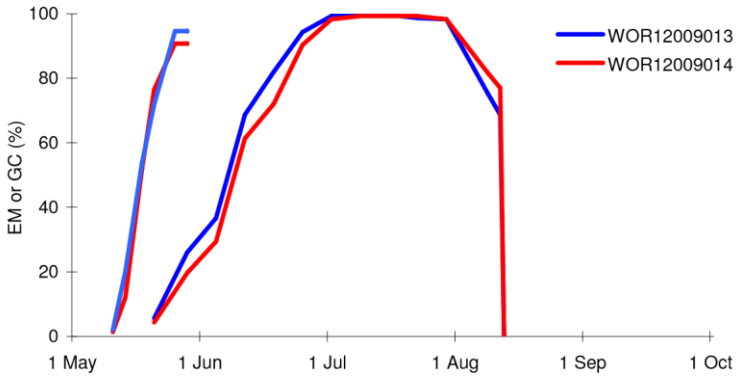
This comparison was done in Field 38 where the previous crop was peas and thus where amounts of residual N were expected to be moderately high. The crop of Maris Piper was planted on 4 April and 50 % plant emergence was achieved on 6 May (32 days after planting). The intended plant population for both the standard and modified N crop was 27 700/ha and whilst this was achieved in the modified crop, the population in the standard area was slightly smaller (Figure 4). Ground cover expansion appeared to be slower in the modified crop but both standard and modified crops achieved complete ground cover and both crops started to senesce in mid- to late August. The intended yield for this crop was 65 t/ha and both crops exceeded this. Numerically, both total yield and yield greater than 40 mm in the modified area were larger than in the standard area but this difference is unlikely to be due to the reduced N application rate. Both crops achieved a mean tuber size of *c.* 65 mm and this was larger than the intended mean tuber size (60 mm).

Analysis of crop performance using the CUF yield model

Using recorded emergence, ground cover and yield data and daily values for incident solar radiation, the CUF yield model produced estimates of total tuber FW yield at defoliation. The average yield sampled at defoliation was 66 t/ha compared with a modelled, average tuber yield of 65 t/ha. For four of the six crops there was good agreement between the modelled yield at the end of the season and the sampled yield (Figure 5). The two exceptions were the Maris Piper crop that received the standard amount of fertilizer (180 kg N/ha) where the sample yield was greater than the model and for the modified seed rate, small Estima, where the sample yield was smaller than modelled. The generally good agreement between modelled and sampled yield suggests that the growth of these crops was not unduly affected by factors such as drought stress, water logging or disease since these factors are not explicitly included within the CUF yield model. These data also suggest that the CUF yield sample in the standard Maris Piper crop may have overestimated the true yield whilst the yield dig in modified, small Estima may have underestimated the true yield.

Figure 2. A H Worth Estima seed rate comparison, small seed (35-45 mm) JEP 44.

Grower:	Worth Farms	Worth Farms
Field name:	JEP44	JEP44
Unique ID:	WOR12009013	WOR12009014
Part Field Name:	Small Standard Seed and Standard N	Small Modified Seed and Standard N
Variety:	Estima	Estima
Intended yield:	65 t/ha	65 t/ha
Intended use:	Bakers	Bakers
Intended mu (μ):	65 mm	65 mm
Planting date (start):	30 Mar	30 Mar
Date of 50 % emergence:	17 May	17 May
Total N applied:	200 kg N/ha	200 kg N/ha
Seed size:	35-45 mm	35-45 mm
Seed count:	1044 per 50 kg	1044 per 50 kg
Planned density:	50.8 000/ha	45.4 000/ha
Planned spacing:	21.5 cm	24.1 cm
Achieved density:	46.9 000/ha	44.2 000/ha
Achieved spacing:	23.3 cm	24.7 cm



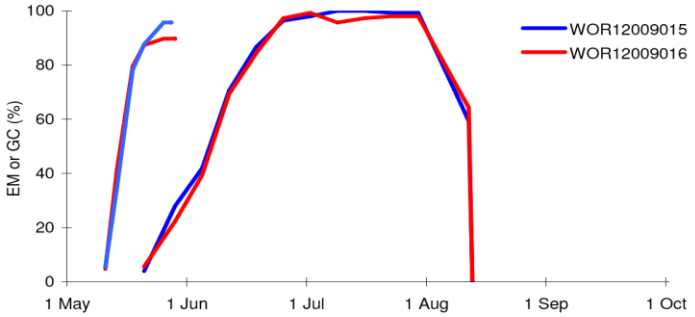
Yield Samples (S.E. in italics)

		Small Standard Seed and Standard N			Small Modified Seed and Standard N	
		16 Jul	21 Aug		16 Jul	21 Aug
		43.7	50.1		45.6	42.8
		1.49	*1.75*		*1.05*	*0.91*
Stems (000/ha)		89.3	90.2	> 10 mm	87.5	82.9
		9.59	*8.20*		*11.53*	*6.02*
Stems/plant		2.0	1.8	> 40 mm	1.9	1.9
		0.18	*0.17*		*0.28*	*0.14*
Tubers (000/ha)		381	373	> 10 mm	381	332
		43.7	*11.0*		*31.7*	*20.5*
Tubers (000/ha)	> 10 mm	270	305	> 40 mm	284	269
		23.1	*6.0*		*12.2*	*10.5*
Tuber yield (t/ha)	> 40 mm	42.3	60.1		42.0	55.2
		2.45	*2.08*		*0.82*	*1.14*
Tuber yield (t/ha)	> 10 mm	40.1	58.7		40.2	54.0
		2.12	*2.02*		*0.46*	*1.12*
DM (%)	> 40 mm	19.6	19.9		19.7	19.8
		0.15	*0.31*		*0.17*	*0.27*
Mean tuber size (mm)		58.0	62.9		56.8	63.0
		0.61	*0.53*		*0.81*	*0.58*

Plants (000/ha)

Figure 3. A H Worth Estima seed rate comparison, large seed (45-55 mm) JEP 44.

Grower:	Worth Farms	Worth Farms
Field name:	JEP44	JEP44
Unique ID:	WOR12009015	WOR12009016
Part Field Name:	Large Standard Seed and Standard N	Large Modified Seed and Standard N
Variety:	Estima	Estima 65 t/ha
Intended yield:	65 t/ha	Bakers
Intended use:	Bakers	65 mm
Intended mu (μ):	65 mm	
Planting date (start):	30 Mar	30 Mar
Date of 50 % emergence:	15 May	15 May
Total N applied:	200 kg N/ha	200 kg N/ha
Seed size:	45-55 mm	45-55 mm
Seed count:	532 per 50 kg	532 per 50 kg
Planned density:	36.4 000/ha	30.7 000/ha 35.6 cm
Planned spacing:	30.0 cm	31.0 000/ha
Achieved density:	37.4 000/ha	
Achieved spacing:	29.3 cm	35.3 cm

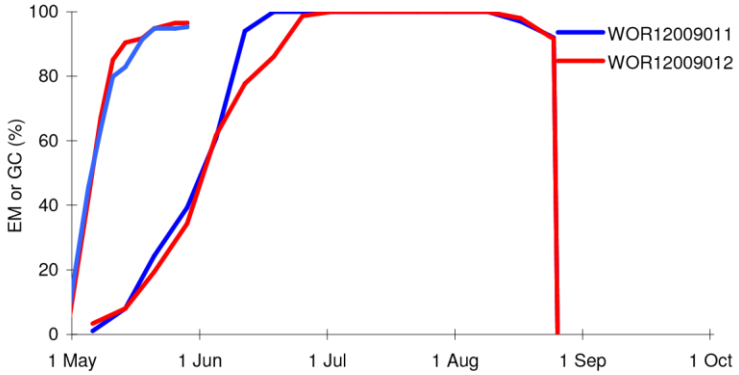


Yield Samples (S.E. in italics)

		Large Standard Seed and Standard N			Large Modified Seed and Standard N	
		16 Jul	21 Aug		16 Jul	21 Aug
Plants (000/ha)		39.2	35.5		31.0	31.0
		2.29	*0.91*		*2.35*	*1.05*
Stems (000/ha)		93.0	94.8	> 10 mm	80.2	84.8
		6.74	*3.94*		*3.33*	*4.56*
Stems/plant		2.4	2.7	> 40 mm	2.6	2.7
		0.05	*0.05*		*0.12*	*0.09*
Tubers (000/ha)		401	417	> 10 mm	361	360
		37.4	*12.8*		*32.7*	*15.7*
Tubers (000/ha)	> 10 mm	304	326	> 40 mm	284	294
		21.1	*15.1*		*20.7*	*11.3*
Tuber yield (t/ha)	> 40 mm	45.0	67.8		45.1	66.2
		3.24	*2.39*		*1.88*	*4.33*
Tuber yield (t/ha)	> 10 mm	43.3	65.8		43.6	65.1
		3.24	*2.44*		*1.83*	*4.44*
DM (%)	> 40 mm	19.4	19.2		19.5	20.2
		0.48	*0.45*		*0.16*	*0.48*
Mean tuber size (mm)		57.1	64.2		58.7	66.0
		0.99	*0.20*		*1.04*	*1.78*

Figure 4. A H Worth Maris Piper nitrogen rate comparison, Field 38.

Grower:	Worth Farms	Worth Farms
Field name:	F38	F38
Unique ID:	WOR12009011	WOR12009012
Part Field Name:	Standard Seed and Standard N	Standard Seed and Modified N
Variety:	Maris Piper	Maris Piper
Intended yield:	65 t/ha	65 t/ha
Intended use:	General Ware	General Ware
Intended mu (µ):	60 mm	60 mm
Planting date (start):	4 Apr	4 Apr
Date of 50 % emergence:	6 May	6 May
Total N applied:	180 kg N/ha	155 kg N/ha
Seed size:	40-50 mm	40-50 mm
Seed count:	678 per 50 kg	678 per 50 kg
Planned density:	27.7 000/ha	27.7 000/ha
Planned spacing:	39.5 cm	39.5 cm
Achieved density:	26.0 000/ha	27.3 000/ha
Achieved spacing:	42.1 cm	40.0 cm

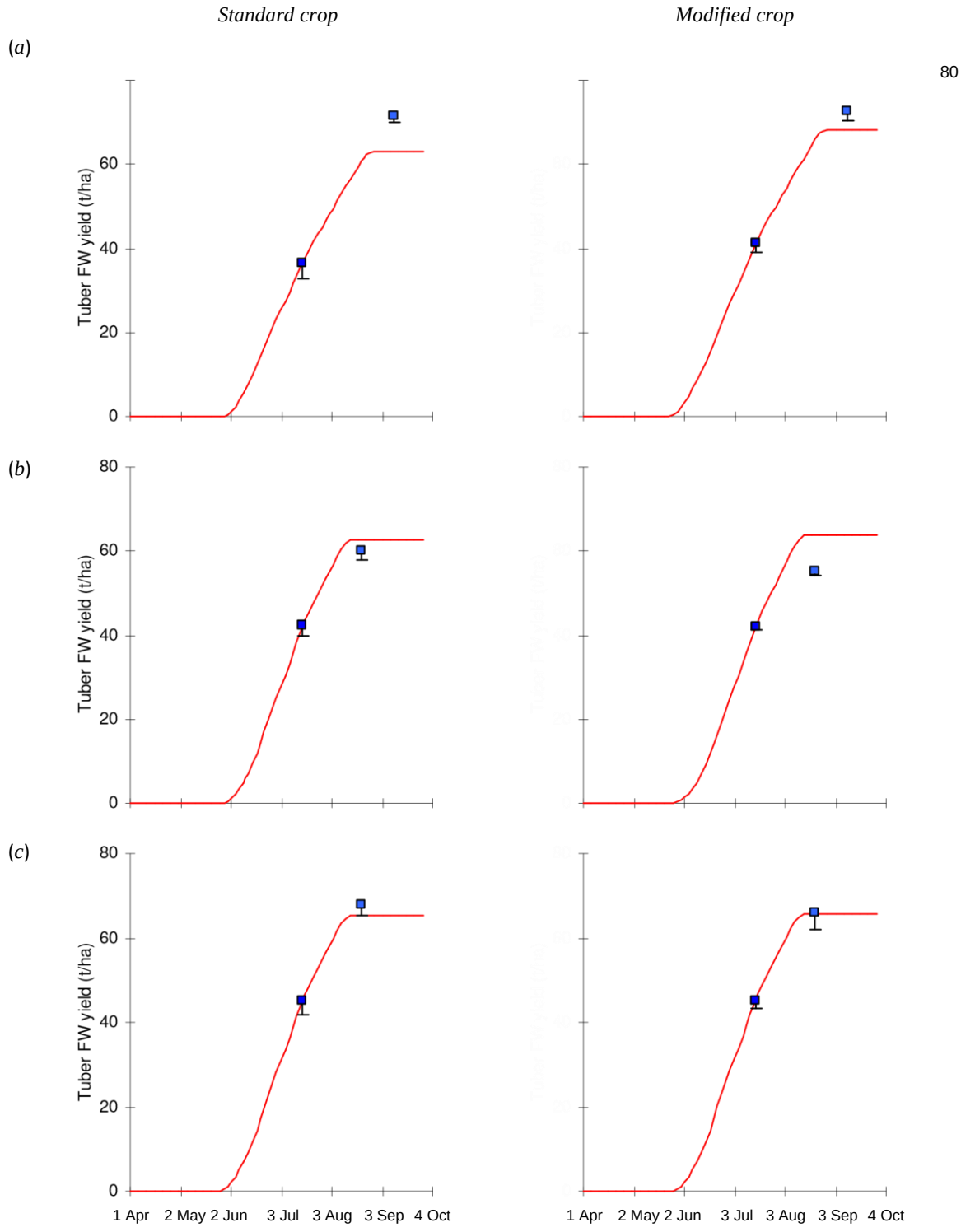


Yield Samples (S.E. in italics)

		Standard Seed and Standard N			Standard Seed and Modified N	
		16 Jul	10 Sep		16 Jul	10 Sep
		25.5	26.4		27.3	27.3
		0.00	*0.91*		*1.82*	*1.05*
Stems (000/ha)		113.0	130.3	> 10 mm	132.1	131.2
		2.10	*10.02*		*5.64*	*12.97*
Stems/plant		4.4	4.9	> 40 mm	4.9	4.8
		0.08	*0.40*		*0.25*	*0.30*
Tubers (000/ha)		354	377	> 10 mm	402	409
		22.0	*28.7*		*36.3*	*28.5*
Tubers (000/ha)	> 10 mm	250	307	> 40 mm	309	327
		25.7	*22.2*		*24.6*	*20.7*
Tuber yield (t/ha)	> 40 mm	36.4	71.4		41.3	72.6
		3.72	*1.29*		*2.14*	*2.21*
Tuber yield (t/ha)	> 10 mm	33.9	69.8		39.0	70.7
		3.90	*1.18*		*1.81*	*2.44*
DM (%)	> 40 mm	19.8	23.3		20.4	24.6
		0.22	*1.07*		*0.30*	*0.83*
Mean tuber size (mm)		53.9	66.1		53.5	65.2
		0.80	*1.01*		*0.78*	*2.08*

Plants (000/ha)

Figure 5. Comparison of model output (red line) and yield samples (blue symbol ± 1 S.E.) for standard and modified crops of (*a*) Maris Piper, (*b*) Estima 35-45 mm and (*c*) Estima 45-55 mm.



Yield digs by A H Worth

In addition to crop samples taken by CUF, staff from A H Worth took yield samples from the standard and modified Estima grown from small or large seed on three occasions during the course of the season. These data are summarised in Table 2. Consistent with CUF data, for the

small Estima, the Worth data show that for both the standard and modified crops the plant populations were smaller than intended and not very different from each other. The Worth estimate for the total yield of the small standard crop (58.0 t/ha) was similar to that found in the corresponding CUF yield dig (60.1 t/ha). However, for the small modified crop the estimate of total yield from Worth was smaller than that of CUF (49.9 compared with 55.2 t/ha, respectively). For the larger seed, the Worth yield sample suggested that there was also little difference in plant population between the standard and modified crops. At final harvest, the Worth samples suggest that total yields in the standard and modified areas were similar and, on average, they were similar to the yields resulting from the CUF samples.

Table 2. A H Worth Estima seed rate comparison (*a*) small (35-45 mm) seed and (*b*) large seed (45-55 mm), JEP 44

(*a*) Yield Samples (S.E. in italics)

		Small Standard Seed and Standard N				Small Modified Seed and Standard N		
		29 Jul	10 Aug	4 Sep		29 Jul	10 Aug	4 Sep
Plants (000/ha)		41.7	38.3	38.3		35.0	36.7	33.3
		1.67	*1.67*	*1.67*		*0.00*	*1.67*	*1.67*
Stems (000/ha)		103.3	98.3	98.3		90.0	86.7	90.0
		15.90	*3.33*	*9.28*		*12.58*	*4.41*	*5.77*
Stems/plant		2.5	2.6	2.6		2.6	2.4	2.7
		0.27	*0.10*	*0.14*		*0.36*	*0.21*	*0.22*
Tubers (000/ha)		368	347	308		295	290	282
	> 0 mm	*41.5*	*19.6*	*1.7*	> 0 mm	*28.4*	*10.0*	*25.9*
Tuber yield (t/ha)		50.0	58.0	52.9		44.0	53.5	49.9
	> 0 mm	*2.18*	*3.06*	*0.87*	> 0 mm	*1.44*	*1.15*	*3.06*

(*b*) Large Yield Samples (S.E. in italics)

		Standard Seed and Standard N				Large Modified Seed and Standard N		
		29 Jul	10 Aug	4 Sep		29 Jul	10 Aug	4 Sep
Plants (000/ha)		25.0	31.7	30.0		25.0	31.7	30.0
		0.00	*1.67*	*2.89*		*0.00*	*1.67*	*0.00*
Stems (000/ha)		98.3	88.3	123.3		81.7	83.3	101.7
		7.26	*12.02*	*26.03*		*7.26*	*6.01*	*4.41*
Stems/plant		3.9	2.8	4.1		3.3	2.6	3.4
		0.29	*0.39*	*0.72*		*0.29*	*0.06*	*0.15*
Tubers (000/ha)		390	322	358		328	307	332
	> 0 mm	*32.5*	*38.4*	*27.4*	> 0 mm	*6.0*	*15.9*	*36.6*
Tuber yield (t/ha)		54.8	52.6	62.8		51.0	56.5	59.9
	> 0 mm	*1.92*	*1.71*	*3.73*	> 0 mm	*2.08*	*2.36*	*2.56*

Commercial yields of Estima

At commercial harvest of the Estima crop a record was made of the number of boxes harvested from the standard and modified areas from both the small and large seed stock. From estimates of average box weights and planted areas it is possible to estimate the gross, commercially harvested yield (Table 3). Compared with the estimates of gross commercial yield, the Worth yield samples were reasonably close, whilst the CUF yield samples and CUF yield model tended to overestimate the commercially achieved yield. However, the estimation of commercially-harvested yield, i.e. the final output against which yield samples are compared, may also be prone to error. For example, a small proportion of tubers will fall through the webs at harvest and will not be accounted for. Likewise, the conversion of a boxcount to a tonnage relies on an estimate of how full each box is and an estimate of the weight of tubers in each box. Finally, field yield estimates require an accurate value for the planted area and this may be

problematic with small, irregularly-shaped cropped area. For the small Estima seed, the ground cover data and stem populations (Figure 2) suggest there was little real difference between the standard and modified areas, however, the commercial yield and sample digs suggest the total yield in the modified area was numerically smaller. Furthermore, the Worth yield digs suggest the modified area had a larger proportion of yield > 65 mm whereas the CUF samples showed no difference. For the large Estima seed, both the Worth and CUF yield digs showed that the modified area had a larger proportion of tuber yield > 65 mm. In conclusion, data from the small seed comparisons have been excluded from the summaries shown on page 48 since the achieved plant population was different from that intended. The comparisons for the large seed have been included. The differences between sampled yields, modelled yields and achieved yields may be due to combinations of field variability and insufficient sampling or poor estimates of commercial yield.

Table 3. Estimate of gross commercial yield of Estima in JEP 44 and comparison with estimate of yield from Worth and CUF yield samples and the CUF yield model

	Small (35-45 mm) seed		Large (45-55 mm) seed	
	Standard	Modified	Standard	Modified
Planted area (ha)	3.27	1.23	0.77	0.82
Estimate of total production (t)	190.1	66.1	47.4	45.7
Estimate of total yield (t/ha)	58.1	53.8	61.6	55.8
Worth yield samples (t/ha)	58.0	49.9	62.8	59.9
Worth yield samples > 65 mm (%)	39.4	49.6	48.1	54.0
CUF yield samples (t/ha)	60.1	55.2	67.8	66.2
CUF yield samples > 65 mm (%)	43.7	43.6	47.8	52.1
CUF yield model (t/ha)	62.6	63.6	65.3	65.8

Effect of N application rates on yields of Maris Piper grown on a silt-textured soil

Introduction

This experiment was designed to complement the PCL Grower Collaboration Project comparisons of "grower" and "CUF Modified" N application rates in a crop of Maris Piper grown by A H Worth at Holbeach Hurn.

Materials and Methods

The experiment was done in Field 38 on land farmed by A H Worth, Holbeach Hurn, Lincolnshire (Ordnance Survey Grid Reference TF408295) and tested the effects of N application rate (0, 50, 100, 150, 200, 250 and 300 kg N/ha) on the growth and yield of Maris Piper. Each treatment was replicated five times and allocated at random to blocks. The experimental area received 100 kg P_2O_5/ha and 490 kg K_2O/ha as part of the standard farm practice but no N fertilizer was applied. Each plot was 5 m long and 4 rows (3.66 m) wide and Maris Piper seed (SE2, 40–50 mm, average weight 73.7 g) was planted by hand-dibbing into pre-formed ridges on 9 April. Within-row spacing was 40 cm and this gave an intended plant population 27 340/ha. Nitrogen was applied as ammonium nitrate (34.5 % N) in a single dose at planting and was then shallowly incorporated into the soil by raking. Emergence and ground covers were measured intermittently by CUF staff during the course of the season and a single harvest was taken on 10 September. At this harvest, 10 plants were dug from the two centre rows of each four-row plot leaving at least 1 m discard at the ends of each harvested area The number of stems was counted and all tubers > 10 mm were

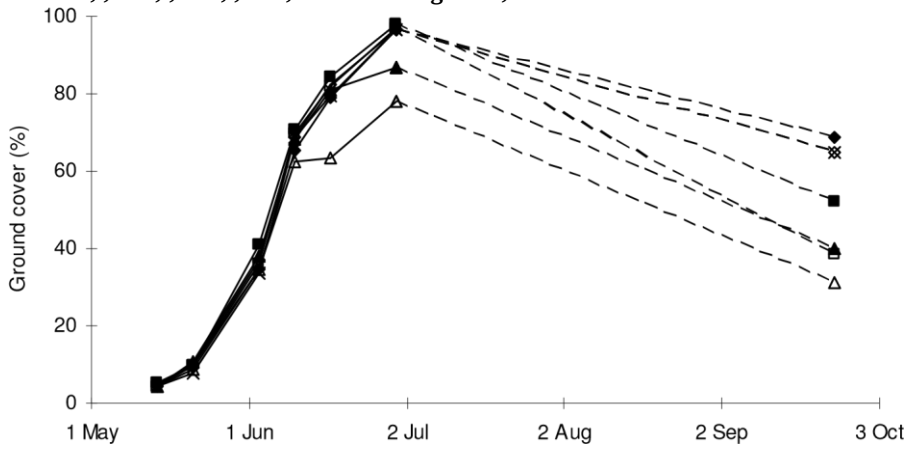
collected and returned to CUF. The number and weight of tubers in each 10 mm size grade was recorded. A 1 kg sample of tubers was removed from the 50-60 mm size grade, washed, chipped and then dried for 48 hours at 90 °C to measure tuber dry matter concentration.

Results and Discussion

Emergence and ground covers

Plant emergence was rapid and 50 % plant emergence was achieved on *c.* 4-6 May (*c.* 25 days after planting) and all treatments achieved complete or near-complete emergence. With the exception of plots that received 0 or 50 kg N/ha, all treatments had achieved near-complete ground cover by the end of June (Figure 6). Assessment of ground cover at final harvest showed that canopies were more persistent with increase in N application rate.

Figure 6. Effect of N application rate on ground cover of Maris Piper in Field 38, A H Worth, 2009. 0, ; 50, ; 100, ; 150, ; 200, ; 250, ♦ and 300 kg N/ha, ×.



Components of yields on 10 September

Nitrogen application rate had no statistically significant effect on the number of mainstems (108 000 ± 5 400/ha) or the tuber population > 10 mm (327 000 ± 13 700/ha). The overall average tuber yield was 63.2 t/ha and when the size of the standard error for yield is considered, increasing the N application rate to *c.* 150 kg N/ha resulted in a statistically significant increase in tuber FW yield but N applications in excess of *c.* 150 kg N/ha had little or no effect (Table 4). There was no effect of N application rate on tuber dry matter concentration. Since N had no effect on tuber population, mean tuber size (μ) was related to tuber FW yield and mean tuber size tended to increase when the N application rate was increased from 0 to *c.* 150 kg N/ha but N had little effect thereafter. The coefficient of variation (COV) of mean tuber size was not affected by N application rate.

Table 4. Effect of N application rate on tuber FW yield > 10 mm, tuber DM concentration, mean tuber size and coefficient of variation (COV) of tuber size distribution for Maris Piper

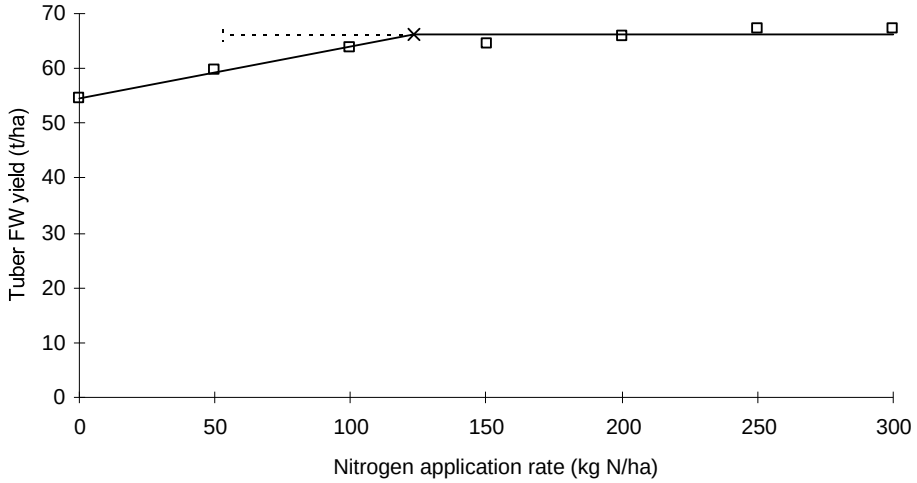
Application rate (kg N/ha)	Tuber FW yield (t/ha)	Tuber DM concentration (%)	Mean tuber size (mm)	COV (%)
0	54.6	26.6	59.8	19.0
50	59.7	27.9	61.5	18.7
100	63.8	27.3	62.9	18.9
150	64.4	27.1	64.0	18.6

200	65.9	26.9	64.7	19.1
250	67.2	26.3	68.7	20.9
300	67.2	26.0	66.3	19.1
Mean	63.2	26.9	64.0	19.2
S.E. (24 D.F.)	1.38	0.48	0.98	0.57

Optimum N application rate and yield at optimum

Examination of treatment means and standard errors suggest that the optimum N application rate for this crop was *c.* 150-200 kg N/ha resulting in a tuber yield > 10 mm of *c.* 65 t/ha. The optimum N application rate was also estimated using the "bent-stick" approach of Boyd (1972). Fitting this model explained 93.5 % of the variation in yield and gave an optimum N application rate of 124 (± 16.4) kg N/ha (Figure 7). The yield at the optimum was estimated to be 66.2 (± 0.59) t/ha.

Figure 7. Relationship between yield and N application of Maris Piper. Measured yield ( ), fitted line ( ), estimate of optimum N application rate (×) and 95 % confidence interval.



Conclusion

The commercial N application rate for this field was 180 kg N/ha compared with 155 kg N/ha for the CUF modified N application rate. Due to the limitations of split-field experiments the effects of the modified-N rate on yield cannot be accurately assessed due to the absence of randomisation and replication. However, this replicated and randomised experiment indicates the modified-N application rate calculated for this site would have reduced costs without compromising yield.

Mease Valley Potatoes & Tame Valley Potatoes (MVP/TVP)

In total, details of eight MVP/TVP crops were sent to CUF. For the half of these crops differences between standard and CUF modified seed or N application rates were less than 10 % and thus there was no worthwhile comparison. However, for four crops differences between CUF and standard agronomy were sufficiently large to make comparisons worthwhile and these were a seed rate comparison for small (30-40 mm) and large (40-50 mm) Lady Rosetta seed and N rate comparisons for Markies and Maris Piper

Lady Rosetta seed rate comparison

Small (30-40 mm) seed

The standard and modified crops were planted on 20 April. The standard crop achieved 50 % plant emergence on 24 May (34 DAE) whilst the modified crop was one day later (Figure 8). The intended planting density for the standard and modified crops were 56 200 and 46 200/ha, respectively. However, for both crops the achieved planting density was smaller than intended and for standard and modified crops the respective plant densities were 48 800 and 40 600/ha. Thus, the achieved planting density in the standard crop was similar to the intended CUF modified density, whilst the achieved planting density in the modified area was less than recommended. Whilst crop grown in the modified and standard areas achieved complete ground cover, expansion of the modified crop was slower, possibly as a consequence of having a stem population that was relatively small. At final harvest on 23 September, yields greater than 10 and 40 mm in both standard and modified areas had exceeded the target yield of 45 t/ha but, numerically, the yield in the standard area was larger than the yield in the modified area. Neither crop achieved the target mean tuber size of 60 mm, but as a consequence of having a small tuber population mean tuber size in the modified crop was closer to the target. Since the intended and achieved plant densities were substantially different from those intended this comparison has been excluded from the summary tables shown on pages 48 and
49.

Medium (40-50 mm) seed

Both the standard and modified areas were planted on 20 April and both had achieved 50 % plant emergence by 26 May (36 DAP). Achieved plant populations were similar to intended plant populations for both the standard and modified areas of crop (Figure 9). The pattern of ground cover expansion was similar in both the standard and modified areas and both crops achieved complete ground cover. The crops were defoliated on 28 August. For the standard crop, yield greater than 40 mm was slightly more than the intended yield (45 t/ha) but the mean tube size was 10.5 mm less than intended. The total yield (greater than 10 mm) of the modified crop was similar to that of the standard crop but since the modified crop had a smaller stem and tuber population, the mean tuber size was closer to the intended and, in consequence, the marketable yield was numerically larger than the standard crop. For Lady Rosetta a tuber count from 70 to 100 tubers/10 kg is usually required. At final harvest the count of the standard crop was 110 compared with 85 tubers/10 kg for the modified crop. The gross commercial yield of the Lady Rosetta crops (irrespective of seed size and planting density) was estimated to be close to the intended yield (45 t/ha) and if harvesting losses and reduced yields on headland are taken into account the yield samples were reasonably good forecasters of commercial yield.

Markies N rate comparison

The Markies crop was grown for French fry production and was planted on 24 April. The standard area received a total of 150 kg N/ha compared with 130 kg N/ha for the modified area. Irrespective of N application rate, both areas attained 50 % plant emergence on 26 May (32 DAP, Figure 10). The pattern of ground cover development was similar in both areas of crop and there was complete ground cover by the end of June. Both crops maintained 100 % ground cover until the end of August when they were both defoliated at *c.* 95 % ground cover. At final harvest on 23 September, differences in total and marketable yield were small between the two areas. The gross commercial yield for the entire field was estimated to be *c.* 50 t/ha and the average total (> 10 mm) of the yield samples in the standard and modified area was 56.1 t/ha. Once allowances

are made as described above, the average of the yield digs gave a reasonable estimate of production from the whole field.

Maris Piper N rate comparison

The Maris Piper crop in Deercote Barn was destined for French fry production and was planted on 26 April. The standard area received a total of 220 kg N/ha compared with 200 kg N/h in the modified area. Emergence was rapid and 50 % plant emergence for both crops was

c. 23 May (27 DAP, Figure 11) and the plant population in the modified area was similar to that recorded in the standard area. Development of ground cover was similar in both standard and modified areas and both reached complete ground cover by late June or early July. Irrespective of N application rate, both areas maintained a complete canopy until the end of August. Unfortunately it was not possible to obtain a yield sample on 15 July. In the area that received 220 kg N/ha, total and marketable yield at final harvest were 64.5 and 59.9 t/ha, respectively. However, total and marketable yields in the area that received 200 kg N/ha were 54.4 and 48.6 t/ha, respectively. Thus reducing the N input by only 20 kg N/ha was associated with a yield penalty of *c.* 10-11 t/ha despite there being no discernable effect on ground cover expansion or duration. The gross commercial yield for the whole field was estimated to be 53 t/ha and therefore it appears that the yield samples in the standard areas may have overestimated gross production, whereas the yield samples taken from the reduced N area may have slightly underestimated true, gross production.

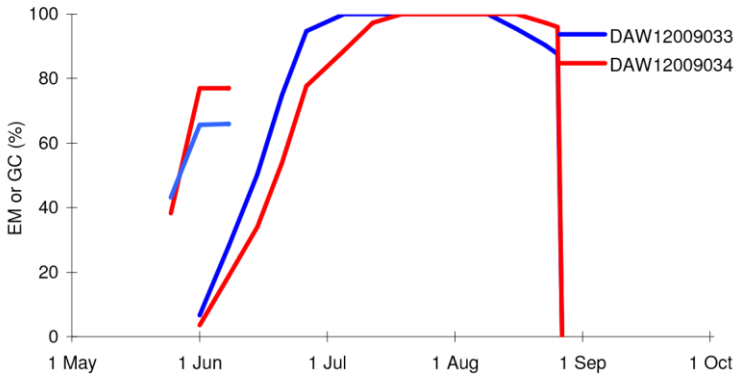
Analysis of crop performance using the CUF yield model

Comparisons of gross commercial yield, sampled and modelled yield for both seed sizes of

Lady Rosetta, Markies and Maris Piper that received standard agronomy are shown in Figure 12. In all cases, the final sample taken at the end of the season overestimated the gross commercial yield. As discussed above, this overestimate may be due to samples being taken in more productive parts of the field (i.e. no hand-dug samples were taken from headlands) and more efficient recovery of tubers in hand-dug samples. In general, there was good agreement between yield forecasts from the CUF yield model and achieved yield. This indicates, that the yield of these crops was mainly controlled by radiation absorption and factors that may have affected the efficiency of conversion of radiation to yield, for example water stress or disease, were probably unimportant. The biggest difference between modelled yield and hand sampled yield was in the Maris Piper crop. This lends support to the hypothesis that the yield sample in the standard crop may have overestimated the true yield resulting in an apparent yield advantage when 220 kg N/ha was applied when compared with areas that received
200 kg N/ha. However, since this hypothesis cannot be proven and there was no valid reason to exclude them, the Maris Piper data have been included in the summaries shown on pages 48 and 49.

Figure 8. MVP/TVP Lady Rosetta seed rate comparison, small seed (30-40 mm), Marsh Barn.

Grower:	WB Daw	WB Daw
Field name:	Marsh Barn	Marsh Barn
Unique ID:	DAW12009033	DAW12009034
Part Field Name:	Standard small Seed Standard N	Modified small Seed Standard N
Variety:	Lady Rosetta	Lady Rosetta
Intended yield:	45 t/ha	45 t/ha
Intended use:	Crisping-Storage	Crisping-Storage
Intended mu (μ):	60 mm	60 mm
Planting date (start):	20 Apr	20 Apr
Date of 50 % emergence:	24 May	25 May
Seed size:	30-40 mm	30-40 mm
Seed count:	1645 per 50 kg	1645 per 50 kg
Planned density:	56.2 000/ha	46.2 000/ha
Planned spacing:	19.6 cm	23.7 cm
Achieved density:	48.8 000/ha	40.6 000/ha
Achieved spacing:	22.4 cm	27.0 cm

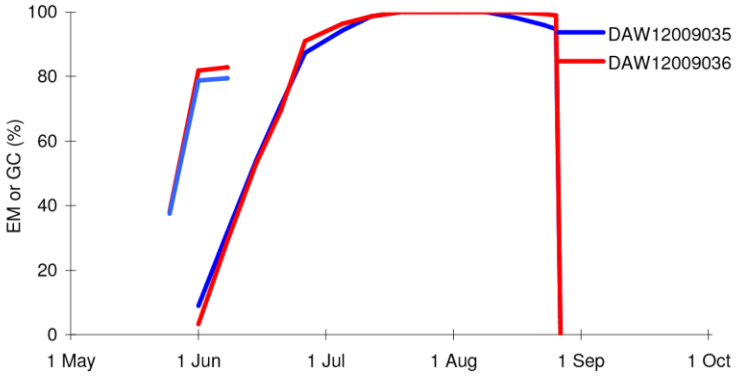


Yield Samples (S.E. in italics)

		Standard small Seed Standard N			Modified small Seed Standard N	
		15 Jul	23 Sep		15 Jul	23 Sep
Plants (000/ha)		44.7	52.9		41.0	40.1
		3.76	*1.82*		*3.76*	*0.00*
Stems (000/ha)		190.5	184.1	> 10 mm	136.7	122.1
		7.79	*4.82*		*17.45*	*7.94*
Stems/plant		4.3	3.5	> 40 mm	3.5	3.0
		0.37	*0.18*		*0.69*	*0.20*
Tubers (000/ha)		864	748	> 10 mm	626	538
		18.9	*45.9*		*69.5*	*17.2*
Tubers (000/ha)	> 10 mm	144	519	> 40 mm	168	398
		13.2	*15.3*		*21.2*	*28.0*
Tuber yield (t/ha)	> 40 mm	25.1	57.6		21.5	51.1
		1.02	*0.32*		*2.14*	*3.46*
Tuber yield (t/ha)	> 10 mm	9.1	52.3		11.3	48.5
		0.81	*0.72*		*0.75*	*3.67*
DM (%)	> 40 mm	20.3	26.7		19.3	23.6
		0.18	*1.29*		*0.22*	*0.25*
Mean tuber size (mm)		38.5	52.3		41.1	56.5
		0.22	*1.31*		*0.50*	*1.66*

Figure 9. MVP/TVP Lady Rosetta seed rate comparison, large (40-50 mm), Marsh Barn.

Grower:	WB Daw	WB Daw
Field name:	Marsh Barn	Marsh Barn
Unique ID:	DAW12009035	DAW12009036
Part Field Name:	Standard medium Seed Standard N	Modified Medium Seed Standard N
Variety:	Lady Rosetta	Lady Rosetta
Intended yield:	45 t/ha	45 t/ha
Intended use:	Crisping-Storage	Crisping-Storage
Intended mu (μ):	60 mm	60 mm
Planting date (start):	20 Apr	20 Apr
Date of 50 % emergence:	26 May	26 May
Seed size:	40-50 mm	40-50 mm
Seed count:	985 per 50 kg	985 per 50 kg
Planned density:	46.7 000/ha	35.4 000/ha
Planned spacing:	23.5 cm	30.9 cm
Achieved density:	44.7 000/ha	36.9 000/ha
Achieved spacing:	24.5 cm	29.6 cm



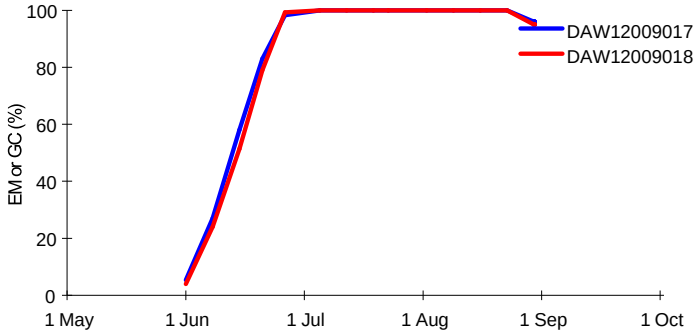
Yield Samples (S.E. in italics)

		Standard medium Seed Standard N			Modified Medium Seed Standard N	
		15 Jul	23 Sep		15 Jul	23 Sep
		42.8	46.5		36.5	37.4
		2.29	*2.29*		*0.00*	*0.91*
Stems (000/ha)		202.3	183.2	> 10 mm	125.8	129.4
		15.85	*22.69*		*13.35*	*9.23*
Stems/plant		4.8	3.9	> 40 mm	3.5	3.5
		0.44	*0.44*		*0.37*	*0.21*
Tubers (000/ha)		896	880	> 10 mm	647	598
		42.1	*83.3*		*89.8*	*10.7*
Tubers (000/ha)	> 10 mm	139	506	> 40 mm	149	410
		18.3	*50.1*		*23.2*	*11.8*
Tuber yield (t/ha)	> 40 mm	24.6	54.5		20.3	52.2
		1.82	*6.63*		*2.90*	*1.62*
Tuber yield (t/ha)	> 10 mm	8.7	46.2		9.3	48.5
		1.25	*7.38*		*1.43*	*1.87*
DM (%)	> 40 mm	19.5	24.3		19.1	25.0
		0.21	*0.72*		*0.26*	*0.47*
Mean tuber size (mm)		37.9	49.4		39.5	55.9
		0.79	*1.57*		*0.39*	*0.98*

Plants (000/ha)

Figure 10. MVP/TVP Markies N rate comparison, Curborough

Grower:	James Daw	James Daw
Field name:	Curborough	Curborough
Unique ID:	DAW12009017	DAW12009018
Part Field Name:	Standard Seed and Standard N	Standard Seed and Modified N
Variety:	Markies	Markies
Intended yield:	50 t/ha	50 t/ha
Intended use:	French-fries	French-fries
Intended mu (μ):	65 mm	65 mm
Planting date (start):	24 Apr	24 Apr
Date of 50 % emergence:	26 May	26 May
Total N applied:	150 kg N/ha	130 kg N/ha
Achieved density:	29.2 000/ha	27.8 000/ha
Achieved spacing:	37.5 cm	39.3 cm

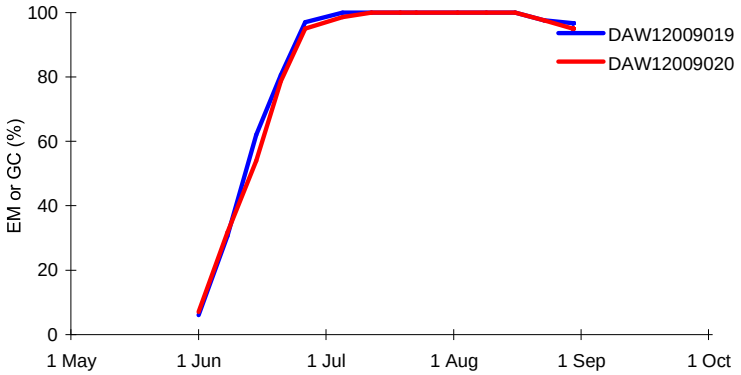


Yield Samples (S.E. in italics)

		Standard Seed and Standard N			Standard Seed and Modified N	
		15 Jul	23 Sep		15 Jul	23 Sep
Plants (000/ha)		29.2 *0.00*	29.2 *0.00*		26.4 *0.91*	29.2 *2.10*
Stems (000/ha)		177.7 *16.86*	167.7 *15.10*	> 10 mm	143.1 *15.56*	162.2 *16.61*
Stems/plant		6.1 *0.58*	5.8 *0.52*	> 40 mm	5.4 *0.57*	5.6 *0.47*
Tubers (000/ha)		611 *65.5*	581 *62.2*	> 10 mm	513 *22.8*	622 *29.6*
Tubers (000/ha)	> 10 mm	148 *18.3*	361 *19.9*	> 40 mm	160 *11.2*	394 *26.8*
Tuber yield (t/ha)	> 40 mm	23.8 *2.13*	56.4 *3.58*		23.3 *0.76*	55.7 *3.58*
Tuber yield (t/ha)	> 10 mm	11.1 *1.60*	51.7 *3.83*		12.6 *1.20*	50.9 *3.28*
DM (%)	> 40 mm	14.2 *0.04*	24.5 *0.35*		14.7 *0.21*	23.5 *0.55*
Mean tuber size (mm)		40.0 *0.63*	53.6 *1.49*		41.1 *0.72*	52.7 *0.94*

Figure 11. MVP/TVP Maris Piper N rate comparison, Deercote Barn.

Grower:	JF & BM Gray Deercote	JF & BM Gray Deercote
Field name:	Barn	Barn
Unique ID:	DAW12009019	DAW12009020
Part Field Name:	Standard Seed and Standard N	Standard Seed and Modified N
Variety:	Maris Piper	Maris Piper
Intended yield:	55 t/ha	55 t/ha
Intended use:	French-fries	French-fries
Intended mu (μ):	65 mm	65 mm
Planting date (start):	26 Apr	26 Apr
Date of 50 % emergence:	22 May	23 May
Total N applied:	220 kg N/ha	200 kg N/ha
Achieved density:	26.0 000/ha	26.4 000/ha
Achieved spacing:	42.1 cm	41.4 cm

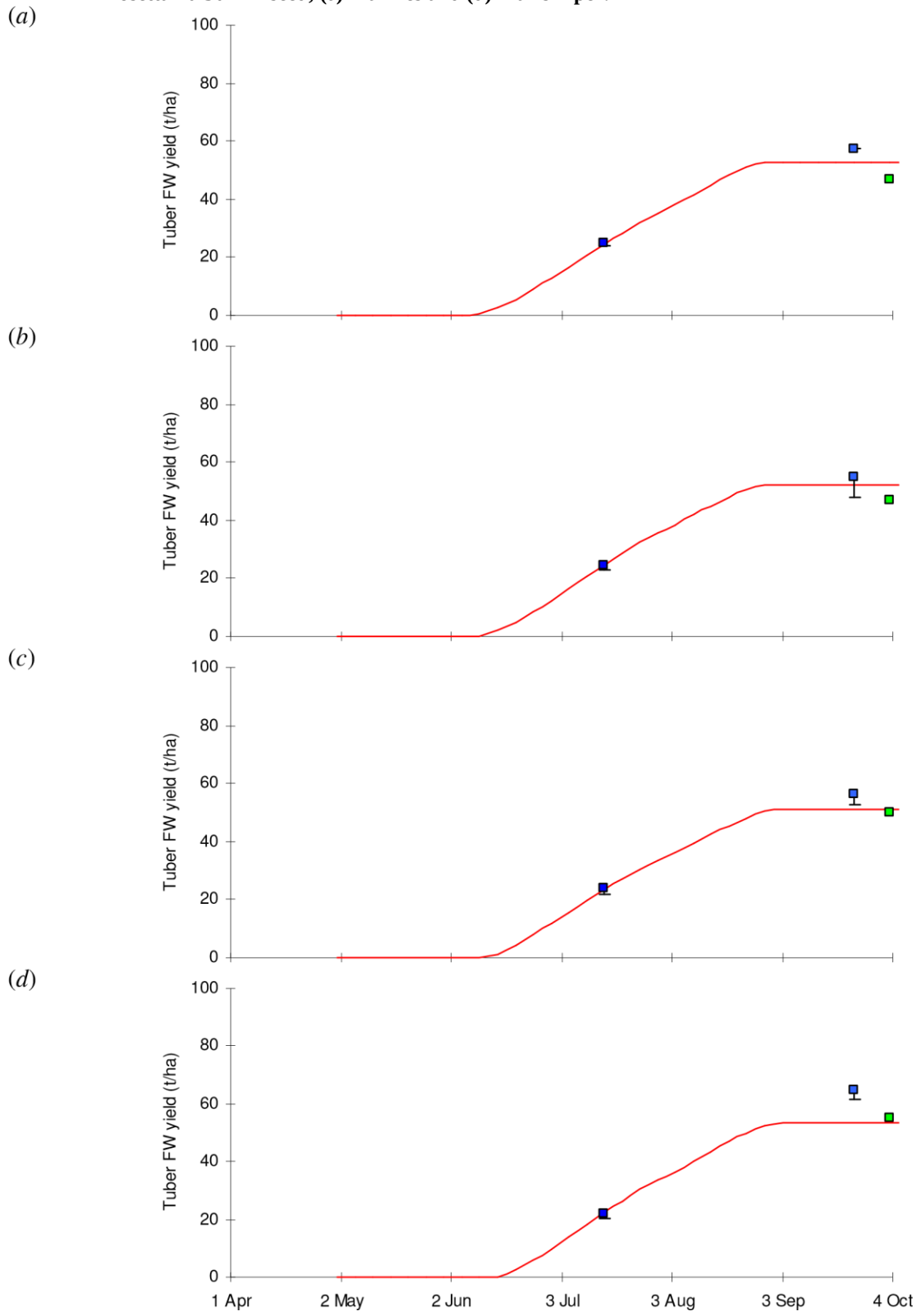


Yield Samples (S.E. in italics)

		Standard Seed and Standard N			Standard Seed and Modified N	
		15 Jul	23 Sep		15 Jul	23 Sep
		23.7	28.3			26.4
		1.05	*0.91*			*0.91*
Stems (000/ha)		92.0	123.0	> 10 mm		111.2
		6.20	*6.88*			*9.47*
Stems/plant		3.9	4.3	> 40 mm		4.2
		0.13	*0.15*			*0.31*
Tubers (000/ha)		426	568	> 10 mm		561
		21.3	*24.7*			*36.9*
Tubers (000/ha)	> 10 mm	170	411	> 40 mm		386
		27.7	*17.2*			*14.7*
Tuber yield (t/ha)	> 40 mm	22.1	64.5			54.4
		1.65	*2.94*			*3.22*
Tuber yield (t/ha)	> 10 mm	14.0	59.9			48.6
		1.77	*2.70*			*3.02*
DM (%)	> 40 mm	16.1	20.4			22.0
		0.47	*1.66*			*0.28*
Mean tuber size (mm)		42.3	55.9			51.8
		0.52	*0.17*			*0.90*

Plants (000/ha)

Figure 12. Comparison of model output (red line), yield samples (blue symbol ± 1 S.E.) and estimates of gross commercial yield (green symbol) for standard crops of (*a*) Lady Rosetta 30-40 mm seed; (*b*) Lady Rosetta 40-50 mm seed; (*c*) Markies and (d) Maris Piper.



Strawson Farming

Hermes seed rate comparison

For this comparison Hermes was grown with a planned planting density of 68 300/ha (withinrow spacing 21.2 cm) and a modified density of 49 500/ha (29.0 cm). Since, estimates of plant and stem population measured at final harvest were unreliable, the achieved planting density was estimated from an initial harvest taken on 30 July. From these data, the achieved planting density in the standard area was estimated to be 57 500 compared with 46 700/ha in the modified area. Both crops attained 50 % plant emergence within one day of each other and whilst initial ground cover expansion of the modified crop was slower than that of the standard crop, both crops reach full ground cover by the last week in June (Figure 13). Canopy persistence was similar in both crops, as was the rate of canopy senescence. Total tuber yield was 42.3 t/ha in the standard crop compared with 39.6 t/ha in the modified and thus neither crop attained the intended yield of 50 t/ha. Ware yields (> 40 m) were 38.7 and 37.5 t/ha in the standard and modified areas, respectively. As a consequence of having fewer tubers, the mean tuber size was larger in the modified area despite having a numerically smaller yield. The tuber counts for the standard and modified areas were 102 and 92 tubers/10 kg, respectively.

Hermes seed rate comparison (intermediate)

This comparison was designed to be a 'halfway house' between the standard and CUF modified seed rates and may represent the approach of many growers when they start to adopt new recommendation and practices. This comparison is not included in the summary tables shown on page 48. The standard crop was as above (intended plant population of 68 300/ha) and the 'intermediate' crop had an intended plant population of 62 500/ha. The date of 50 % emergence of both standard and intermediate crops was 28 May. The pattern of ground cover development was similar in the standard and intermediate crops (Figure 14). Both crops reached complete ground cover by mid to late June and both started to senesce in late July. Total (> 10 mm) and ware (> 40 mm) yields were 42.3 and 38.7 t/ha, respectively in the standard crop and 39.1 and 36.1 t/ha, respectively, in the intermediate crop. Tuber dry matter concentrations were similar in both standard and intermediate crops and averaged 22.1 %. The tuber count was 102 tubers/10 kg in the standard area compared with 96 tubers/10 kg in the intermediate area.

Hermes N rate comparison

The standard rate of N application in Wood 10 was 210 kg N/ha and on the basis of information supplied to CUF a modified N application rate of 185 kg N/ha was included as a comparison. Records for emergence and early ground cover data are incomplete (Figure 15) but both standard and modified crops reached complete ground cover. Both crops started to senesce in late July and the rate of senescence was initially faster in the modified crop. The total yield of the crop that received 210 kg N/ha was 37.6 t/ha compared with 44.0 t/ha for the crop that received a reduced input of N fertilizer. Ware yields in the standard and modified areas were 35.3 and 41.4 t/ha, respectively. Yield of both crops were small and neither attained the target yield of 50 t/ha. However, these data suggest that the yields were not limited by insufficient N since yields were numerically larger in the areas where N inputs had been reduced. Tuber DM concentration was 19.2 % in the standard area and 20.8 % in the modified.

Saturna N rate comparison

This comparison examined the effects of applying either a standard rate of 220 kg N/ha or a modified rate of 195 kg N/ha to a crop of Saturna. Again, records for emergence and early ground cover data are incomplete (Figure 16), but both standard and modified crops reached complete

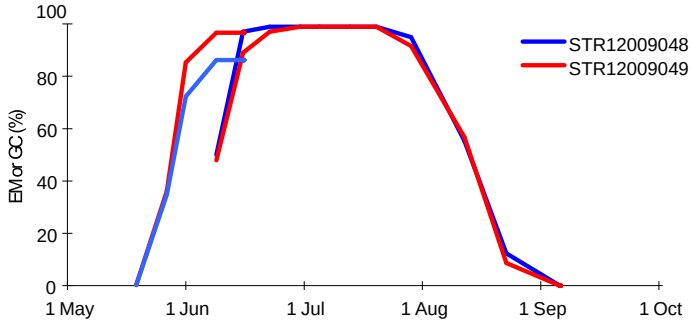
ground cover by mid July. Both crops senesced slowly from early August onward and no canopy remained at the final sampling on 5 October. The yield of both the standard and modified crops exceeded the intended yield. For the standard crop, the total and ware yields were 63.1 and 60.5 t/ha, respectively, whereas in the modified area the corresponding yields were 58.9 and 55.9 t/ha, respectively. Tuber dry matter concentrations averaged 24.6 % and the count was 82 tubers/10 kg in both crops.

Analysis of crop performance using the CUF yield model

Since emergence and ground cover data were incomplete for the N rate comparisons in the Hermes and Saturna crops it was not possible to analyse the performance of these crops with the CUF yield model. Figure 17, compares the yield forecasts for the Hermes standard seed rate crop produced by the CUF yield model with hand-dug samples taken on 30 July and 26 October. The model overestimated yield at the final sampling but the error was small (*c.* 4 t/ha) and this overestimate is unlikely to be a consequence of the crop being unduly stressed at any point in the season so that the relatively small yield was largely a consequence of the short lived canopy.

Figure 13. Strawson Farming Hermes seed rate comparison, Sansom Wood 14.

Grower:	Strawson Farming	Strawson Farming
Field name:	Sansom Wood 14	Sansom Wood 14
Unique ID:	STR12009048	STR12009049
Part Field Name:	Standard Seed Standard N	Modified Seed Standard N
Variety:	Hermes	Hermes
Intended yield:	48 t/ha	50 t/ha
Intended use:	Crisping-Storage	Crisping-Storage
Intended mu (μ):	NA	58.5 mm
Planting date (start):	22 Apr	22 Apr
Date of 50 % emergence:	28 May	29 May
Total N applied:	217 kg N/ha	217 kg N/ha
Seed size:	35-45 mm	35-45 mm
Seed count:	1089 per 50 kg	1089 per 50 kg
Planned density:	68.3 000/ha	49.5 000/ha
Planned spacing:	21.2 cm	29.0 cm

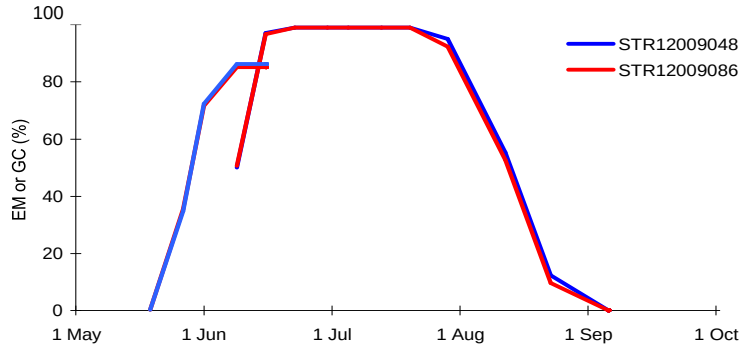


Yield Samples (S.E. in italics)

		Standard Seed Standard N			Modified Seed Standard N	
		30 Jul	26 Oct		30 Jul	26 Oct
Plants (000/ha)		57.5	172.5		46.7	161.7
		6.61	*2.89*		*3.63*	*6.01*
Stems (000/ha)		219.2	678.3	> 10 mm	151.7	538.3
		30.87	*14.60*		*2.20*	*11.76*
Stems/plant		3.8	3.9	> 40 mm	3.3	3.3
		0.19	*0.11*		*0.23*	*0.05*
Tubers (000/ha)		577	539	> 10 mm	454	428
		47.6	*17.9*		*27.1*	*16.7*
Tubers (000/ha)	> 10 mm	382	392	> 40 mm	330	345
		21.9	*27.8*		*31.7*	*21.8*
Tuber yield (t/ha)	> 40 mm	36.2	42.3		35.4	39.6
		1.47	*3.63*		*0.79*	*2.95*
Tuber yield (t/ha)	> 10 mm	31.9	38.7		32.4	37.5
		1.48	*4.14*		*1.40*	*3.34*
Zeal DM (%)	> 40 mm	20.8	22.2		20.7	21.3
		0.30	*0.12*		*0.52*	*0.69*
Mean tuber size (mm)		49.2	52.2		51.7	54.7
		0.63	*1.11*		*1.04*	*1.45*

Figure 14. Strawson Farming Hermes seed rate comparison (intermediate), Sansom Wood 14.

Grower:	Strawson Farming	Strawson Farming
Field name:	Sansom Wood 14 STR12009048	Sansom Wood 14
Unique ID:	Standard Seed Standard N	STR12009086
Part Field Name:	Hermes	Intermediate Seed Standard
Variety:	48 t/ha	N Hermes
Intended yield:	Crisping-Storage	48 t/ha
Intended use:	NA	Crisping-Storage
Intended mu (µ):		NA
Planting date (start):	22 Apr	22 Apr
Date of 50 % emergence:	28 May	28 May
Total N applied:	217 kg N/ha	217 kg N/ha
Seed size:	35-45 mm	35-45 mm
Seed count:	1089 per 50 kg	1089 per 50 kg
Planned density:	68.3 000/ha	62.5 000/ha
Planned spacing:	21.2 cm	23.0 cm

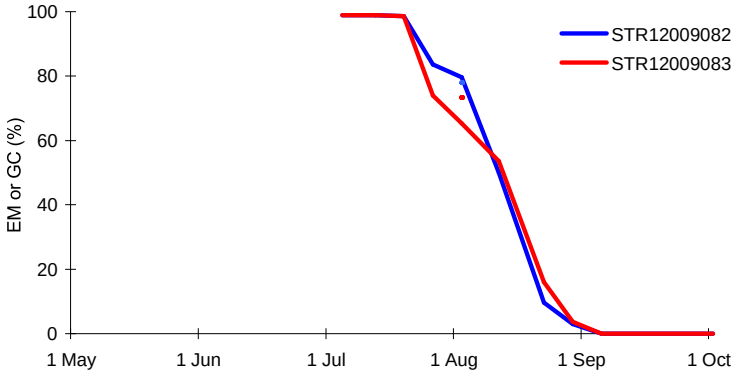


Yield Samples (S.E. in italics)

		Standard Seed Standard N			Intermediate Seed Standard N	
		30 Jul	26 Oct		30 Jul	26 Oct
Plants (000/ha)		57.5	172.5		53.3	164.2
		6.61	*2.89*		*1.67*	*6.01*
Stems (000/ha)		219.2	678.3	> 10 mm	180.8	573.3
		30.87	*14.60*		*13.72*	*27.62*
Stems/plant		3.8	3.9	> 40 mm	3.4	3.5
		0.19	*0.11*		*0.18*	*0.28*
Tubers (000/ha)		577	539	> 10 mm	454	472
		47.6	*17.9*		*32.5*	*33.9*
Tubers (000/ha)	> 10 mm	382	392	> 40 mm	299	345
		21.9	*27.8*		*14.2*	*26.3*
Tuber yield (t/ha)	> 40 mm	36.2	42.3		27.5	39.1
		1.47	*3.63*		*0.26*	*3.37*
Tuber yield (t/ha)	> 10 mm	31.9	38.7		24.0	36.1
		1.48	*4.14*		*0.94*	*3.40*
Zeal DM (%)	> 40 mm	20.8	22.2		20.5	22.0
		0.30	*0.12*		*0.61*	*0.27*
Mean tuber size (mm)		49.2	52.2		48.9	53.2
		0.63	*1.11*		*1.16*	*0.56*

Figure 15. Strawson Farming Hermes N rate comparison, Wood 10.

Grower:	Strawson Farming	Strawson Farming
Field name:	Wood 10	Wood 10
Unique ID:	STR12009082	STR12009083
Part Field Name:	Standard Seed Standard N	Standard Seed Modified
Variety:	Hermes	N Hermes
Intended yield:	50 t/ha	50 t/ha
Intended use:	Crisping-Storage	Crisping-Storage
Intended mu (µ):	NA	NA
Planting date (start):	23 Apr	23 Apr
Date of 50 % emergence:	30 May	30 May
Total N applied:	210 kg N/ha	185 kg N/ha
Seed size:	45-55 mm	45-55 mm
Seed count:	895 per 50 kg	895 per 50 kg
Planned density:	57.5 000/ha	57.5 000/ha
Planned spacing:	27.5 cm	27.5 cm
Achieved density:	41.7 000/ha	41.2 000/ha
Achieved spacing:	36.0 cm	36.4 cm

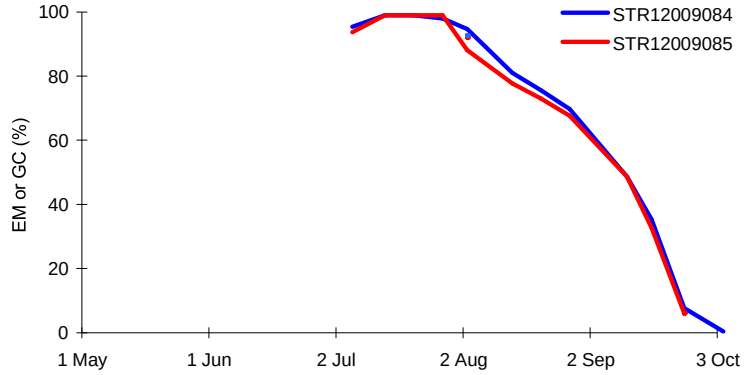


Yield Samples (S.E. in italics)

		Standard Seed Standard N			Standard Seed Modified N	
		4 Aug	7 Oct		4 Aug	7 Oct
		42.5	40.8		40.0	42.5
		2.89	*4.41*		*2.50*	*2.50*
Stems (000/ha)		154.2	165.0	> 10 mm	190.0	155.0 Plants
		6.67	*7.64*		*17.50*	*6.61* (000/ha)
Stems/plant		3.7	4.2	> 40 mm	4.8	3.7
		0.28	*0.68*		*0.48*	*0.37*
Tubers (000/ha)		383	418	> 10 mm	436	482
		60.2	*49.5*		*22.5*	*14.6*
Tubers (000/ha)	> 10 mm	308	302	> 40 mm	282	334
		44.8	*32.3*		*2.2*	*24.6*
Tuber yield (t/ha)	> 40 mm	34.5	37.6		31.6	44.0
		4.50	*3.93*		*0.58*	*3.09*
Tuber yield (t/ha)	> 10 mm	32.7	35.3		28.5	41.4
		4.05	*3.97*		*0.63*	*3.15*
Zeal DM (%)	> 40 mm	19.0	19.2		20.1	20.8
		0.70	*0.30*		*0.46*	*0.38*
Mean tuber size (mm)		55.4	58.5		53.3	58.7
		0.88	*0.98*		*0.82*	*0.67*

Figure 16. Strawson Farming Saturna N rate comparison, Godfrey 13.

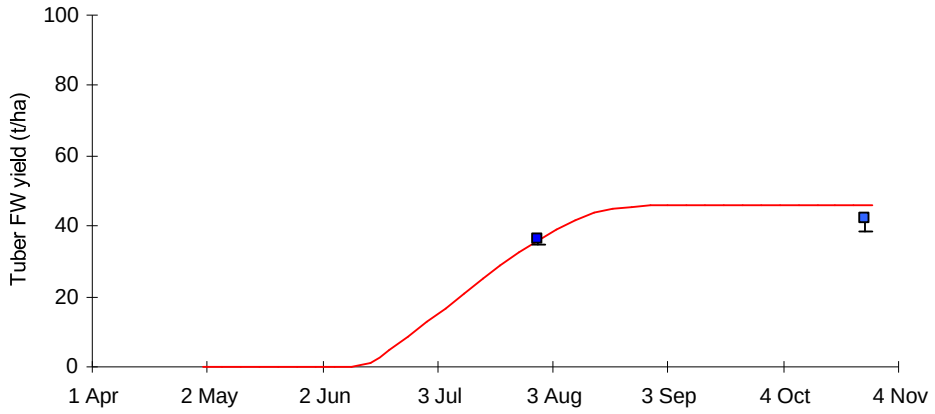
Grower:	Strawson Farming	Strawson Farming
Field name:	Godfrey 13	Godfrey 13
Unique ID:	STR12009084	STR12009085
Part Field Name:	Standard Seed Standard N	Standard Seed Modified
Variety:	Saturna	N Saturna
Intended yield:	50 t/ha	50 t/ha
Intended use:	Crisping-Storage	Crisping-Storage
Planting date (start):	14 Apr	14 Apr
Date of 50 % emergence:	19 May	19 May
Total N applied:	220 kg N/ha	195 kg N/ha
Seed size:	45-55 mm	45-55 mm
Seed count:	600 per 50 kg	600 per 50 kg
Planned density:	29.9 000/ha	29.9 000/ha
Planned spacing:	50.3 cm	50.3 cm
Achieved density:	27.1 000/ha	26.2 000/ha
Achieved spacing:	55.4 cm	57.1 cm



Yield Samples (S.E. in italics)

		Standard Seed Standard N			Standard Seed Modified N	
		3 Aug	5 Oct		3 Aug	5 Oct
Plants (000/ha)		27.5	26.7		27.5	25.0
		2.89	*0.83*		*2.50*	*3.82*
Stems (000/ha)		84.2	75.8		90.8	102.5
		11.21	*3.00*		*13.87*	*4.33*
Stems/plant		3.0	2.9		3.3	4.3
		0.14	*0.16*		*0.36*	*0.58*
Tubers (000/ha)		545	607		542	589
		38.9	*80.1*		*72.6*	*79.7*
Tubers (000/ha)	> 10 mm	399	495		411	460
		19.6	*64.1*		*40.8*	*60.0*
Tuber yield (t/ha)	> 40 mm	49.0	63.1		45.9	58.9
		0.25	*6.35*	> 10 mm	*3.00*	*3.57*
Tuber yield (t/ha)	> 10 mm	43.6	60.5		42.5	55.9
		1.20	*5.97*	> 40 mm	*2.50*	*3.18*
Zeal DM (%)	> 40 mm	22.5	24.8		22.0	24.3
		0.06	*0.44*	> 10 mm	*0.19*	*0.28*
Mean tuber size (mm)		51.4	57.6		52.4	57.5
		1.10	*1.14*	> 40 mm	*1.95*	*2.53*

Figure 17. Comparison of model output (red line), yield samples (blue symbol ± 1 S.E.) for standard crops of Hermes.



South West Agronomy Group (SWAG)

Matt Bere, Marfona

This crop was grown for early baking potato production with a target mean tuber size of 65 mm. The crop was planted on 28 March and 50 % plant emergence was attained 37 days later (4 May, Figure 18). Initial ground cover expansion was relatively slow but the crop reached 100 % ground cover by 17 June and this was maintained until defoliation on 15 July. At the final sampling tuber yield > 10 mm was 48.5 t/ha which was less than the target yield of 55 t/ha. However, as a consequence of the small tuber population (287 000/ha), the mean tuber size was 67.6 mm and if this crop had been allowed to grow on there would have been the risk of production on excessive oversize potatoes. However, the advantage of having relatively few tubers meant that the crop could be defoliated harvested and marketed when supplies of early backing potato were still relatively low and thus increasing the value of this crop.

Matt Bere, Maris Piper

This crop had a target yield of 50 t/ha with a mean tuber size of 60 mm and was destined for French fry production. The crop was planted on 5 April and 50 % plant emergence was recorded on 7 May (32 DAP, Figure 18). Expansion of ground cover was rapid and complete ground cover was achieved on 23 June. Full ground cover was maintained until 5 August when the crop was defoliated. At defoliation, total tuber yield was 63.7 t/ha and the mean tuber size was 65.4 mm. This crop exceeded the target yield by *c.* 14 t/ha and, in part, this was due to a relatively small tuber dry matter concentration.

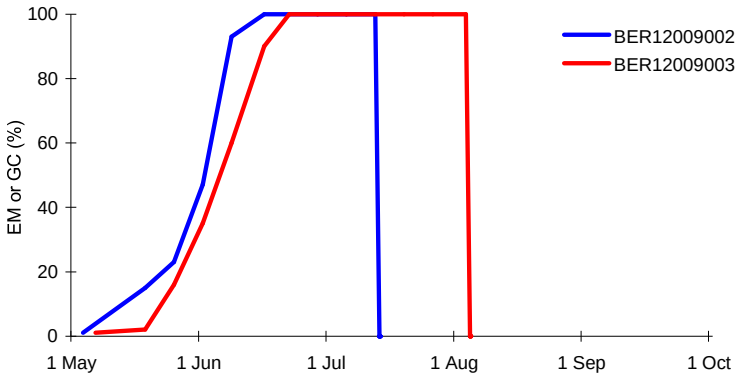
James Pullen, Estima

The Estima crop was grown for production of baking potatoes and had a target mean tuber size of 65 mm. The field was planted on 3 April and achieved 50 % plant emergence by 5 May (31 DAP) and the achieved plant population (30 500/ha) was similar to that intended (32 200/ha, Figure 19). Complete ground cover was reached on 18 June and was maintained until defoliation on 25 July. The crop was defoliated once it had achieved the target mean tuber size (65 mm). At sampling on 24 August the yield > 10 mm was 69.5 t/ha and the yield > 60 mm was 46.1 t/ha. The target total yield for this crop was 50 t/ha and this was exceeded by *c.* 20 t/ha. In part the large yields were a consequence of a relatively low tuber dry matter concentration as well as a persistent canopy that remained healthy until defoliation.

All three SWAG crops were grown with small amount of N fertilizer (100-150 kg N/ha) and all three crops were defoliated at complete ground cover suggesting that no crop was short of N.

Figure 18. SWAG Matt Bere Marfona, Notaro Field and Maris Piper, Pond Field.

Grower:	Matt Bere	Matt Bere
Field name:	Notaro	Pond Field
Unique ID:	BER12009002	BER12009003
Part Field Name:	Standard Crop	Standard Crop
Variety:	Marfona	Maris Piper
Intended yield:	55 t/ha	50 t/ha
Intended use:	Bakers	French-fries
Intended mu (μ):	60 mm	60 mm
Planting date (start):	28 Mar	5 Apr
Date of 50 % emergence:	4 May	7 May
Total N applied:	135 kg N/ha	100 kg N/ha
Seed size:	35-45 mm	35-45 mm
Seed count:	1080 per 50 kg	980 per 50 kg
Planned density:	49.5 000/ha	34.8 000/ha
Planned spacing:	22.1 cm	31.4 cm
Achieved density:	41.5 000/ha	28.7 000/ha
Achieved spacing:	26.4 cm	38.1 cm



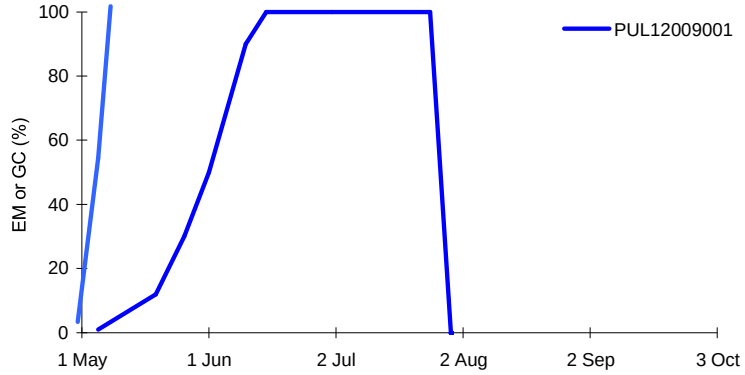
Yield Samples (S.E. in italics)

		Standard Crop 1 Jul	Standard Crop 30 Jul		Standard Crop 1 Jul	Standard Crop 24 Aug
		42.8	40.1		30.1	27.3
		4.04	*1.49*		*0.91*	*1.05*
Stems (000/ha)		87.5	92.0	> 10 mm	98.4	94.8
		7.44	*6.20*		*6.82*	*13.88*
Stems/plant		2.1	2.3	> 40 mm	3.3	3.4
		0.18	*0.15*		*0.25*	*0.40*
Tubers (000/ha)		272	287	> 10 mm	348	342
		11.3	*21.9*		*35.4*	*46.2*
Tubers (000/ha)	> 10 mm	211	245	> 40 mm	244	299
		7.0	*21.2*		*30.6*	*35.6*
Tuber yield (t/ha)	> 40 mm	35.2	48.5		30.1	63.7
		2.21	*3.08*		*1.79*	*1.86*
Tuber yield (t/ha)	> 10 mm	34.1	47.5		27.8	62.7
		2.26	*3.14*		*1.82*	*1.93*
DM (%)	> 40 mm	14.9	16.4		14.1	18.5
		0.30	*0.67*		*0.12*	*0.23*
Mean tuber size (mm)		62.8	67.6		51.9	65.4
		1.11	*1.24*		*0.46*	*2.10*

Plants (000/ha)

Figure 19. SWAG James Pullen Estima, Gaundle Field.

Grower:	James Pullen
Field name:	Gaundle
Unique ID:	PUL12009001
Part Field Name:	Standard Crop
Variety:	Estima
Intended yield:	50 t/ha
Intended use:	Bakers
Intended mu (μ):	65 mm
Planting date (start):	3 Apr
Date of 50 % emergence:	5 May
Total N applied:	150 kg N/ha
Seed size:	45-55 mm
Planned density:	32.2 000/ha
Planned spacing:	34.0 cm
Achieved density:	30.5 000/ha
Achieved spacing:	35.8 cm



Yield Samples (S.E. in italics)

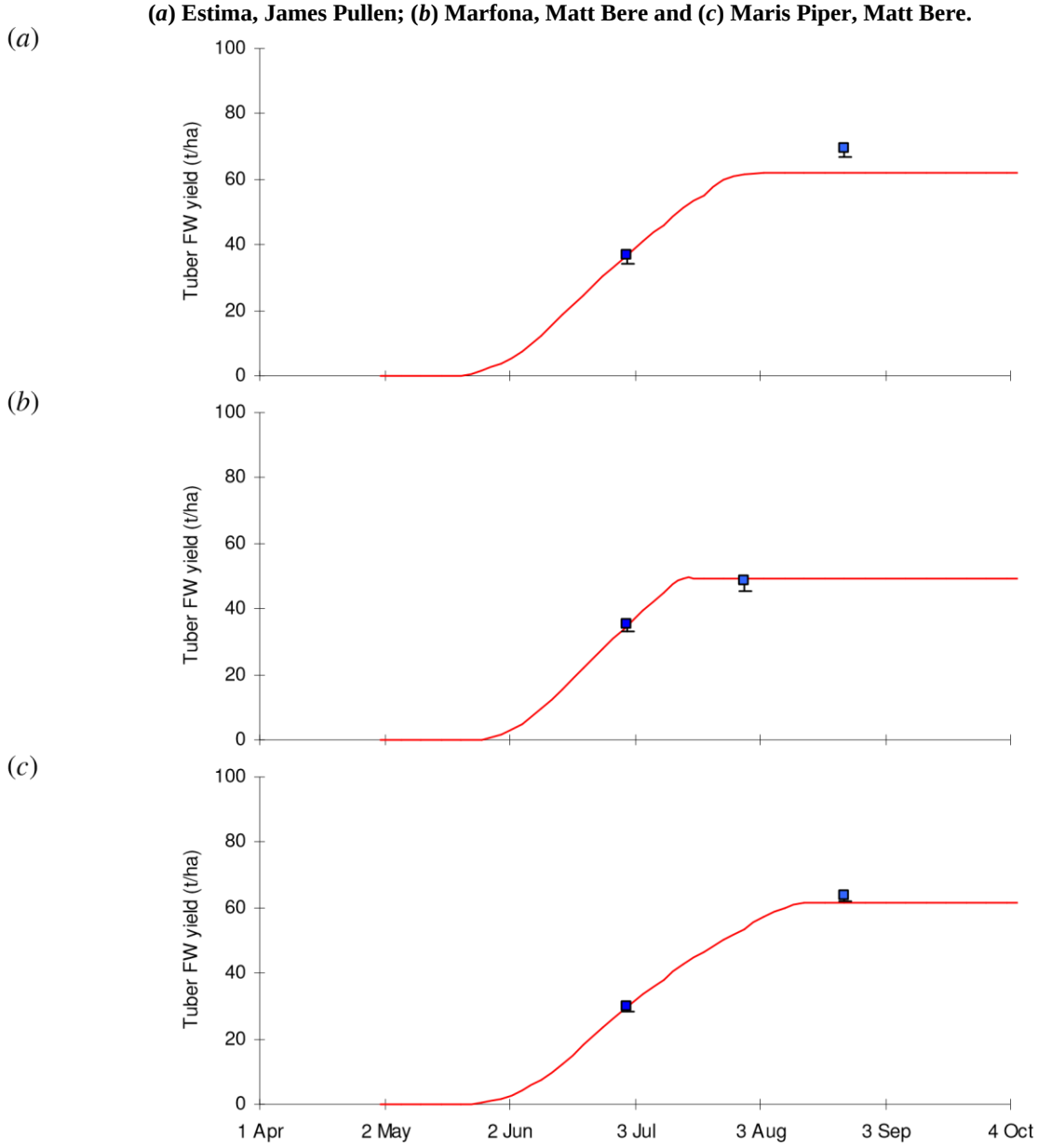
		Standard Crop 1 Jul	Standard Crop 24 Aug
Plants (000/ha)		30.1	31.0
		0.91	*1.82*
Stems (000/ha)		98.4	88.4
		6.82	*5.24*
Stems/plant		3.3	2.9
		0.25	*0.24*
Tubers (000/ha)		415	349
		14.9	*6.0*
Tubers (000/ha)	> 10 mm	22	140
		8.0	*10.5*
Tuber yield (t/ha)	> 60 mm	37.1	69.5
		2.77	*2.87*
Tuber yield (t/ha)	> 10 mm	5.0	46.1
		1.77	*4.87*
DM (%)	> 60 mm	13.8	16.4
		0.28	*0.50*
Mean tuber size (mm)		52.9	65.1
		1.00	*1.12*

Analysis of crop performance using the CUF yield model

Comparisons of sampled and modelled yields for the three SWAG crops monitored in 2009 are shown in Figure 20. In general there was good agreement between yields forecasted by the model and hand-dug sample. For the Estima crop, the model underestimated total FW yield and this was mainly due to the unusually small tuber dry matter concentration. The model was

expecting this crop to have a tuber DM of *c*. 18.5% but the measured tuber DM was 16.4 %. If the model forecast (62 t/ha) is corrected for the difference in tuber dry matter concentration then there is good agreement between modelled and measured yields. There was no evidence that the yield of any of these crops was limited by either water or disease and they achieved the potential set by their canopies.

Figure 20. Comparison of model output (red line), yield samples (blue symbol ± 1 S.E.) for standard crops of (*a*) Estima, James Pullen; (*b*) Marfona, Matt Bere and (*c*) Maris Piper, Matt Bere.



North Norfolk Potato Growers (NNPG)

Hermes seed rate comparison

Bakers 55

The Hermes crop in Bakers 55 was planted on 10 April and both the standard and modified crops achieved 50 % plant emergence 36 days later on 16 May. For the standard crop the intended and achieved plant populations were 42 900 and 41 900/ha, respectively whilst for the CUF modified crop the intended and achieved plant populations were 33 600 and 35 100/ha, respectively

(Figure 21). The achieved seed rates were 2.99 t/ha for the standard area and 2.50 t/ha for the CUF modified area. Ground cover expansion was similar in both the standard and modified crop and both achieved 100 % ground cover by the end of June. The standard crop started to senesce in late July whereas the modified crop persisted at complete ground cover for a further week. On 16 September total (> 10 mm) and marketable (> 40 mm) yields in the standard crop were 56.6 and 52.1 t/ha, respectively. In the modified crop, the total yield was 58.2 t/ha and the marketable yield was 55.8 t/ha. Both crops exceeded the target yield (50 t/ha) but due to the reduction in stem and tuber populations, the modified crop had a larger mean tuber size. The count > 40 mm for the standard crop was 85 tubers/10 kg compared with 74 tubers/10 kg for the modified crop. Tuber dry matter concentrations for both crops were acceptable for processing.

Long Lions

The Hermes crop in Long Lions was planted on 9 April and both standard and modified crops reached 50 % plant emergence on 22 May (43 DAP, Figure 22). The achieved plant population in the standard crop was smaller than intended whereas for the modified crop the achieved plant population was larger than intended. In consequence, the achieved within-row plant spacings were 29.3 cm for the standard crop compared with 27.6 cm for the modified crop. Initial expansion of ground cover was erratic in the modified crop, but both standard and modified crops reach full ground cover by late June and early July. It was noted that this crop was not uniform and there were many misses and doubles. The erratic spacing may have had an effect on ground cover expansion and, subsequently, also on tuber uniformity. The crops started to senesce in late July and the rate of senescence was slightly faster in the modified area. However, this difference in senescence is probably due to crop variability since the plant populations in both standard and modified areas were similar. Total and marketable yields on the 16 September were 57.0 and 54.7 t/ha, respectively, in the standard crop compared with 62.2 and 59.6 t/ha in the modified crop. Both crops exceeded the intended yield and both crops had similar mean tuber size (*c*. 58-59 mm) and count (70-72 tubers/10 kg). Tuber dry matters concentrations were similar in standard and modified areas and averaged 25 %. Because of the large disparity between intended and achieved populations, this comparison has been excluded from the summaries shown on pages 48 and 49.

Saturna seed rate comparison

The Saturna seed rate comparison was done in Bakers 27 field and is one of limited number of comparison where the modified plant population was larger than the standard. The field was planted on 7 April and the interval between planting and 50 % plant emergence was 43 and 46 days for the standard and modified crop, respectively (Figure 23). The planned and achieved plant populations in the standard area were 42 100 and 36 500/ha, respectively. In the modified area, the planned and achieved plant populations were 48 000 and 41 900/ha, respectively. Actual seed rates were 1.53 t/ha (standard) and 1.76 t/ha (modified). Ground cover expansion, persistence and the onset of senescence were similar in both the standard and modified areas. Complete ground cover was reached in the first week of July and was maintained until the end of July. Total yield on 16 September was 48.8 and 54.2 t/ha in the standard and modified areas, respectively, whereas ware yields (> 40 mm) were 46.4 and 50 t/ha, respectively. Despite the modified area having a larger yield, the mean tuber size was smaller than that recorded in the standard area and this was a consequence of having more stems and tubers. The count for the standard area was 68 compared with 77 tubers/10 kg for the modified area and tuber dry matter concentration ranged from 25.5 to 26.4 %. Despite, there being differences between the planned and achieved plant population in each comparison these data were included in the summary since the relative difference between seed rate in the standard and modified was maintained.

Saturna N rate comparison

The standard N application rate for the Saturna grown in Bakers 27 was 240 kg N/ha. On the basis of information supplied to CUF by NNPG, the CUF modified rate was reduced to 180 kg N/ha. Reducing the N application rate had no effect on the date of 50 % plant emergence which was 20 May (43 DAP) for both the standard and modified crops (Figure 24). The plant population was similar in both areas and averaged (37 600/ha, equivalent to 29.1 cm within-row spacing). Ground cover expansion was similar in both areas as was canopy persistence. Both crops started to senesce in late July but the subsequent rate of senescence was faster in the modified crop. Total and ware yields in the standard area were 48.8 and 46.4 t/ha, respectively. In the modified area, total and ware yields were 52.0 and 49.4 t/ha, respectively. Tuber dry matter concentrations were not affected by N application rate and averaged 25.4 % and the tuber count averaged *c.* 70/10 kg.

Hermes N rate comparison

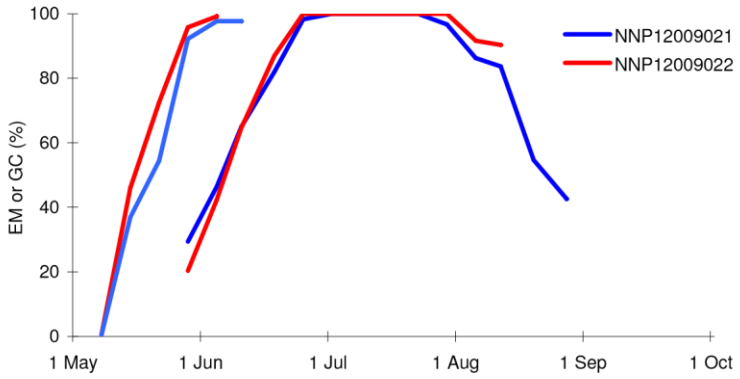
The Hermes N rate comparison was done in Long Lions field. The standard, achieved N application rate was 191 kg N/h and the modified N application rate was 181 kg N/ha. The difference in N application was planned to be larger (i.e. 220 compared with 180 kg N/ha) but some N top-dressings in the standard crop were omitted resulting in a less than 10 % difference in N application rates. The pattern of plant emergence and ground cover development was similar irrespective of N application rate and both areas attained 50 % plant emergence complete ground cover on similar dates (Figure 25). Total and ware yield were *c.* 4 t/ha larger in the reduced N areas compared with the standard area. Both crops, irrespective of the amount of N applied exceeded the intended yield of 45 t/ha. Tuber DM concentration averaged 24.7 % and the average tuber count was *c.* 71/10 kg.

Analysis of crop performance using the CUF yield model

Comparisons of sampled and modelled yields for standard seed and N rates of two Hermes and one Saturna crop monitored in 2009 are shown in Figure 26. In general, there was agreement between the model forecast and the hand-dug samples. This agreement suggests that the performance of these crops was not limited by either too much or too little water or by disease and thus the recorded yield was proportional to the amount of radiation absorbed by the canopy. For the Hermes grown in Long Lions the model overestimated the sample yield by *c.* 4 t/ha. This may be due to stress that was not accounted for by the model, but it is more likely that the yield samples underestimated the true yield of the standard area. If this were the case the yield of standard Hermes in Long Lions would be more similar to the yields recorded in either the modified seed or modified N areas.

Figure 21. NNPG Hermes seed rate comparison, Bakers 55.

Grower:	James Harrison	James Harrison
Field name:	Bakers 55	Bakers 55
Unique ID:	NNP12009021	NNP12009022
Part Field Name:	Standard Seed and Standard N	Modified Seed and Standard
Variety:	Hermes	N Hermes
Intended yield:	50 t/ha	50 t/ha
Intended use:	Crisping-Storage	Crisping-Storage
Intended mu (µ):	NA	58.5 mm
Planting date (start):	10 Apr	10 Apr
Date of 50 % emergence:	16 May	16 May
Total N applied:	220 kg N/ha	220 kg N/ha
Seed size:	40-50 mm	40-50 mm
Seed count:	702 per 50 kg	702 per 50 kg
Planned density:	42.9 000/ha	33.6 000/ha
Planned spacing:	25.5 cm	32.5 cm
Achieved density:	41.9 000/ha	35.1 000/ha
Achieved spacing:	26.1 cm	31.2 cm

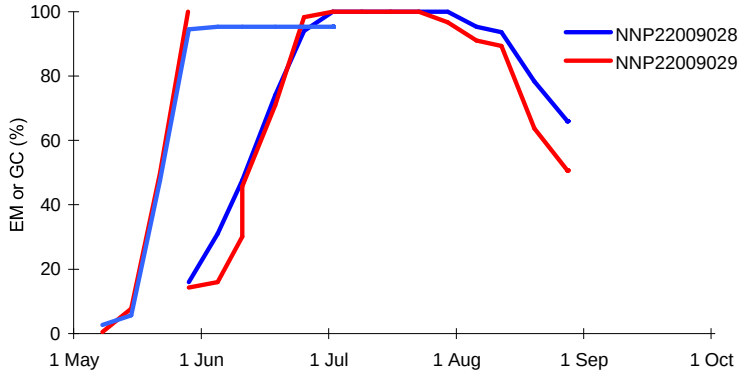


Yield Samples (S.E. in italics)

		Standard Seed and Standard N			Modified Seed and Standard N	
		8 Jul	16 Sep		8 Jul	16 Sep
		41.9	41.9		32.8	37.4
		2.35	*2.35*		*2.58*	*4.79*
Plants (000/ha)						
Stems (000/ha)	> 10 mm	158.6	156.8	> 10 mm	143.1	127.6
		13.02	*14.27*		*13.42*	*18.29*
Stems/plant	> 40 mm	3.8	3.7	> 40 mm	4.4	3.4
		0.20	*0.15*		*0.26*	*0.14*
Tubers (000/ha)	> 10 mm	465	613	> 10 mm	485	536
		68.8	*34.3*		*49.6*	*33.6*
Tubers (000/ha)	> 40 mm	262	443	> 40 mm	267	414
		40.9	*21.5*		*18.2*	*19.7*
Tuber yield (t/ha)		27.4	56.6		26.0	58.2
		3.68	*0.83*		*1.18*	*3.60*
Tuber yield (t/ha)		22.6	52.1		20.8	55.8
		3.30	*0.38*		*1.33*	*3.51*
DM (%)		16.8	23.4		17.7	22.7
		0.33	*0.20*		*0.26*	*0.01*
		46.0	53.7		45.8	57.0
		0.57	*1.29*		*0.67*	*0.94*

Figure 22. NNPG Hermes seed rate comparison, Long Lions.

Grower:	Toby Mermagen	Toby Mermagen
Field name:	Long Lions	Long Lions
Unique ID:	NNP22009028	NNP22009029
Part Field Name:	Standard Seed and Standard N	Modified Seed and Standard
Variety:	Hermes	N Hermes
Intended yield:	45 t/ha	50 t/ha
Intended use:	Crisping-Storage	Crisping-Storage
Intended mu (µ):	NA	58.5 mm
Planting date (start):	9 Apr	9 Apr
Date of 50 % emergence:	22 May	22 May
Total N applied:	191 kg N/ha	191 kg N/ha
Seed size:	40-50 mm	40-50 mm
Seed count:	702 per 50 kg	702 per 50 kg
Planned density:	42.7 000/ha	33.7 000/ha
Planned spacing:	26.0 cm	32.9 cm
Achieved density:	37.4 000/ha	39.6 000/ha
Achieved spacing:	29.3 cm	27.6 cm

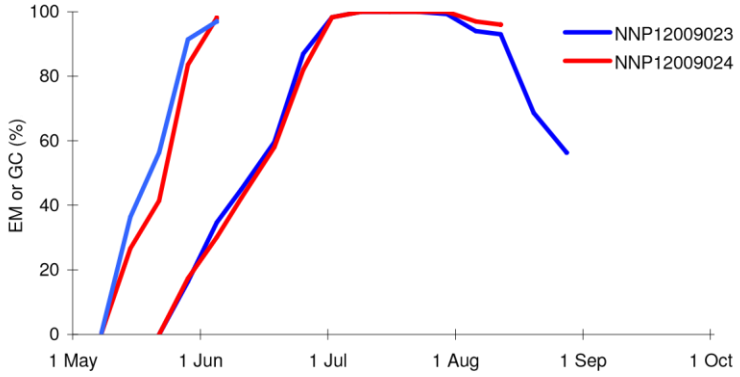


Yield Samples (S.E. in italics)

		Standard Seed and Standard N			Modified Seed and Standard N	
		8 Jul	16 Sep		8 Jul	16 Sep
		35.5	39.2		45.6	33.7
		1.75	*2.29*		*2.35*	*0.91*
Plants (000/ha)						
Stems (000/ha)		151.3	154.9	> 10 mm	188.6	138.5
		11.67	*7.06*		*11.07*	*4.94*
Stems/plant		4.2	4.0	> 40 mm	4.1	4.1
		0.16	*0.06*		*0.15*	*0.04*
Tubers (000/ha)		499	495	> 10 mm	540	528
		30.4	*37.4*		*40.7*	*25.7*
Tubers (000/ha)	> 10 mm	260	394	> 40 mm	276	415
		12.7	*19.3*		*14.2*	*30.1*
Tuber yield (t/ha)	> 40 mm	25.4	57.0		26.9	62.2
		1.74	*2.53*		*1.31*	*4.10*
Tuber yield (t/ha)	> 10 mm	19.8	54.7		21.0	59.6
		1.83	*2.22*		*1.12*	*3.94*
DM (%)	> 40 mm	16.9	24.9		16.8	25.0
		0.25	*0.27*		*0.33*	*0.41*
Mean tuber size (mm)		45.0	57.8		45.6	58.7
		0.64	*0.69*		*0.37*	*0.37*

Figure 23. NNPG Saturna seed rate comparison, Bakers 27.

Grower:	James Harrison	James Harrison
Field name:	Bakers 27	Bakers 27
Unique ID:	NNP12009023	NNP12009024
Part Field Name:	Standard Seed and Standard N	Modified Seed and Standard
Variety:	Saturna	N Saturna
Intended yield:	45 t/ha	50 t/ha
Intended use:	Crisping-Storage	Crisping-Storage
Intended mu (µ):	NA	51 mm
Planting date (start):	7 Apr	7 Apr
Date of 50 % emergence:	20 May	23 May
Total N applied:	240 kg N/ha	240 kg N/ha
Seed size:	30-40 mm	30-40 mm
Seed count:	1190 per 50 kg	1190 per 50 kg
Planned density:	42.1 000/ha	48.0 000/ha
Planned spacing:	26.0 cm	22.8 cm
Achieved density:	36.5 000/ha	41.9 000/ha
Achieved spacing:	30.0 cm	26.1 cm

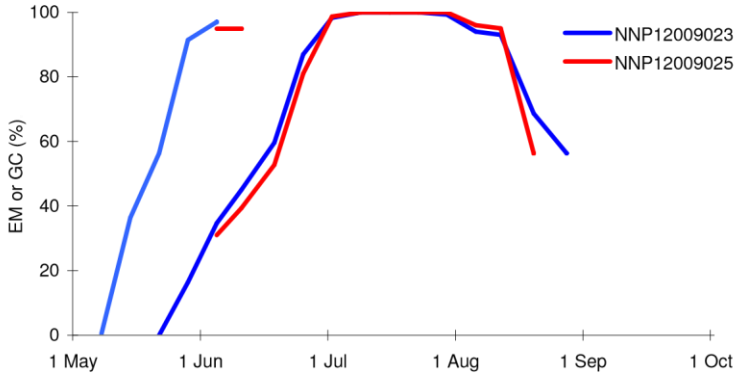


Yield Samples (S.E. in italics)

		Standard Seed and Standard N			Modified Seed and Standard N	
		8 Jul	16 Sep		8 Jul	16 Sep
		37.4	35.5		39.2	44.7
		3.11	*0.91*		*0.91*	*2.29*
Plants (000/ha)						
Stems (000/ha)	> 10 mm	120.3	115.7	> 10 mm	141.3	146.7
		5.37	*8.20*		*8.34*	*10.35*
Stems/plant	> 40 mm	3.3	3.3	> 40 mm	3.6	3.3
		0.33	*0.19*		*0.15*	*0.20*
Tubers (000/ha)	> 10 mm	353	387	> 10 mm	373	525
		38.8	*32.6*		*11.3*	*19.5*
Tubers (000/ha)	> 40 mm	200	316	> 40 mm	212	386
		29.2	*23.0*		*28.1*	*5.4*
Tuber yield (t/ha)		18.9	48.8		20.3	54.2
		2.57	*4.27*		*1.79*	*4.04*
Tuber yield (t/ha)		14.2	46.4		15.4	50.0
		2.39	*3.87*		*2.23*	*4.27*
DM (%)		20.3	25.5		20.7	26.4
		0.23	*0.17*		*0.45*	*0.25*
		43.8	57.8		44.0	54.7
		0.76	*0.77*		*0.91*	*1.92*

Figure 24. NNPG Saturna N rate comparison, Bakers 27.

Grower:	James Harrison	James Harrison
Field name:	Bakers 27	Bakers 27
Unique ID:	NNP12009023	NNP12009025
Part Field Name:	Standard Seed and Standard N	Standard Seed and Modified
Variety:	Saturna	N Saturna
Intended yield:	45 t/ha	45 t/ha
Intended use:	Crisping-Storage	Crisping-Storage
Intended mu (µ):	NA	NA
Planting date (start):	7 Apr	7 Apr
Date of 50 % emergence:	20 May	20 May
Total N applied:	240 kg N/ha	180 kg N/ha
Seed size:	30-40 mm	30-40 mm
Seed count:	1190 per 50 kg	1190 per 50 kg
Planned density:	42.1 000/ha	42.1 000/ha
Planned spacing:	26.0 cm	26.0 cm
Achieved density:	36.5 000/ha	38.7 000/ha
Achieved spacing:	30.0 cm	28.2 cm

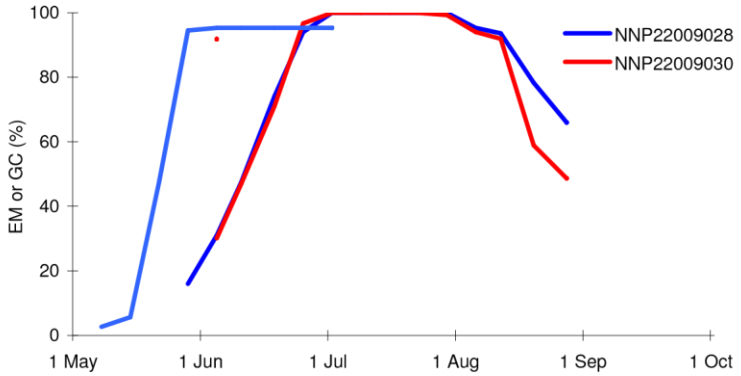


Yield Samples (S.E. in italics)

		Standard Seed and Standard N			Standard Seed and Modified N	
		8 Jul	16 Sep		8 Jul	16 Sep
		37.4	35.5		35.5	41.9
		3.11	*0.91*		*1.75*	*1.05*
Plants (000/ha)						
Stems (000/ha)		120.3	115.7	> 10 mm	108.4	102.1
		5.37	*8.20*		*6.38*	*3.33*
Stems/plant		3.3	3.3	> 40 mm	3.1	2.4
		0.33	*0.19*		*0.13*	*0.10*
Tubers (000/ha)		353	387	> 10 mm	364	430
		38.8	*32.6*		*27.0*	*12.9*
Tubers (000/ha)	> 10 mm	200	316	> 40 mm	250	353
		29.2	*23.0*		*14.1*	*8.5*
Tuber yield (t/ha)	> 40 mm	18.9	48.8		24.2	52.0
		2.57	*4.27*		*1.77*	*2.79*
Tuber yield (t/ha)	> 10 mm	14.2	46.4		20.6	49.4
		2.39	*3.87*		*1.39*	*2.68*
DM (%)	> 40 mm	20.3	25.5		20.8	25.3
		0.23	*0.17*		*0.18*	*0.27*
Mean tuber size (mm)		43.8	57.8		45.7	56.4
		0.76	*0.77*		*0.47*	*0.65*

Figure 25. NNPG Hermes N rate comparison, Long Lions.

Grower:	Toby Mermagen	Toby Mermagen
Field name:	Long Lions	Long Lions
Unique ID:	NNP22009028	NNP22009030
Part Field Name:	Standard Seed and Standard N	Standard Seed and Modified N Hermes
Variety:	Hermes	45 t/ha
Intended yield:	45 t/ha	Crisping-Storage
Intended use:	Crisping-Storage	NA
Intended mu (µ):	NA	
Planting date (start):	9 Apr	9 Apr
Date of 50 % emergence:	22 May	22 May
Total N applied:	191 kg N/ha	181 kg N/ha
Seed size:	40-50 mm	40-50 mm
Seed count:	702 per 50 kg	702 per 50 kg
Planned density:	42.7 000/ha	42.7 000/ha 26.0 cm
Planned spacing:	26.0 cm	41.9 000/ha
Achieved density:	37.4 000/ha	26.1 cm
Achieved spacing:	29.3 cm	



Yield Samples (S.E. in italics)

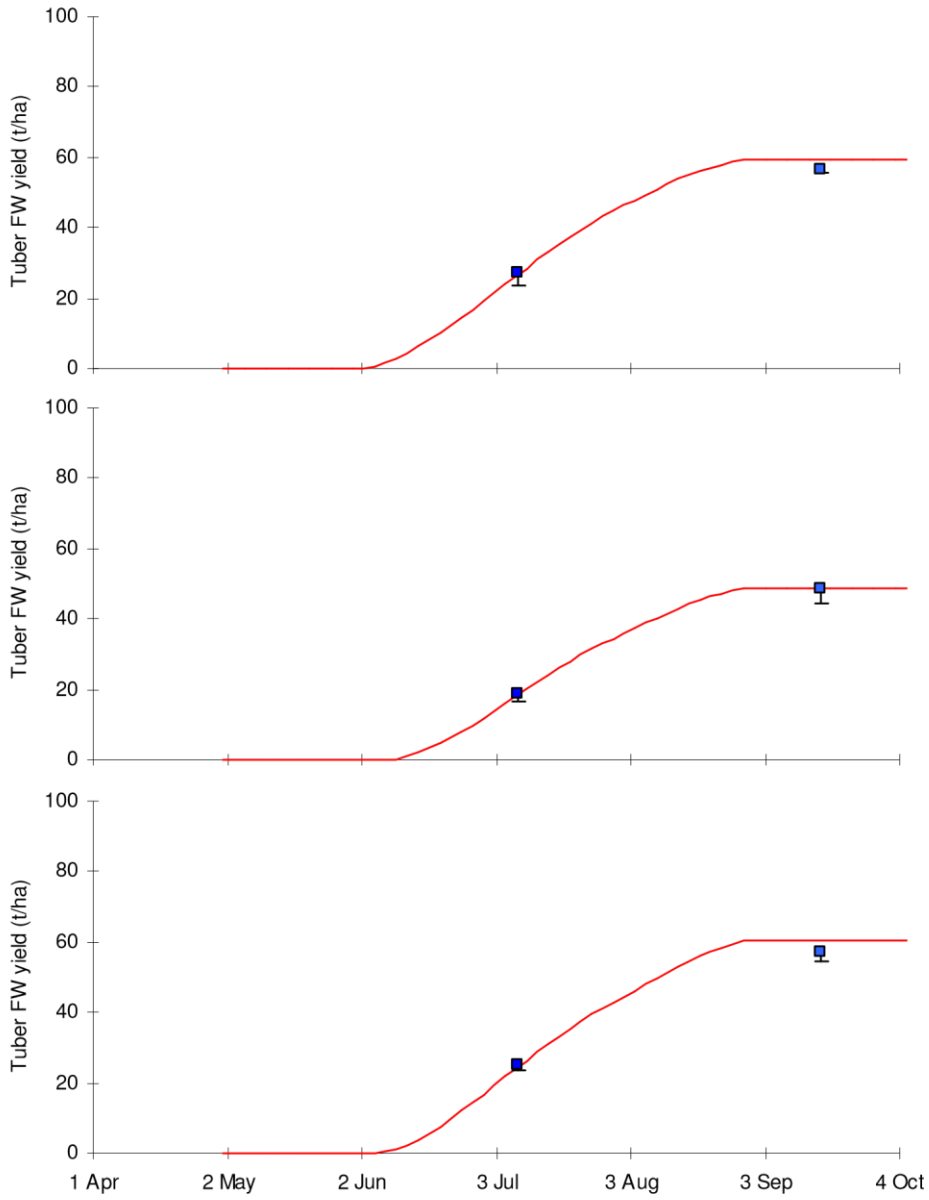
		Standard Seed and Standard N			Standard Seed and Modified N	
		8 Jul	16 Sep		8 Jul	16 Sep
		35.5	39.2		41.9	41.9
		1.75	*2.29*		*2.35*	*1.05*
Plants (000/ha)						
Stems (000/ha)	> 10 mm	151.3	154.9	> 10 mm	138.5	185.0
		11.67	*7.06*		*9.98*	*12.12*
Stems/plant	> 40 mm	4.2	4.0	> 40 mm	3.3	4.4
		0.16	*0.06*		*0.06*	*0.27*
Tubers (000/ha)	> 10 mm	499	495	> 10 mm	506	528
		30.4	*37.4*		*29.4*	*44.6*
Tubers (000/ha)	> 40 mm	260	394	> 40 mm	264	400
		12.7	*19.3*		*25.9*	*22.9*
Tuber yield (t/ha)		25.4	57.0		25.2	61.0
		1.74	*2.53*		*1.87*	*4.25*
Tuber yield (t/ha)		19.8	54.7		20.7	58.1
		1.83	*2.22*		*2.12*	*3.91*
DM (%)		16.9	24.9		17.0	24.4
		0.25	*0.27*		*0.50*	*0.32*
		45.0	57.8		45.7	59.4
		0.64	*0.69*		*0.50*	*0.42*

Figure 26. Comparison of model output (red line), yield samples (blue symbol ± 1 S.E.) for standard seed and N rate crops of (*a*) Hermes (Bakers 55); (*b*) Saturna (Bakers 27) and (*c*) Hermes (Long Lions).

(*a*)

(*b*)

(*c*)



Summary

A summary of the 2009 crop comparisons is given in Table 5. Three crops have been omitted from this table owing to failure to achieve the intended plant population. In total, seven comparisons were made of a reduced N rate, four comparisons were made of a reduced seed rate and one comparison used an increased seed rate. For crops where the rate of N was modified, the average reduction from standard practice was 27 kg N/ha and the average seed rate reduction was *c*. 0.5 t/ha.

Table 5. Summary of crop comparisons in 2009

Comparison	Number of crops	Difference in fertilizer (kg N/ha) or seed (t/ha)	Difference in total yield (t/ha)	Difference in yield > 40 mm (t/ha)
N reduced	7	–27	+0.09	–0.16
Seed rate reduced	4	–0.49	–1.24	+1.11
Seed rate increased	1	+0.23	+5.70	+3.60

Note: Comparisons of monitored crops were excluded from this summary where:
Achieved seed rates in the standard crops were smaller than planned and were close to modified seed rates (n=3)

On average, differences between the total and marketable yield of the standard and reduced-N crops were < 0.5 t/ha. On average, the total and marketable of the standard crop was slightly greater than for the reduced seed rate crop but the ware yield (> 40 mm) of the reduced seed rate crops was slightly greater. For the one crop where the seed application rate was increased, this was associated with an increase in total and marketable tuber yield of 5.7 and 3.6 t/ha, respectively. For both the N and seed rate comparisons, the average yield differences were small and so similar yields were achieved in the modified crops and standard crops with savings in both seed and fertilizer. In both sets of comparisons, means were dominated by some aberrant values for yields and thus yield differences between standard and modified crops were probably not real. However, when split-field comparisons are repeated over several seasons and sites it may be possible to get a better assessment of the true effects of any change in crop agronomy.

Table 6 summarises the effects of changes in agronomy on total and marketable tuber yields during 2007 to 2009. For three crops, an increase in seed rate was associated with a small numerical increase in total and marketable yield. Similarly, for the 31 comparisons completed, a reduction in either N or seed rates was on average associated with a small increase in marketable yield. Analysis of the reduced N and seed rate comparisons using T tests showed that differences in total and marketable yield between standard and modified crops were not significant (see Appendix, Table 10). A financial analysis done on a subset of crops in 2008 showed that there was the potential to save *c*. £110/ha in seed costs and *c*. £50/ha in N fertilizer cost whilst maintaining marketable yield. There is some evidence that growers involved in the program have started to change their standard agronomy to be become more similar to the modified agronomy. For example, in 2009 there were proportionally fewer

comparisons where differences between standard and modified agronomy were larger than 10 % than there were in
2007. In addition many growers have also included their own comparisons that are intermediate between their standard and the modified agronomy to enable a more gradual progression towards the full modification.

The proposed programme of work in 2010 is expected to be on a similar scale to previous seasons and will include some new collaborators to explore further opportunities to identify where inputs may be reduced without reducing marketable yields. **Table 6. Combined summary of crop comparisons in 2007, 2008 and 2009**

Comparison	Number of crops	Difference in fertilizer (kg N/ha) or seed (t/ha)	Difference in total yield (t/ha)	Difference in yield > 40 mm (t/ha)
N reduced†	12	–38	+1.7	+1.0
Seed rate reduced	19	–0.60	–0.8	+0.3
Seed rate increased	3	+0.25	+1.6	+0.4

Note: Comparisons of monitored crops were excluded from this summary where:
Achieved seed rates in the standard crops were smaller than planned and were close to modified seed rates (n=6) Nitrogen applications were smaller than planned (n=1) or PCN affected crop growth (n=1)

References

BOYD, D. A. (1972). Some recent ideas on fertilizer response curves. *Proceedings of the 9th Congress of International Potash Institute*, pp. 461-473.

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Appendix 1.

Table 7. Summary of all N rate comparison data collected in PCL/CUF grower collaboration project 2007-2009. Yield data are hand-dug samples taken at defoliation

Year	Grower	Field	Variety	Standard N applied (kg N/ha)	Modified N applied (kg N/ha)	Change in N applied (kg N/ha)	Standard yield > 10 mm (t FW/ha)	Modified yield > 10 mm (t FW/ha)	Change in yield > 10 mm (t FW/ha)	Standard yield > 40 mm (t FW/ha)	Modified yield > 40 mm (t FW/ha)	Change in yield > 40 mm (t FW/ha)
2007	MVP/TVP	Upper Trent	Russet Burbank	220	165	–55	59.5	67.6	8.1	56.4	64.1	7.7
2007	NNPG	Market Style	Saturna	240	175	–65	40.2	51.0	10.8	29.9	36.4	6.5
2008	MVP/TVP	MFL B*	Russet Burbank	200	160	–40	69.1	64.5	–4.6	52.8	46.8	–6.0
2008	NNPG	Malthouse	Saturna	240	175	–65	45.2	48.6	3.4	42.1	45.4	3.3
2008	NNPG	Horseshoes	Hermes	210	175	–35	50.4	53.6	3.2	47.4	50.9	3.6
2008	Strawson	Bower 8†	Hermes	193	169	–24	66.2	60.6	–5.6	63.8	58.2	–5.6
2008	A H Worth	Field 13	Maris Piper	180	140	–40	56.0	50.9	–5.1	53.3	47.9	–5.3
2009	MVP/TVP	Curborough	Markies	150	130	–20	56.4	55.7	–0.7	51.7	50.9	–0.9
2009	MVP/TVP	Deercote Barn	Maris Piper	220	200	–20	64.5	54.4	–10.1	59.9	48.6	–11.3
2009	NNPG	Bakers 27	Saturna	247	180	–67	48.8	52.0	3.2	46.4	49.4	3.1
2009	NNPG	Long Lions	Hermes	190	180	–10	57.0	61.0	4.0	54.7	58.1	3.4
2009	Strawson	Wood 10	Hermes	210	185	–25	37.6	44.0	6.4	35.3	41.4	6.1
2009	Strawson	Godfrey 13	Saturna	220	195	–25	63.1	58.9	–4.2	60.5	55.9	–4.6
2009	A H Worth	F38	Maris Piper	180	155	–25	71.4	72.6	1.1	69.8	70.7	0.9
			Average (n=12)	209	171	–38	54.2	55.9	1.7	50.6	51.6	1.1

*Not included in averages and summaries since crop severely affected by potato cyst nematode. † Not included since both N rates were less than intended

Table 8. Summary of all seed rate comparison data (seed rate increased) collected in PCL/CUF grower collaboration project 2007-2009. Yield data are hand-dug samples taken at defoliation

Year	Grower	Field	Variety	Standard seed rate (t/ha)	Modified seed rate (t/ha)	Change in seed rate (t/ha)	Standard yield > 10 mm (t FW/ha)	Modified yield > 10 mm (t FW/ha)	Change in yield > 10 mm (t FW/ha)	Standard yield > 40 mm (t FW/ha)	Modified yield > 40 mm (t FW/ha)	Change in yield > 40 mm (t FW/ha)
2007	MVP/TVP	Thorpe 41	Saturna	1.38	1.59	0.22	54.2	50.1	–4.1	51.8	46.1	–5.7
2007	Strawson	Godfrey	Saturna	2.42	2.73	0.31	69.0	72.4	3.4	67.4	70.7	3.3
2009	NNPG	Bakers 27	Saturna	1.53	1.76	0.23	48.8	54.2	5.4	46.4	50.0	3.7
			Average (n=3)	1.78	2.03	0.25	57.3	58.9	1.6	55.2	55.6	0.4

Table 9. Summary of all seed rate comparison data (seed rated increased) collected in PCL/CUF grower collaboration project 2007-2009. Yield data are handdug samples taken at defoliation

Year	Grower	Field	Variety	Standard seed rate (t/ha)	Modified seed rate (t/ha)	Change in seed rate (t/ha)	Standard yield > 10 mm (t FW/ha)	Modified yield > 10 mm (t FW/ha)	Change in yield > 10 mm (t FW/ha)	Standard yield > 40 mm (t FW/ha)	Modified yield > 40 mm (t FW/ha)	Change in yield > 40 mm (t FW/ha)
2007	MVP/TVP	Ellis B	Hermes	2.89	2.47	–0.42	64.4	75.8	11.4	60.5	71.9	11.4
2007	MVP/TVP	Thorpe 41	Saturna	3.18	2.47	–0.71	58.8	51.4	–7.4	56.0	46.5	–9.5
2007	NNPG	Site X	Saturna	2.57	2.15	–0.41	68.7	62.8	–5.9	64.7	59.9	–4.8
2007	NNPG	Site X1	Hermes	3.07	2.16	–0.91	49.8	54.0	4.2	45.5	51.0	5.5
2007	Strawson	Knights Narborough	Saturna	2.30	2.11	–0.20	51.0	49.8	–1.2	48.2	47.8	–0.4
2007	Strawson	Shammar Creake	Hermes	3.43	2.46	–0.97	47.5	46.8	–0.7	46.9	46.4	–0.5
2007	Strawson	Bower Carburton	Hermes	4.39	2.81	–1.58	55.5	58.6	3.1	52.3	56.7	4.4
2008	MVP/TVP	Bowling Alley	Lady Rosetta	3.45	3.04	–0.41	66.9	64.7	–2.1	62.2	60.9	–1.2
2008	MVP/TVP	Packington Quarry	Hermes	4.00	2.72	–1.29	57.8	55.0	–2.8	51.8	49.9	–1.9
2008	NNPG	Millfield	Hermes	2.31	1.51	–0.80	53.9	59.3	5.5	49.0	56.8	7.7
2008	NNPG	Malthouse	Saturna	2.15	1.96	–0.20	45.2	43.3	–1.9	42.1	41.3	–0.8
2008	NNPG	Horseshoes	Hermes	2.46	2.00	–0.46	50.4	53.6	3.2	47.4	51.7	4.3
2008	Strawson	Bower 8	Hermes	3.16	2.47	–0.69	66.2	57.9	–8.3	63.8	56.2	–7.6
2008	Strawson	Hoggard 6*	Saturna	2.21	2.03	–0.18	67.6	60.1	–7.5	62.6	56.5	–6.1
2008	Strawson	Godfrey 8	Saturna	2.61	2.50	–0.11	50.6	52.0	1.5	46.8	48.5	1.6

2008	A H Worth	Field 69*	Estima	2.33	1.85	–0.48	59.0	59.6	0.6	56.5	56.1	–0.5
2008	A H Worth	Field 69*	Estima	3.00	2.59	–0.41	59.2	69.8	10.6	56.1	67.1	10.9
2008	A H Worth	Field 13	Maris Piper	1.49	1.13	–0.36	64.4	56.0	–8.4	59.9	53.3	–6.7
2009	MVP/TVP	Barnes*	Lady Rosetta	1.48	1.23	–0.25	57.6	51.1	–6.5	52.3	48.5	–3.8
2009	MVP/TVP	Barnes	Lady Rosetta	2.27	1.88	–0.39	54.5	52.2	–2.3	46.2	48.5	2.3
2009	NNPG	Bakers 55	Hermes	2.98	2.50	–0.49	56.6	58.2	1.6	52.1	55.8	3.7
2009	NNPG	Long Lions*	Hermes	2.66	2.82	0.16	57.0	62.2	5.2	54.7	59.6	4.9

Table 9. continued

2009	Strawson	Sansom Wood 14	Hermes	2.80	2.30	–0.50	42.3	39.6	–2.7	38.7	37.5	–1.2
2009	A H Worth	Jep44*	Estima	2.25	2.12	–0.13	60.1	55.2	–4.9	58.7	54.0	–4.7
2009	A H Worth	Jep44	Estima	3.51	2.91	–0.60	67.8	66.2	–1.6	65.8	65.1	–0.7
			Average (n=19)	2.89	2.29	–0.60	56.4	55.7	–0.78	52.6	52.9	0.30

* Excluded from averages and summaries since achieved seed rates different from intended

Appendix 2

Table 10. Summary statistics comparing standard seed and N rates with modified for all comparison and restricted to valid comparisons. P is the probability that the difference between standard and modified agronomy is zero

	Tuber yield > 10 mm (t/ha)		Tuber yield > 40 mm (t/ha)	
Comparison	Standard	Reduced	Standard	Reduced
N rate All data (n=14)	56.1 (± 2.81)	56.8 (± 2.10)	51.7 (± 2.91)	51.8 (± 2.40)
Difference	+0.7 (± 1.60) t/ha; P = 0.662		+0.1 (± 1.54) t/ha; P = 0.975	
Summary (n=12)	54.2 (± 2.91)	55.9 (± 2.33)	50.6 (± 3.23)	51.6 (± 2.73)
Difference	+1.7 (± 1.71); P = 0.345		+1.0 (± 1.63); P = 0.541	
Seed rate All data (n=25)	57.3 (± 1.48)	56.6 (± 1.60)	53.6 (± 1.49)	53.9 (± 1.57)
Difference	–0.7 (± 1.09) t/ha; P = 0.525		+0.3 (± 1.10) t/ha; P = 0.809	
Summary (n=19)	56.4 (± 1.86)	55.6 (± 1.92)	52.6 (± 1.86)	52.9 (± 1.88)
Difference	–0.8 (± 1.15) t/ha; P = 0.498		+0.3 (± 1.21) t/ha; P = 0.804	

Grower Collaboration Project (R295) Report for 2010

M F Allison & D M Firman

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Introduction

This is the fourth year of the project and its objectives were to collaborate with growers in planning the agronomic components of their potato production systems utilising current agronomic knowledge and documenting the process and differences from previous practice. The project aims to examine the accuracy of the agronomic decisions in relation to crop growth, potential yield and timing of harvest, meeting irrigation requirements and other criteria. Collaboration was undertaken with the following growers and grower groups: Branston Holdings Ltd, The Co-operative Farms, South West Agronomy Group (SWAG), R S Cockerill Ltd and A H Worth & Co.

Materials and Methods

Information on cropping plans, including varieties, seed stocks, intended planting date and yield, target tuber size, seed rates, soil data and fertilizer application rates, was obtained from collaborating growers. Fertilizer and seed rate recommendations were calculated for some of the crops using the information supplied. The dates of seed crop emergence and ware crop planting were factors accounted for in determining CUF seed rate recommendations but these were not used by growers to determine their 'standard' seed rates (except for SWAG growers already using CUF advice). Cases where the current 'standard' grower's plans differed substantially (*i.e.* by at least 10 %) from recommendations based on the best information available to CUF were identified and opportunities for making comparisons of 'standard' with 'CUF modified' recommendations discussed. In each case, generally a width of *c.* 24 m within a field received modified agronomy whilst standard agronomy was applied to the rest of the field. These unreplicated comparisons are not experiments and their limitations must be appreciated in regard to any confounding influences on the results and the variation associated with estimates of the variates recorded, particularly of crop samples from limited areas. In other cases, even where there were no substantial differences between 'standard' and 'CUFmodified' recommendations, crops were identified with a view to recording performance in relation to agronomic inputs and environmental conditions. Opportunities for additional experiments and data collection were discussed and a nitrogen fertilizer experiment was conducted at one site. A set of protocols and templates for data recording were sent to growers for recording the appropriate data on the crops so that each grower could collect data and send updates to CUF during the season. Staff from CUF visited most of the crops following establishment and some

data were collected during these visits to complement data collected by growers. Emergence, ground cover and yield data were usually collected from three or four replicate areas. To complement meteorological data available for the sites, data from a calibrated pyranometer (Campbell CS300) installed at each site was collected on a logger (Tiny-Tag RE-ED) to provide daily total incident radiation data.

Results and Discussion

Sites and monitored crops

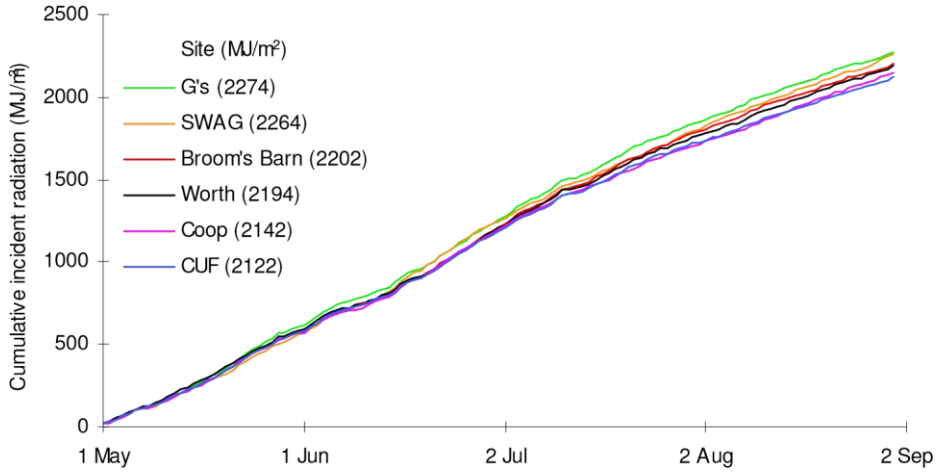
In 2010 a total of 23 crops were monitored and key details for these crops are shown Table 1. For some crops the 'standard' was used for comparisons against both modified seed and modified N rates.

Table 1. Summary of crops monitored as part of PCL/CUF grower collaboration program in 2010

Grower group	Sector	Varieties in program	Number of seed rate comparisons	Number of N rate comparisons
A H Worth & Co	Fresh	Marfona & Melody	1	2
Co-operative Farms	Fresh	Estima	1	1
SWAG	Fresh	Estima & Sante	No comparisons	
Branston Ltd	Fresh	Desiree & King Edward	1	1
R S Cockerill Ltd	Processing	Hermes & Saturna	3	3

Cumulative (May to August) incident radiation for CUF, Broom's Barn (Higham, Suffolk) and four grower collaboration sites is shown in Figure 1. Missing data (caused by the logger overwriting previous records or not logging by 1 May) were replaced with data from the nearest available sites. No data were available for the Cockerills Site in County Durham. Cumulative, May to August total incident radiation at CUF in 2010 was 2122 MJ/m^2. For comparison total incident radiation in 2008 and 2009 was 2005 and 2135 MJ/m^2, respectively. In 2010, the difference between the brightest Grower Collaboration site (SWAG) and the dullest (Co-operative Farms) was 122 MJ/m^2. This difference was smaller than that found in 2008 (161 MJ/m^2) and 2009 (260 MJ/m^2) and is unlikely to have had much effect on yield potential since the rate of crop establishment, canopy expansion and persistence tend to have much larger effects on yield.

Figure 1. Cumulative incident radiation May-August 2010 at Cambridge, Broom's Barn and collaboration sites.



A H Worth

This was the third year of collaborative work involving A H Worth and CUF. Analysis of cropping plans showed that there were opportunities to reduce N and seed application rates in a crop of Marfona at one site (Field 26/27) and opportunities to reduce N application rates in a crop of Melody (JEP 28). The seed for the Marfona crop emerged on 20 May 2009 and using information on intended ware crop planting date (26 March), intended yield (60 t/ha) and size specification, it was decided that this crop specification could be achieved with a reduced seed rate. Similarly, examination of previous cropping, soil type, variety and intended season length suggested that N application rates for the Marfona crop could be reduced by 30 kg N/ha and by 25 kg N/ha for the crop of Melody. Thus in 2010, the plan was to compare standard and modified seed rates in one crop (Marfona) and standard and modified N rates in two crops (Marfona and Melody).

Marfona seed rate comparison

The Marfona crop was planted on 13 April (three weeks later than intended). The standard and modified crops both achieved 50 % plant emergence on 15 May (32 days after planting). Harvest data showed that for both the standard and modified crops the achieved plant population were less than those planned. For example, the planned plant density in the standard crop was 35 400/ha (equivalent to an average 30.9 cm within row spacing) whereas the achieved population was 28 300/ha (38.7 cm spacing), Figure 2. For the standard and modified crops, ground cover expansion was similar and both crops attained complete (100 %) ground cover. Canopy persistence was similar in both crops and both crops had just started to senesce before they were defoliated on 24 July. At final harvest on 4 August, total and yield > 60 mm were numerically larger in the area with a smaller plant population. However, these differences in yield cannot easily be attributed to the observed differences in plant population.

Marfona N rate comparison

This comparison was done in Field 26/27 where the previous crop was peas and, since the soil should be nutrient retentive, where the amount of residual N should have been moderately large. The modified N application rate was 30 kg N/ha less than that in the standard area. When compared with the standard N application rate, reducing the amount of N applied had no effect on the date of 50 % plant emergence or on the rate of ground cover expansion, canopy persistence and rate of canopy senescence (Figure 3). Plant populations in the standard N and modified N areas were similar (28 300 and 27 300/ha, respectively). Numerically, total and yield > 60 mm were larger in the area that had received less N, but these differences in yield are unlikely to be due to the 30 kg N/ha difference in N application rate.

Melody N rate comparison

The crop of Melody in JEP28 was also grown on water and nutrient retentive soil and where residual N from the previous pea crop should have been relatively large. The Melody crop was planted on 20 April and both the standard (180 kg N/ha) and modified crops (155 kg N/ha) achieved 50 % plant emergence on 15 May (25 days after planting). The achieved plant population in the standard and modified areas were 26 900 and 25 500/ha, respectively (Figure 4). For both crops the achieved populations were less than that intended (28 100). In general, the pattern of ground cover expansion, persistence and senescence was similar in both the standard and reduced N areas. However, the most notable feature was that neither crop managed to achieve complete ground cover and both crops had started to senesce by early July. The target total yield for this crop was 60 t/ha but as consequence of the poor ground cover neither crop achieved this target, although the total yield was numerically larger in the area that had received less N.

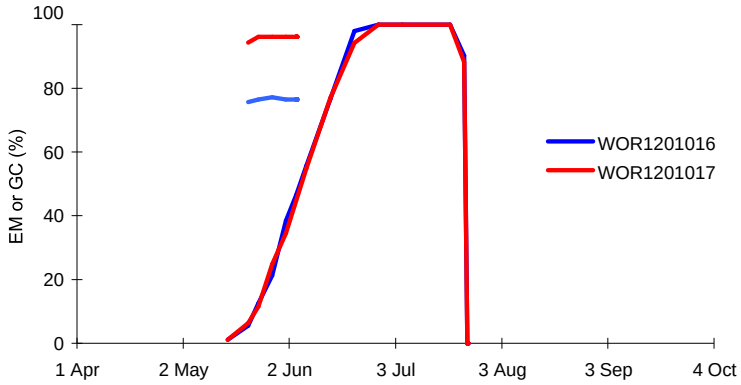
Analysis of crop performance using the CUF yield model

The yield model developed at CUF can use information on the environment (principally incident radiation) and the crop (emergence and ground cover) to help understand the performance of crops. Figure 5 compares the yield predicted by the model with yield digs taken in the middle and at the end of the season. The mid-season samples are used to parameterise the model and thus there should always be good agreement between the model and these samples. Once standard errors were considered, there was reasonable agreement between the observed final yield of the standard Marfona crop and the modelled yield (Figure 5*a*). The good agreement between the observed and modelled yields suggests that the efficiency with which the standard Marfona crop converted absorbed radiation into tuber yield was not greatly affected by factors such as drought or heat stress, water logging or disease since these factors are not explicitly included within the CUF yield model. For both the modified seed (Figure 6*b*) and modified N crops (Figure 6*c*) the observed yield was larger than would be expected from the model. On the basis of their ground covers, the CUF model predicted a yield of *c*. 52 t/ha for both of modified crops. These data suggest, that numeric differences between the modified and standard crops may have been due to the samples in modified crops overestimating the yield. For the standard and modified crops of Melody there was good agreement between the observed and modelled yields (Figure 6*a* and *b*,

respectively). These data suggest that the poor yields of this crop were mainly a consequence of an inadequate crop canopy. The most likely explanation for this is that this crop was grown on compacted soils which restricted water and nutrient uptake and the effects of the compaction were exacerbated by the hot and dry weather in June and early July. Despite the Melody crop struggling to achieve complete ground cover and maintain a productive canopy there was no evidence that this crop's problems were exacerbated when the N application rate was reduced. (see also report for the Co-operative Farm Estima crop p. 15).

Figure 2. A H Worth Marfona seed rate comparison, Field 26/27

Grower:	AH Worth & Co Field	AH Worth & Co
Field name:	26/27	Field 26/27
Unique ID:	WOR1201016	WOR1201017
Part Field Name:	Standard Seed & Standard N	Modified Seed & Standard N
Variety:	Marfona	Marfona
Intended yield:	60 t/ha	60 t/ha
Intended use:	Bakers	Bakers
Intended mu (µ):	65 mm	65 mm
Planting date (start):	13 Apr	13 Apr
Date of 50 % emergence:	15 May	15 May
Total N applied:	180 kg N/ha	180 kg N/ha
Seed size:	45-55 mm	45-55 mm
Seed count:	551 per 50 kg	551 per 50 kg
Planned density:	35.4 000/ha	28.1 000/ha
Planned spacing:	30.9 cm	38.9 cm
Achieved density:	28.3 000/ha	25.1 000/ha
Achieved spacing:	38.7 cm	43.6 cm

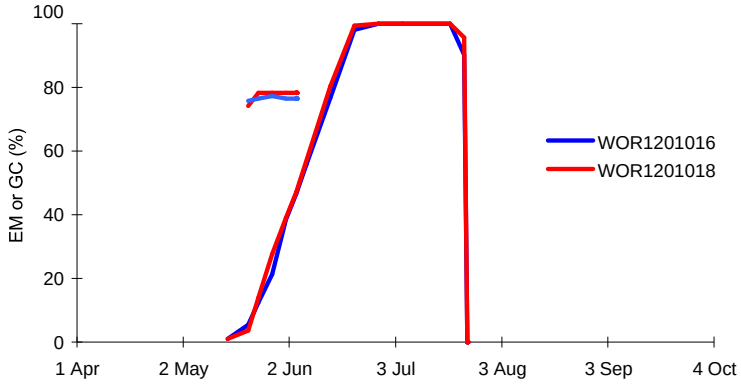


Yield Samples (S.E. in italics)

		Standard Seed & Standard N			Modified Seed & Standard N	
		2 Jul	4 Aug		2 Jul	4 Aug
Plants (000/ha)		30.1	26.4		25.5	24.6
		0.91	*2.29*		*1.49*	*0.91*
Stems (000/ha)		132.1	90.2		99.3	115.7
		10.97	*6.02*		*4.79*	*8.73*
Stems/plant		4.4	3.5		3.9	4.7
		0.26	*0.39*		*0.18*	*0.24*
Tubers (000/ha)		361	310		301	366
		14.7	*26.1*		*4.8*	*18.1*
Tubers (000/ha)	> 10 mm	24	155		44	168
		6.9	*18.5*		*4.5*	*6.1*
Tuber yield (t/ha)	> 60 mm	29.1	54.8		27.4	63.3
		1.34	*3.46*	> 10 mm	*1.26*	*1.98*
Tuber yield (t/ha)	> 10 mm	4.4	42.9		8.8	48.4
		1.25	*5.46*	> 60 mm	*0.71*	*2.17*
DM (%)	> 60 mm	14.4	18.2		13.9	18.2
		0.04	*0.53*	> 10 mm	*0.39*	*0.21*
Mean tuber size (mm)		53.1	67.9		56.0	67.7
		1.19	*1.90*	> 60 mm	*0.46*	*0.91*

Figure 3. A H Worth Marfona, N rate comparison, Field 26/27.

Grower:	AH Worth & Co Field	AH Worth & Co Field
Field name:	26/27	26/27
Unique ID:	WOR1201016	WOR1201018
Part Field Name:	Standard Seed & Standard N	Standard Seed & Modified N
Variety:	Marfona	Marfona
Intended yield:	60 t/ha	60 t/ha
Intended use:	Bakers	Bakers
Intended mu (µ):	65 mm	65 mm
Planting date (start):	13 Apr	13 Apr
Date of 50 % emergence:	15 May	15 May
Total N applied:	180 kg N/ha	150 kg N/ha
Seed size:	45-55 mm	45-55 mm
Seed count:	551 per 50 kg	551 per 50 kg
Planned density:	35.4 000/ha	35.4 000/ha
Planned spacing:	30.9 cm	30.9 cm
Achieved density:	28.3 000/ha	27.3 000/ha
Achieved spacing:	38.7 cm	40.0 cm

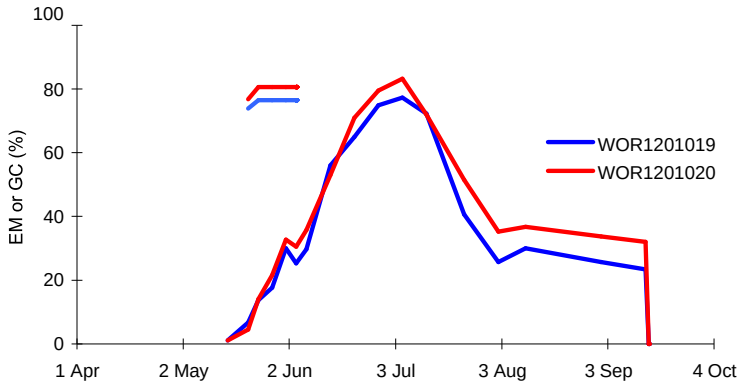


Yield Samples (S.E. in italics)

		Standard Seed & Standard N			Standard Seed & Modified N	
		2 Jul	4 Aug		2 Jul	4 Aug
Plants (000/ha)		30.1	26.4		29.2	25.5
		0.91	*2.29*		*0.00*	*1.49*
Stems (000/ha)		132.1	90.2		130.3	109.4
		10.97	*6.02*		*2.29*	*8.29*
Stems/plant		4.4	3.5		4.5	4.3
		0.26	*0.39*		*0.08*	*0.36*
Tubers (000/ha)		361	310		365	347
		14.7	*26.1*		*6.1*	*25.6*
Tubers (000/ha)	> 10 mm	24	155		30	156
		6.9	*18.5*		*5.2*	*7.3*
Tuber yield (t/ha)	> 60 mm	29.1	54.8		30.2	60.9
		1.34	*3.46*	> 10 mm	*0.95*	*2.60*
Tuber yield (t/ha)	> 10 mm	4.4	42.9		5.5	45.5
		1.25	*5.46*	> 60 mm	*0.97*	*2.29*
DM (%)	> 60 mm	14.4	18.2		14.2	18.0
		0.04	*0.53*	> 10 mm	*0.42*	*0.24*
Mean tuber size (mm)		53.1	67.9		54.8	68.3
		1.19	*1.90*	> 60 mm	*0.49*	*1.36*

Figure 4. A H Worth Melody N rate comparison, JEP28

Grower:	AH Worth & Co JEP28	AH Worth & Co
Field name:	WOR1201019	JEP28
Unique ID:	Standard Seed & Standard N	WOR1201020
Part Field Name:	Melody	Standard Seed & Modified N
Variety:	60 t/ha	Melody
Intended yield:	Bakers	60 t/ha
Intended use:	65 mm	Bakers
Intended mu (µ):		65 mm
Planting date (start):	20 Apr	20 Apr
Date of 50 % emergence:	15 May	15 May
Total N applied:	180 kg N/ha	155 kg N/ha
Seed size:	35-45 mm	35-45 mm
Seed count:	844 per 50 kg	844 per 50 kg
Planned density:	28.1 000/ha	28.1 000/ha
Planned spacing:	38.9 cm	38.9 cm
Achieved density:	26.9 000/ha	25.5 000/ha
Achieved spacing:	40.7 cm	42.9 cm



Yield Samples (S.E. in italics)

		Standard Seed & Standard N			Standard Seed & Modified N	
		2 Jul	23 Sep		2 Jul	23 Sep
Plants (000/ha)		25.5	28.3		24.6	26.4
		1.49	*0.91*		*0.91*	*0.91*
Stems (000/ha)		146.7	152.2		144.9	200.5
		5.24	*17.63*		*8.20*	*11.81*
Stems/plant		5.8	5.4		5.9	7.6
		0.30	*0.54*		*0.31*	*0.63*
Tubers (000/ha)		412	514		382	524
		44.0	*16.6*		*7.5*	*25.6*
Tubers (000/ha)	> 10 mm	0	19		0	21
		0.0	*5.2*		*0.0*	*5.6*
Tuber yield (t/ha)	> 60 mm	15.9	44.2		14.2	46.5
		0.44	*1.34*		*0.35*	*1.62*
Tuber yield (t/ha)	> 10 mm	0.0	4.8	> 10 mm	0.0	5.4
		0.00	*1.42*		*0.00*	*1.38*
DM (%)	> 60 mm	20.0	21.4	> 60 mm	19.7	22.7
		0.47	*0.51*		*0.38*	*0.18*
Mean tuber size (mm)		37.4	50.5	> 10 mm	36.9	51.2
		1.09	*0.76*	> 60 mm	*0.29*	*0.69*

Figure 5. Comparison of model output (red line) and yield samples (blue symbol ± 1 S.E.) for Marfona Field 26/27 (*a*) standard crop, (*b*) modified seed rate and (*c*) modified N rate.

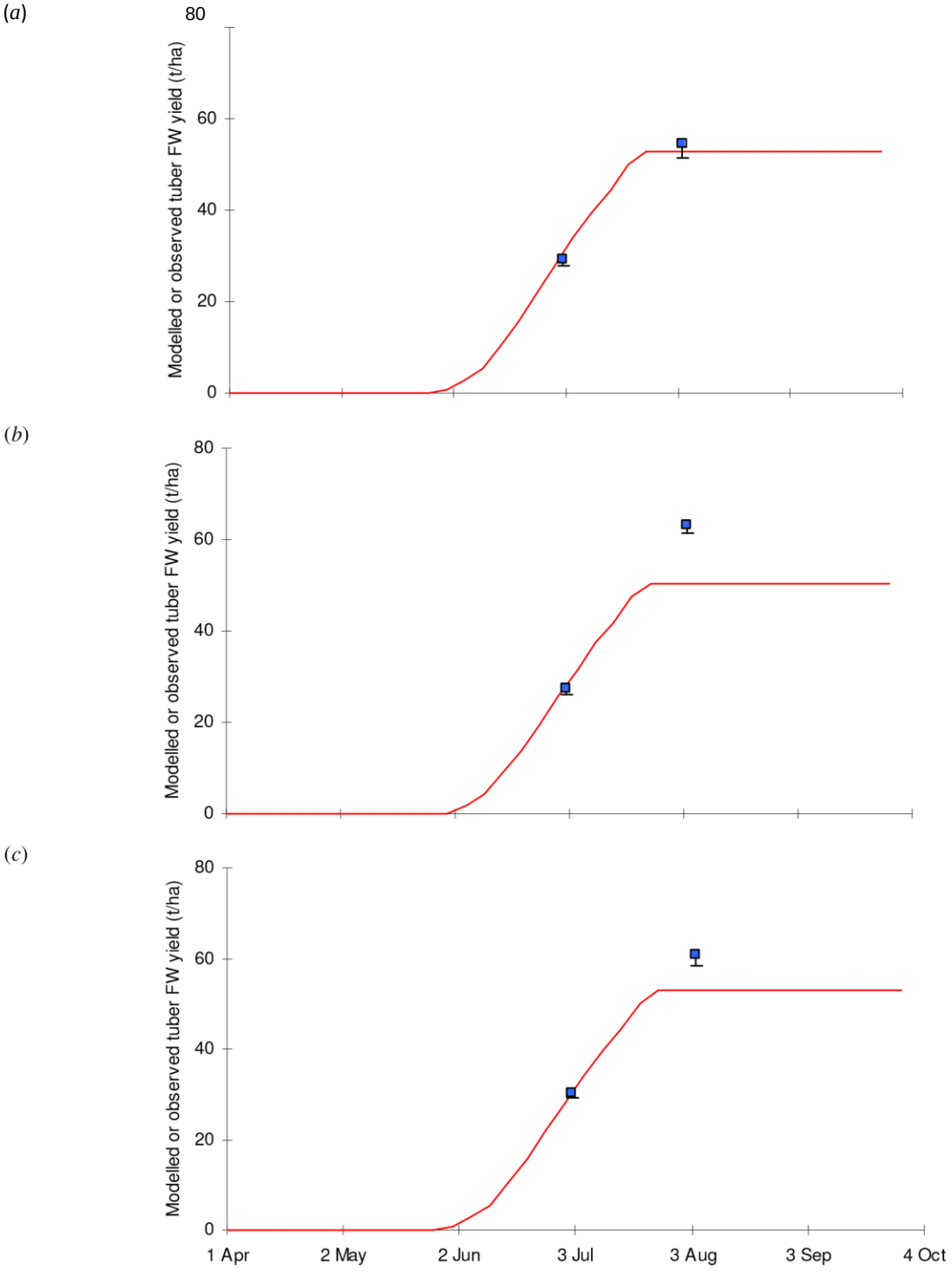
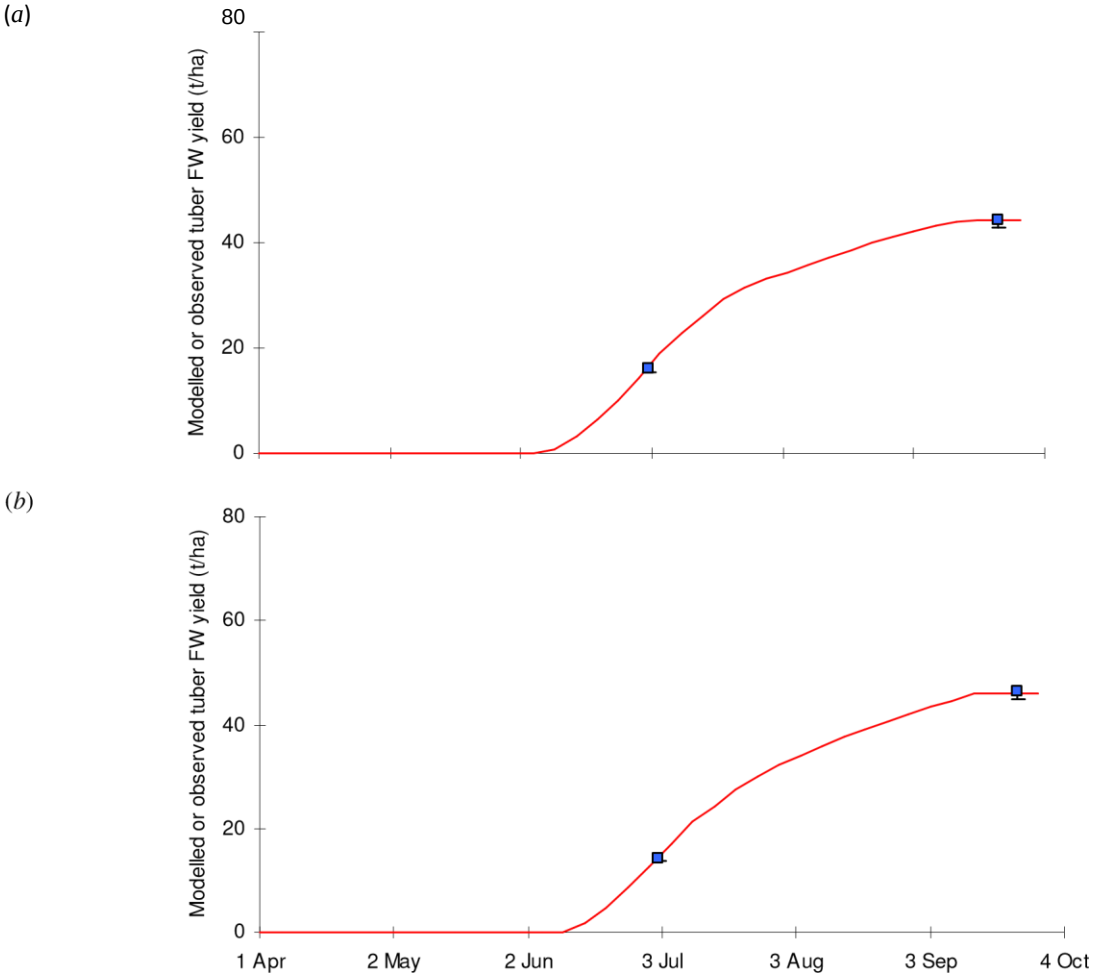


Figure 6. Comparison of model output (red line) and yield samples (blue symbol ± 1 S.E.) for Melody JEP28 (*a*) standard crop and (*b*) modified N rate.



Effect of N application rates on yields of Marfona grown on a silt-textured soil

Introduction

This experiment was designed to complement the Potato Council Grower Collaboration Project comparisons of "grower" and "CUF Modified" N application rates in a crop of Marfona grown in Field 26/27by A H Worth at Holbeach Hurn.

Materials and Methods

The experiment was done in Field 26/27 on land farmed by A H Worth, Holbeach Hurn, Lincolnshire (Ordnance Survey Grid Reference TF407279) and tested the effects of N application rate (0, 50, 100, 150, 200, 250 and 300 kg N/ha) on the growth and yield of Marfona. Each treatment was replicated five times and allocated at random to blocks. The experimental area received 50 kg P_2O_5/ha and 340 kg K_2O/ha as part of the standard farm practice but no N fertilizer was applied. Each plot was 5 m long and four rows (3.66 m) wide and Marfona seed (E1, 45–55 mm, average weight 90.7 g) was planted by hand-dibbing into pre-formed ridges on

27 April. Within-row spacing was 35 cm and this gave an intended plant population 31 246/ha. Nitrogen was applied as ammonium nitrate (34.5 % N) in a single dose at planting and was then shallowly incorporated into the soil by raking. A single harvest was taken on 4 August after the crop had been defoliated on 24 July. At this harvest, 10 plants were dug from the two centre rows of each four-row plot leaving at least 1 m discard at the ends of each harvested area The number of stems was counted and all tubers > 10 mm were collected and returned to CUF. The number and weight of tubers in each 10 mm size grade was recorded. A 1 kg sample of tubers was removed from the 50-60 mm size grade, washed, chipped and then dried for 48 hours at 90 °C to measure tuber dry matter concentration.

Results and Discussion

Components of yields on 4 August

Nitrogen application rate had no statistically-significant effect on the number of mainstems (125 000 ± 8 100/ha) or the tuber population > 10 mm (414 500 ± 22 300/ha). The overall, average tuber yield was 48.0 t/ha and when the size of the standard error for yield is considered, increasing the N application rate to *c*. 50 kg N/ha resulted in a statistically significant increase in tuber FW yield but N applications in excess of *c*. 50 kg N/ha had no effect (Table 2). There was a statistically significant decrease in tuber dry matter concentration as the N application rate was increased. Since N had no effect on tuber population, mean tuber size (μ) was related to tuber FW yield and mean tuber size tended to increase when the N application rate was increased from 0 to *c*. 50 kg N/ha but N had little effect thereafter. The coefficient of variation (COV) of mean tuber size was not affected by N application rate.

Table 2. Effect of N application rate on tuber FW yield > 10 mm, tuber DM concentration, mean tuber size and coefficient of variation (COV) of tuber size distribution for Marfona

Application rate (kg N/ha)	Tuber FW yield (t/ha)	Tuber DM concentration (%)	Mean tuber size (mm)	COV (%)
0	38.5	20.0	58.4	24.5
50	51.9	19.3	60.5	21.1
100	49.4	19.5	60.3	20.9
150	48.1	19.1	61.2	20.7
200	48.3	18.6	61.4	21.6
250	50.4	18.5	63.7	21.6
300	49.3	18.7	62.4	22.3
Mean	48.0	19.1	61.1	21.8
S.E. (24 D.F.)	2.04	0.30	0.99	0.67

Conclusion

The commercial N application rate for this field was 180 kg N/ha compared with 155 kg N/ha for the CUF modified N application rate. Due to the limitations of split-field experiments the effects of the modified-N rate on yield cannot be accurately assessed due to the absence of randomisation and replication. However, this replicated and randomised experiment indicates the modified-N application rate calculated for this site would have reduced costs without compromising yield and also suggests that the N application could have been reduced even further without compromising yield.

Co-operative Farms

Cooperative Farms joined the Grower Collaboration program in 2010. Analysis of their cropping plans showed that differences between standard and modified agronomy would be sufficiently large to make a worthwhile comparison of seed rate and N rates in a crop of Estima (Field 3/5/7B).

Estima seed rate comparison

The Estima seed crop emerged on 20 May 2009 and the ware crop was planted on 1 May 2010 (an interval between emergence and replanting of 346 days). The standard crop attained 50 % plant emergence on 4 June whilst the crop planted at the modified seed rate achieved 50 % plant emergence two days later (Figure 7). Both standard and modified crops achieved plant populations close to those intended. For both the standard and modified crops, initial ground cover expansion was slow and neither crop reached 100 % ground cover. Canopy senescence started in early August and the rate of senescence was broadly similar for both the standard and modified seed rate crops. The target total yield for the Estima crop was 50 t/ha and due to the poor ground covers and lack of radiation absorption, neither crop attained this and the average yield for the standard and modified crop was *c*. 38 t/ha. Numerically, the total and baker (> 60 mm) yield was larger in the crop planted at the wider spacing. When averaged over both harvests, the total tuber population was 373 000/ha in the standard crop and 331 000/ha in the modified, and this together with the larger total yield, resulted in the modified crop having a mean tuber size closer to that intended.

Estima N rate comparison

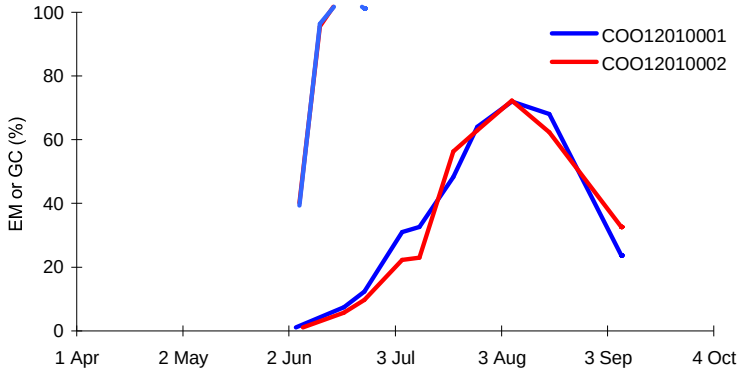
The field was a deep, fertile silt that had a moderate amount of soil organic matter (2-6 %) and the previous crop was a cereal. Using these data and information on variety and season length it was decided that a comparison could be done between the standard (230 kg N/ha) and a modified (205 kg N/ha) application rate. Reducing the N application rate from 230 to 205 kg N/ha had no significant effect on either date of 50 % plant emergence (Figure 8) or plant population. Irrespective of the amount of N applied the rate of ground cover expansion, maximum ground cover and canopy persistence were similar. Neither the standard nor modified areas achieved the target total yield of 50 t/ha but total and yield >60 mm were numerically larger in the area receiving less N.

Analysis of crop performance using the CUF yield model

For the standard and modified seed and modified N crops the CUF yield model overestimated total tuber yield at final harvest by *c*. 5 t/ha (Figure 9*a*, *b* and *c*, respectively). In part, the failure of the crops to achieve the yields suggested by the amount of radiation absorbed by their canopies suggest that their yield may have been compromised by water or heat stress or other, unknown factors. It is also probable that some of the difference between the modelled observed yields was due to the variability of the crop (e.g. standard errors of yield estimates in Figure 7 and variation in ground covers shown in Figure 10*a*). In variable crops the number of replicate measurements should be increased and great care needs to be taken to ensure that the replicate measurements are truly representative of the entire crop.

Figure 7. Co-operative Farms Estima seed rate comparison, Field 3/5/7B

Grower:	Co-op Goole	Co-op Goole
Field name:	3/5/7/ B	3/5/7/ B
Unique ID:	COO12010001	COO12010002
Part Field Name:	Seed Standard & N Standard	Seed Modified & N Standard
Variety:	Estima	Estima
Intended yield:	50 t/ha	50 t/ha
Intended use:	Bakers	Bakers
Intended mu (µ):	60 mm	60 mm
Planting date (start):	1 May	1 May
Date of 50 % emergence:	4 Jun	6 Jun
Total N applied:	230 kg N/ha	230 kg N/ha
Seed size:	45-55 mm	45-55 mm
Seed count:	530 per 50 kg	530 per 50 kg
Planned density:	29.7 000/ha	25.0 000/ha
Planned spacing:	36.8 cm	43.8 cm
Achieved density:	30.1 000/ha	26.0 000/ha
Achieved spacing:	36.4 cm	42.1 cm

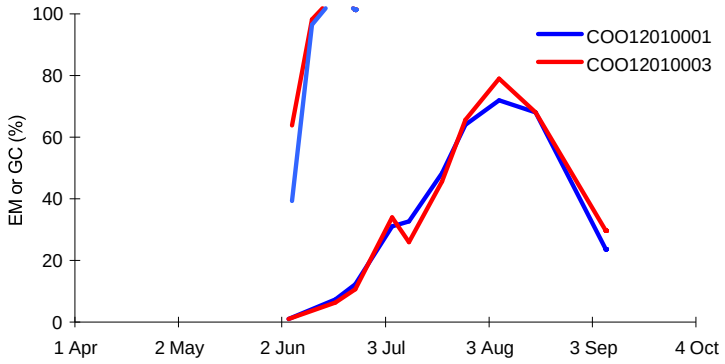


Yield Samples (S.E. in italics)

		Seed Standard & N Standard			Seed Modified & N Standard	
		19 Jul	31 Aug		19 Jul	31 Aug
Plants (000/ha)		28.3	31.9		25.5	26.4
		0.91	*0.91*		*1.49*	*0.91*
Stems (000/ha)		97.6	106.7		82.1	83.0
		4.31	*6.02*		*9.71*	*4.80*
Stems/plant		3.5	3.3		3.2	3.2
		0.13	*0.16*		*0.20*	*0.24*
Tubers (000/ha)		363	389		323	339
		12.1	*15.0*		*25.0*	*22.3*
Tubers (000/ha)	> 10 mm	0	34		0	57
		0.0	*7.0*		*0.0*	*15.2*
Tuber yield (t/ha)	> 60 mm	13.2	35.9		14.9	39.5
		1.06	*2.99*		*1.73*	*3.88*
Tuber yield (t/ha)	> 10 mm	0.0	6.6	> 10 mm	0.0	13.0
		0.00	*1.93*		*0.00*	*3.19*
DM (%)	> 60 mm	17.0	22.2	> 60 mm	16.1	21.2
		0.40	*0.15*		*0.48*	*0.29*
Mean tuber size (mm)		39.9	52.9	> 10 mm	42.0	56.2
		1.72	*0.97*	> 60 mm	*1.11*	*0.91*

Figure 8. Co-operative Farms Estima N rate comparison, Field 3/5/7B.

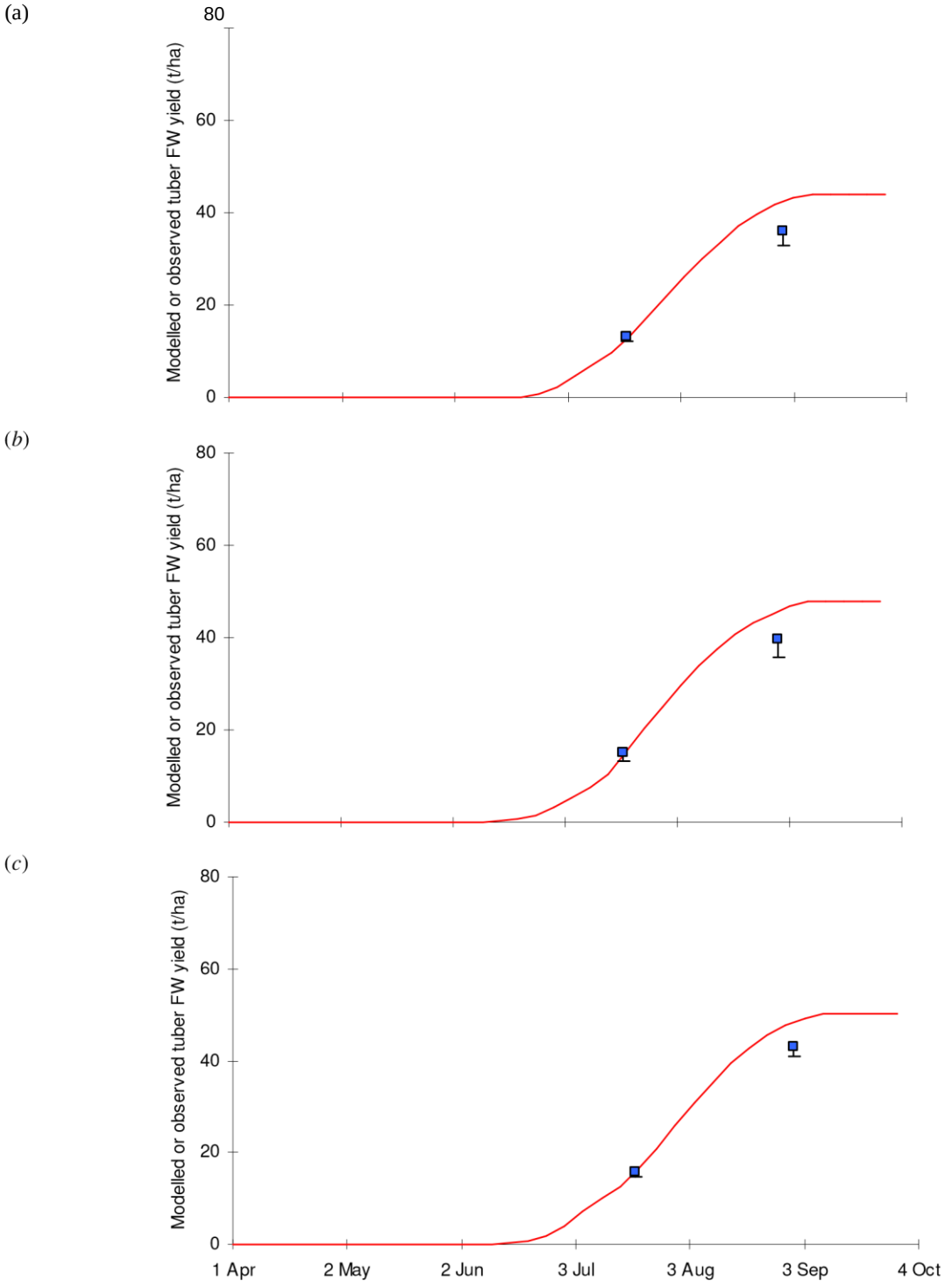
Grower:	Co-op Goole	Co-op Goole
Field name:	3/5/7/ B	3/5/7/ B
Unique ID:	COO12010001	COO12010003
Part Field Name:	Seed Standard & N Standard	Seed Standard & N Modified
Variety:	Estima	Estima
Intended yield:	50 t/ha	50 t/ha
Intended use:	Bakers	Bakers
Intended mu (μ):	60 mm	60 mm
Planting date (start):	1 May	1 May
Date of 50 % emergence:	4 Jun	4 Jun
Total N applied:	230 kg N/ha	205 kg N/ha
Seed size:	45-55 mm	45-55 mm
Seed count:	530 per 50 kg	530 per 50 kg
Planned density:	29.7 000/ha	29.7 000/ha
Planned spacing:	36.8 cm	36.8 cm
Achieved density:	30.1 000/ha	32.4 000/ha
Achieved spacing:	36.4 cm	33.8 cm



Yield Samples (S.E. in italics)

		Seed Standard & N Standard			Seed Standard & N Modified	
		19 Jul	31 Aug		19 Jul	31 Aug
Plants (000/ha)		28.3	31.9		31.9	32.8
		0.91	*0.91*		*0.91*	*0.00*
Stems (000/ha)		97.6	106.7		103.0	110.3
		4.31	*6.02*		*4.56*	*2.29*
Stems/plant		3.5	3.3		3.2	3.4
		0.13	*0.16*		*0.14*	*0.07*
Tubers (000/ha)		363	389		396	449
		12.1	*15.0*		*9.2*	*7.0*
Tubers (000/ha)	> 10 mm	0	34		0	42
		0.0	*7.0*		*0.0*	*8.1*
Tuber yield (t/ha)	> 60 mm	13.2	35.9		15.7	43.1
		1.06	*2.99*		*1.09*	*2.12*
Tuber yield (t/ha)	> 10 mm	0.0	6.6	> 10 mm	0.0	9.2
		0.00	*1.93*		*0.00*	*1.88*
DM (%)	> 60 mm	17.0	22.2	> 60 mm	16.1	22.8
		0.40	*0.15*		*0.18*	*0.22*
Mean tuber size (mm)		39.9	52.9	> 10 mm	40.6	53.9
		1.72	*0.97*	> 60 mm	*1.14*	*1.00*

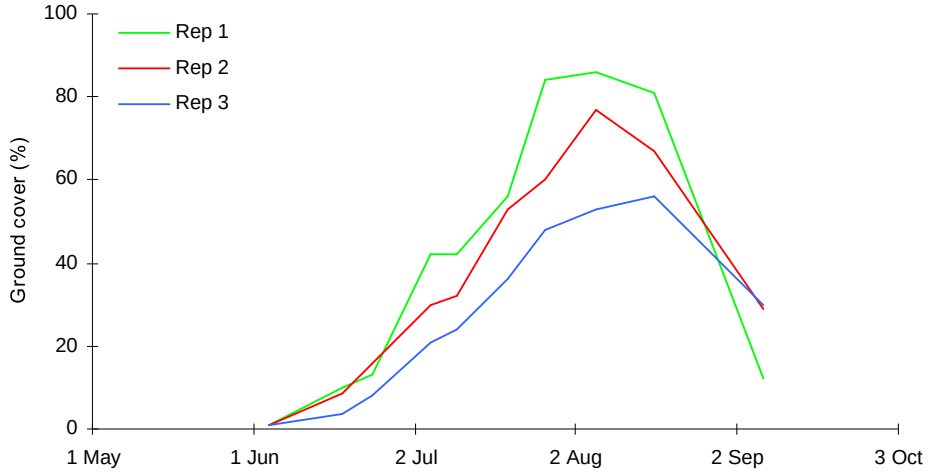
Figure 9. Comparison of model output (red line) and yield samples (blue symbol ± 1 S.E.) for Estima Field 3/5/7 (*a*) standard crop, (*b*) modified seed rate and (*c*) modified N rate.



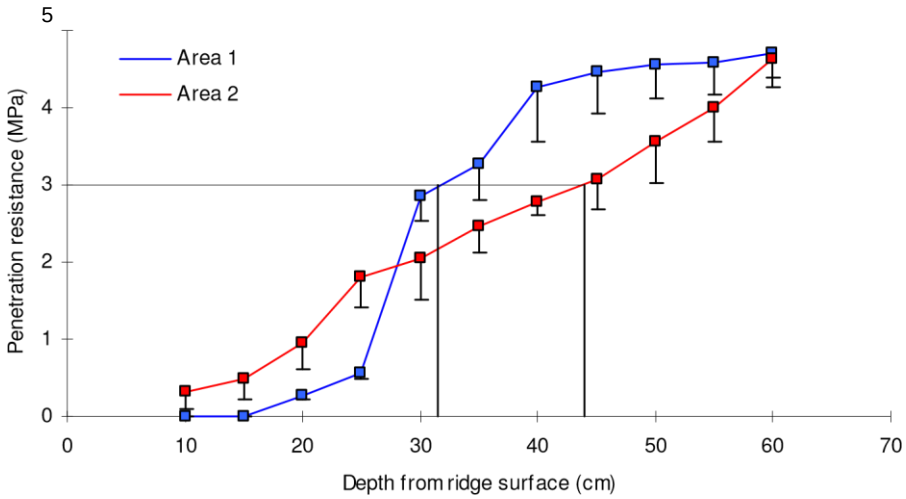
The reason for the poor canopy expansion and the failure to achieve complete ground cover cannot be known with certainty. However, it is probable that the poor canopy and poor yield was a consequence of soil compaction limiting root growth and, in consequence, water and nutrient uptake. Previous work on soil penetration resistance has shown that the rate of rooting halves once soil resistance exceeds 1 MPa and effectively ceases at 3 MPa (Stalham *et al*. 2007). Penetrometer readings taken in two areas of Field 3/5/7B at final harvest on 31 August show that the soil in this field was very compact (Figure 10*b*). Whilst penetrometer readings taken in the autumn are not ideal since the soils will often be dry resulting in larger values for penetration resistance, these data show that in one area rooting was probably restricted to within *c*. 30 cm of the soil surface and in the other area to *c*. 45 cm. These data suggest that soil compaction may have reduced the extent of the canopy resulting in a substantial loss of total and ware yield. It is hoped that work in 2011 will help identify the causes of soil compaction and lead to practical solution.

Figure 10. (*a*), Comparison of individual replicate values of ground cover for Estima grown with a standard seed and N rate and (*b*) measurement of penetration resistance in two areas of field 3/5/7B on 31 August. Each resistance value is the mean of five replicate measurements taken in the ridge centre. The black line indicates the depth at which a penetration resistance of 3 MPa was achieved.

(*a*)



(b)



Branston Ltd

Branston Ltd joined the Grower Collaboration program in 2010, and meetings with their agronomists resulted in the identification of two crops where comparisons of standard and modified agronomy would be useful. The first comparison was in Pit Field (farmed by G M Ward &Co) where the effects on growth and yield of a standard rate of N (140 kg N/ha) compared with a modified rate (120 kg N/ha). The second comparison was done in Hall Field (farmed by G R Ward) where a modified seed rate was compared with a standard seed rate in a crop of King Edward.

King Edward seed rate comparison

The King Edward seed used to plant Hall Field came from a seed crop that emerged on 1 June 2009. The ware crop was planted 9 (standard seed rate) or 10 April (modified seed rate) and the interval between seed crop emergence and re-planting of the progeny tubers was 311312 days. The planned plant population in the standard crop was 27 400/ha (equivalent to an average within-row spacing of 36.6 cm) compared with 24 000/ha (41.7 cm) in the modified crop. Harvest data showed that the achieved plant populations were slightly smaller than intended for both the standard and modified crops (Figure 11). Whilst initial ground cover expansion was rapid for both crops, neither crop achieved 100 % ground cover and the ground cover in the standard crop was consistently slightly larger than that the modified crop from early July onward. Both crops started to senesce in mid-August. At final harvest on 14 September, the total yield was slightly larger in the standard seed rate area than in the modified area (67.2 compared with 66.0 t/ha) and this small difference is consistent with the observed difference in ground cover. However, the ware yield (i.e. > 40 mm) was numerically larger in the modified area although this difference was small. When averaged over both sample dates, the standard crop had an average total tuber population of 712 000/ha compared with 622 000/ha in the modified area. Since the standard and modified areas had similar total yields but the tuber population was smaller in the modified area, the mean tuber size was larger in crop planted at a smaller density.

Desiree N rate comparison

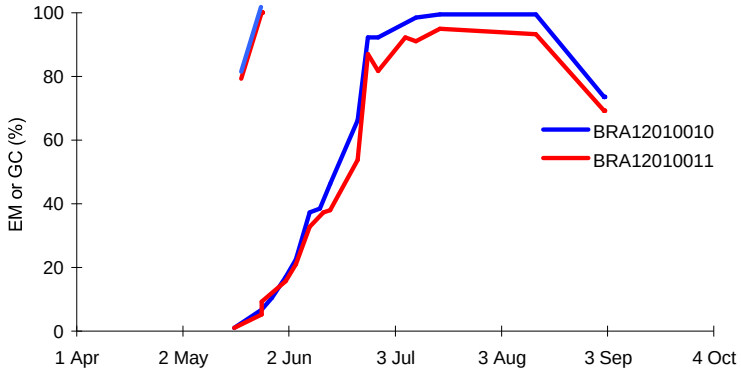
The crop of Desiree was planted on 21 April and both the standard and modified crops achieved 50 % plant emergence on 21 May (30 days after planting). Both the standard and modified crops had a similar plant population (36 300 and 37 100/ha, respectively). Initial ground cover expansion was rapid irrespective of N application rate and both the standard and modified crops reached near complete ground cover (> 95 %) by early July (Figure 12). Ground cover persistence was also similar in both crops. At final harvest on 14 September, both crops had total yields substantially larger than planned for at the start of the season. The combined average total and ware (> 40 mm) yield for the standard and modified crops was *c*. 75 and 72 t/ha, respectively. Numerically, the modified crops (in the area that received 120 kg N/ha) had a larger yield than the standard area (140 kg N/ha) but these differences were small and should not be attributed to the effects of N application rate.

Analysis of crop performance using the CUF yield model

Analysis showed that there was close agreement between observed total yield at final harvest and those predicted by the CUF yield model for the standard and modified crops of King Edward (Figure 13) and Desiree (Figure 14). This close agreement suggests that none of these crops was unduly stressed during the season by, for example, inadequate or excessive irrigation or disease.

Figure 11. Branston Ltd King Edward seed rate comparison, Hall Field.

Grower:	GR Ward	GR Ward
Field name:	Hall Field	Hall Field
Unique ID:	BRA12010010	BRA12010011
Part Field Name:	Standard Seed	Modified Seed
Variety:	King Edward	King Edward
Intended yield:	48 t/ha	48 t/ha
Intended use:	General Ware	General Ware
Intended mu (µ):	NA	NA
Planting date (start):	9 Apr	10 Apr
Date of 50 % emergence:	17 May	17 May
Total N applied:	200 kg N/ha	200 kg N/ha
Seed size:	45-55 mm	45-55 mm
Seed count:	640 per 50 kg	640 per 50 kg
Planned density:	27.4 000/ha	24.0 000/ha
Planned spacing:	36.6 cm	41.7 cm
Achieved density:	25.8 000/ha	23.8 000/ha
Achieved spacing:	38.7 cm	42.1 cm



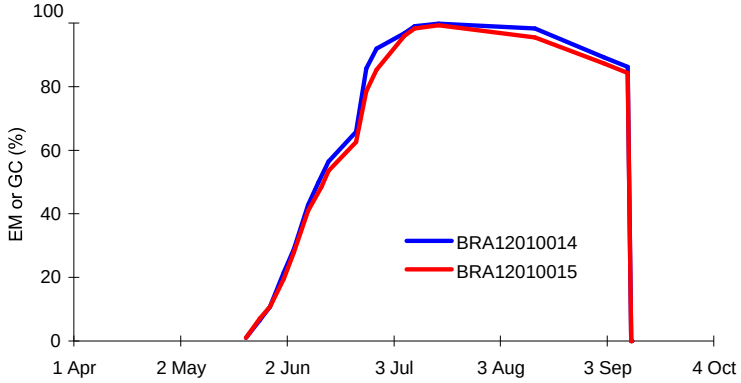
Yield Samples (S.E. in italics)

Plants (000/ha)		26.7	25.0			23.3	24.2
		0.00	*0.96*			*0.00*	*0.83*
Stems (000/ha)		129.2	109.2			99.2	106.7
		6.44	*3.94*			*6.85*	*7.20*
Stems/plant		4.8	4.4			4.3	4.4
		0.24	*0.18*			*0.29*	*0.16*
Tubers (000/ha)		706	718			596	648
		68.5	*25.2*			*19.2*	*15.0*
Tubers (000/ha)	> 10 mm	251	473		> 10 mm	240	457
		30.1	*29.9*			*16.4*	*9.1*
Tuber yield (t/ha)	> 40 mm	32.5	67.2		> 10 mm	30.7	66.0
		0.64	*4.51*			*1.23*	*0.80*
Tuber yield (t/ha)	> 10 mm	19.9	60.6		> 40 mm	20.5	61.3
		2.79	*4.57*			*1.92*	*0.86*
DM (%)	> 40 mm	18.2	23.5		> 10 mm	18.6	22.9
		0.40	*0.43*			*0.40*	*0.27*
Mean tuber size (mm)		41.9	53.9		> 40 mm	42.9	54.7
		1.34	*1.13*			*0.73*	*0.97*

	Standard Seed			Modified Seed	
	14 Jul	14 Sep		14 Jul	14 Sep

Figure 12. Branston Ltd Desiree N rate comparison, Pit Field.

Grower:	GM Ward & Co	GM Ward & Co
Field name:	Pit Field	Pit Field
Unique ID:	BRA12010014	BRA12010015
Part Field Name:	Standard N	Modified N
Variety:	Desiree	Desiree
Intended yield:	50 t/ha	50 t/ha
Planting date (start):	21 Apr	21 Apr
Date of 50 % emergence:	21 May	21 May
Total N applied:	140 kg N/ha	120 kg N/ha
Seed size:	35-50 mm	35-50 mm
Seed count:	970 per 50 kg	970 per 50 kg
Achieved density:	36.3 000/ha	37.1 000/ha
Achieved spacing:	27.6 cm	27.0 cm



Yield Samples (S.E. in italics)

Plants (000/ha)		37.5	35.0			36.7	37.5
		0.83	*1.67*			*1.36*	*1.60*
Stems (000/ha)		125.0	147.5			138.3	133.3
		6.45	*22.33*			*6.31*	*8.39*
Stems/plant		3.3	4.2			3.8	3.6
		0.14	*0.57*			*0.21*	*0.14*
Tubers (000/ha)		603	603			559	560
		31.5	*19.0*			*36.4*	*24.8*
Tubers (000/ha)	> 10 mm	223	438		> 10 mm	253	418
		5.6	*13.6*			*22.7*	*6.5*
Tuber yield (t/ha)	> 40 mm	32.3	74.3		> 10 mm	34.0	75.8
		1.60	*3.27*			*2.28*	*2.93*
Tuber yield (t/ha)	> 10 mm	20.4	70.7		> 40 mm	24.4	72.2
		1.01	*3.41*			*3.51*	*3.57*
DM (%)	> 40 mm	18.5	21.4		> 10 mm	17.9	22.7
		0.33	*0.52*			*0.57*	*0.22*
Mean tuber size (mm)		42.3	60.0		> 40 mm	44.1	57.0
		0.28	*2.74*			*1.41*	*1.32*

	Standard N		Modified N	
	14 Jul	14 Sep	14 Jul	14 Sep

Figure 13. Comparison of model output (red line) and yield samples (blue symbol ± 1 S.E.) for King Edward, Hall Field (*a*) standard crop, (*b*) modified seed rate.

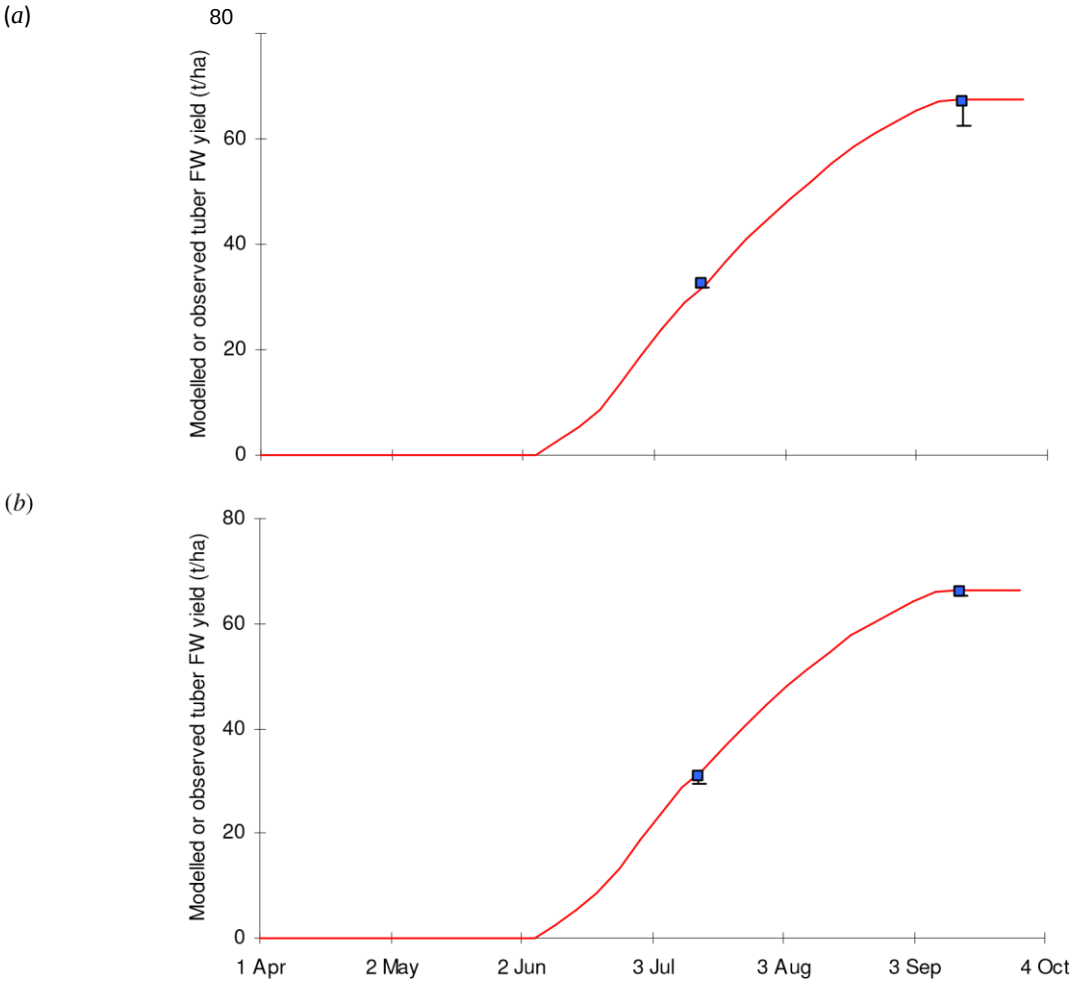
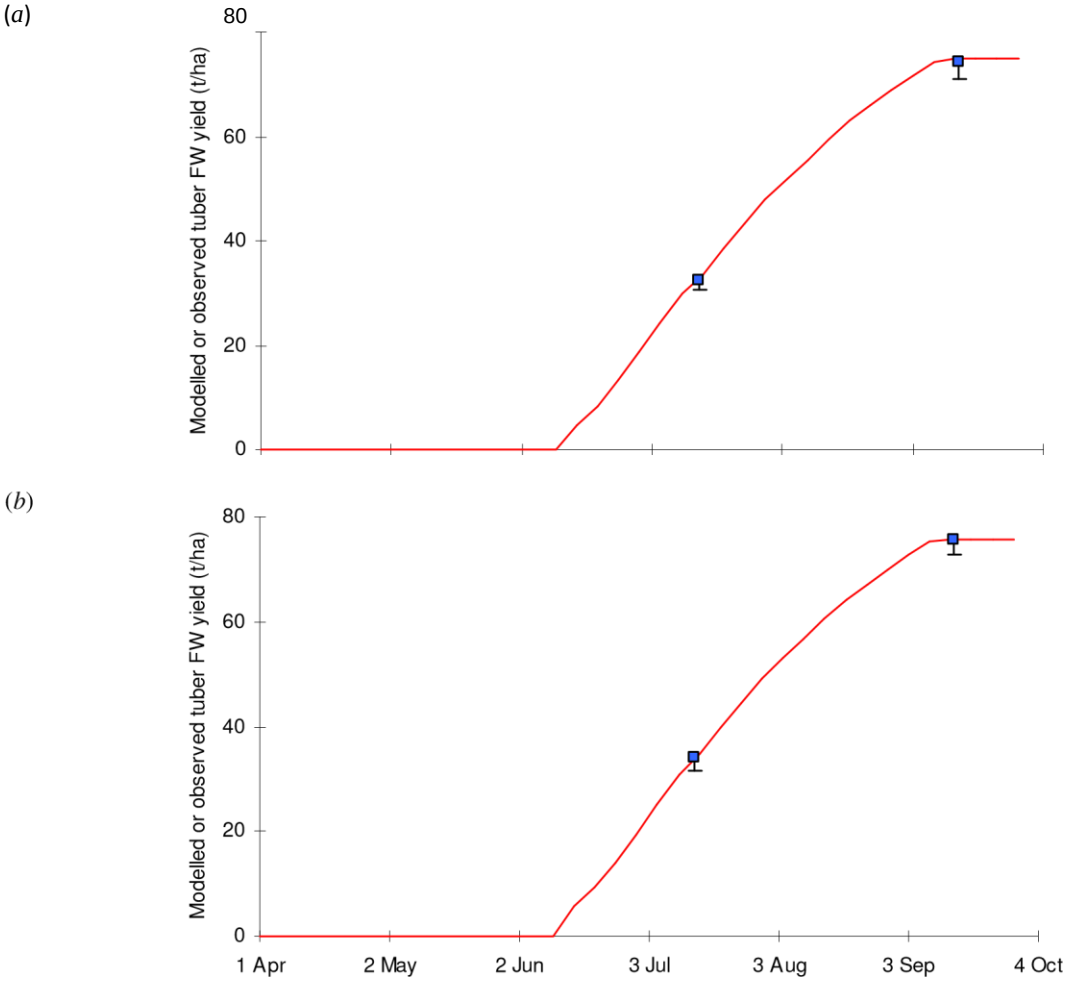


Figure 14. Comparison of model output (red line) and yield samples (blue symbol ± 1 S.E.) for Desiree, Pit Field (*a*) standard crop, (*b*) modified N rate.



South West Agronomy Group (SWAG)

Much of the agronomic advice relating to seed and fertilizer rates used by the SWAG growers is already 'best practice' and in consequence there are seldom opportunities to compare standard with modified agronomy. However, each year two or three crops grown by SWAG growers are monitored so that variations in yield and quality in well-grown crops can be better understood and information gained on factors that may be limiting yield or attainments of size distribution in these crops.

Matt Bere, Sante

This crop was grown for general ware and was planted on 12 May and achieved 50 % plant emergence on 7 June. Ground cover expansion was rapid and the crop achieved 100 % ground cover by mid-July. Complete ground cover was then maintained for several weeks until the crop was defoliated in late August (Figure 15). The achieved plant population was slightly less than that intended (50 100 plants/ha compared with 55 000/ha). Stem and tuber populations

(< 10 mm) were consistent between samples taken on 29 July and 2 September. At the final harvest tuber FW yield > 10 mm averaged 58.4 t/ha and most of this yield was > 40 mm. The mean tuber size at final harvest was 64.2 mm.

Matt Bere, Estima

The Estima crop was grown to produce a large proportion of baking potatoes and had an intended mean tuber size of *c*. 62 mm. The crop was planted on 8 May and achieved 50 % plant emergence on 7 June (Figure 15). The achieved plant population (47 400/ha) was slightly less than that intended (50 000/ha). Ground cover expansion was rapid and the crop achieved complete ground cover by mid-July. Despite restrictions to the supply of irrigation water, complete canopy cover was maintained for several weeks until the crop was defoliated in mid-August. Total (> 10 mm) yield at the final sampling in early September was 66.9 t/ha and the mean tuber size of 61.5 mm was close to that intended.

James Pullen, Estima

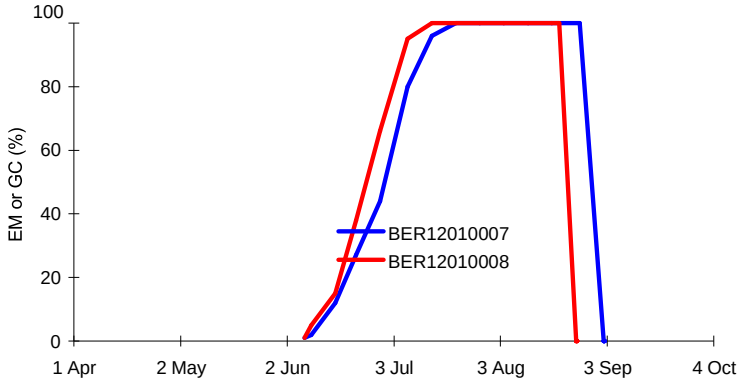
This crop was grown for production of baking potatoes and had a target tuber size of *c*. 65 mm. The crop was planted on 19 April and achieved 50 % plant emergence on 22 May. The achieved plant population was slightly larger than intended (Figure 16). Whilst initial ground cover expansion was rapid, this crop did not quite achieve complete ground cover, but nearcomplete ground cover was maintained for several weeks until defoliation in early August. When compared with previous seasons, the observed total tuber population was larger than average and this may have been a consequence of this crop initiating tubers under brighter than average conditions in mid-June in addition to the establishment of larger plant populations than intended. A final sampling was taken, after defoliation, on 17 August when the total yield was *c*. 67 t/ha. Due to the larger than expected tuber population, the achieved mean tuber size was less than intended (59.1 mm compared with 63 mm). For comparison, the Estima crop monitored in 2009, achieved a total yield of *c*. 70 t/ha and had a mean tuber size of 65 mm.

Analysis of crop performance using the CUF yield model

The CUF yield model used ground cover data supplied on a weekly basis by the growers and values of daily, incident radiation measured by a pyranometer located on Matt Bere's farm (see earlier section). For the Sante and Estima crops grown by Matt Bere and the Estima crop grown by James Pullen there was reasonably good agreement between the predicted total yield at final harvest and the observed yield (Figure 17). For these three crops the average, observed yield at final harvest was *c*. 64 t/ha compared with an average modelled yield of *c*. 61 t/ha. There was no evidence that the yield of these three crops was unduly limited by water availability or disease and they achieved the yield potentials dictated by their canopy persistence.

Figure 15. SWAG Matt Bere Sante, Fordgate Field and Estima, Millers Field.

Grower:	Matt Bere	Matt Bere
Field name:	Fordgate	Millers
Unique ID:	BER12010007	BER12010008
Part Field Name:	Standard Seed Standard N	Standard Seed Standard N
Variety:	Sante	Estima
Intended yield:	55 t/ha	60 t/ha
Intended use:	General Ware	Bakers
Planting date (start):	12 May	8 May
Date of 50 % emergence:	7 Jun	7 Jun
Total N applied:	145 kg N/ha	125 kg N/ha
Seed size:	30-45 mm	45-50 mm
Seed count:	1720 per 50 kg	910 per 50 kg
Planned density:	55.0 000/ha	50.0 000/ha
Planned spacing:	19.9 cm	21.9 cm
Achieved density:	50.1 000/ha	47.4 000/ha
Achieved spacing:	21.8 cm	23.1 cm

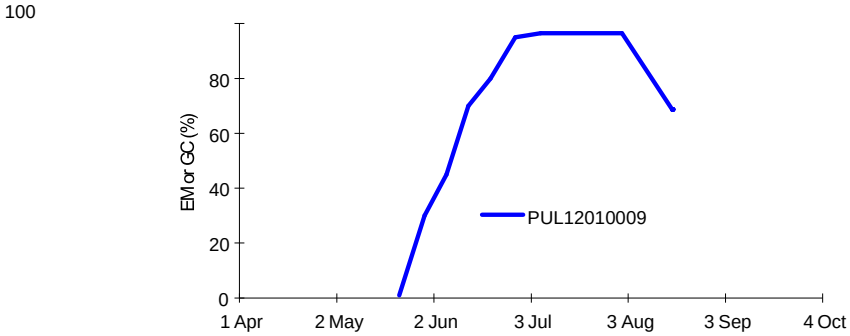


Yield Samples (S.E. in italics)

		Standard Seed Standard N			Standard Seed Standard N	
		29 Jul	2 Sep		29 Jul	2 Sep
Plants (000/ha)		50.1	50.1		47.4	47.4
		5.44	*5.44*		*5.37*	*5.37*
Stems (000/ha)		108.4	108.4		102.1	102.1
		5.44	*5.44*		*6.31*	*6.31*
Stems/plant		2.2	2.2		2.2	2.2
		0.22	*0.22*		*0.13*	*0.13*
Tubers (000/ha)		420	431		493	507
		34.7	*13.7*		*19.8*	*33.2*
Tubers (000/ha)	> 10 mm	280	322		340	400
		25.4	*6.6*		*17.3*	*25.8*
Tuber yield (t/ha)	> 40 mm	28.5	58.4		42.8	66.9
		2.32	*1.04*	> 10 mm	*1.55*	*4.74*
Tuber yield (t/ha)	> 10 mm	25.4	57.0		39.8	65.1
		2.44	*1.06*	> 40 mm	*1.43*	*4.79*
DM (%)	> 40 mm	17.0	21.2		18.4	20.1
		0.47	*0.54*	> 10 mm	*0.47*	*0.50*
Mean tuber size (mm)		49.0	64.2		52.9	61.5
		0.71	*1.16*	> 40 mm	*0.71*	*1.81*

Figure 16. SWAG James Pullen Estima, Moonlight Field.

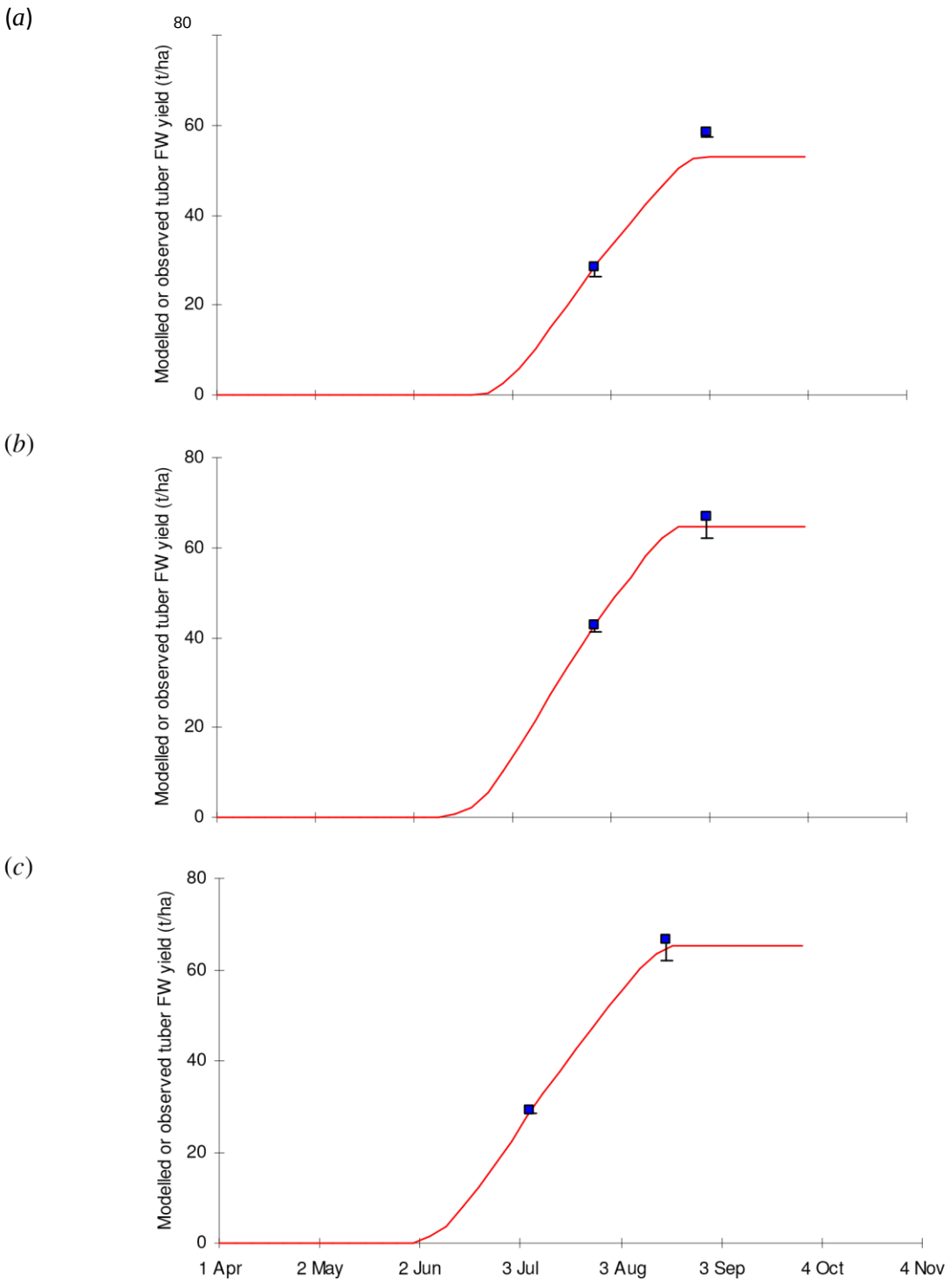
Grower:	James Pullen
Field name:	Moonlight
Unique ID:	PUL12010009
Part Field Name:	Standard Seed and N
Variety:	Estima
Intended yield:	60 t/ha
Intended use:	Bakers
Intended mu (μ):	63 mm
Planting date (start):	19 Apr
Date of 50 % emergence:	22 May
Total N applied:	160 kg N/ha
Seed size:	45-55 mm
Seed count:	570 per 50 kg
Planned density:	33.3 000/ha
Planned spacing:	32.8 cm
Achieved density:	36.0 000/ha
Achieved spacing:	30.4 cm



Yield Samples (S.E. in italics)

		Standard Seed and N	
		6 Jul	17 Aug
Plants (000/ha)		37.4	34.6
		2.29	*1.05*
Stems (000/ha)		123.9	116.7
		0.00	*7.73*
Stems/plant		3.4	3.4
		0.19	*0.26*
Tubers (000/ha)		548	594
		18.1	*43.3*
Tubers (000/ha)	> 10 mm	252	416
		13.4	*28.3*
Tuber yield (t/ha)	> 40 mm	29.3	66.5
		0.68	*4.57*
Tuber yield (t/ha)	> 10 mm	22.7	63.5
		0.93	*4.50*
DM (%)	> 40 mm	15.5	21.2
		0.43	*0.85*
Mean tuber size (mm)		46.3	59.1
		0.38	*1.91*

Figure 17. Comparison of model output (red line), yield samples (blue symbol ± 1 S.E.) for standard crops of (*a*) Sante, Matt Bere; (*b*) Estima, Matt Bere and (*c*) Estima, James Pullen.



R S Cockerill Ltd

R S Cockerill Ltd joined the Grower Collaboration program in 2010. They are based in Dunnington, Yorkshire and a major component of their business is the supply of processing potatoes to Walkers Snack Foods. Preliminary discussions with Cockerill identified two of their growers (Westgarth Farms, County Durham and Fridlington Farms, Yorkshire) as potential hosts for comparisons of standard and modified agronomy. Examination of cropping plans showed that at Westgarth's comparisons of modified seed rates or modified N application rates with standard agronomy could be done in crops of Hermes (Field 16) and Saturna (Field 35). At Fridlington, a comparison of a standard and a modified N application rate was done in a crop of Hermes (Field 81). The standard and modified crops at Westgarth and Fridlington Farms were also used as part of a larger PepsiCo program designed to understand the effects of standard and modified agronomies on crop performance, storage and processing quality. The data reported here was collected in collaboration with PepsiCo staff as part of PepsiCo funded project.

Westgarth, Saturna (Field 35)

Seed rate comparison

The Saturna seed used to plant Field 35 originated from a seed crop that emerged on 25 May 2009. The Saturna ware crop in Field 35 was planted on 28 April 2010 and the interval between seed crop emergence and re-planting of the progeny tubers was therefore 338 days. The standard and modified crops reach 50 % plant emergence on 30 May (32 days after planting) and 29 May (31 days after planting), respectively. The intended plant population in the standard crop was 29 700 plants/ha (equivalent to a within-row spacing of 36.5 cm) whilst the intended, modified plant population was 28 600 plants/ha (38.3 cm spacing). For the modified crop, the achieved plant spacing was close to that intended (Figure 18) but for the standard crop, the achieved spacing was wider than intended so that there was little difference between the modified and standard crops. The pattern of ground cover expansion was similar in both crops and both achieved complete ground cover which was maintained for several weeks until the onset of senescence in mid-August. A final yield dig was taken on 7 September, and despite having very similar plant populations and ground cover curves the total and ware (>40 mm) tuber FW yields were numerically larger in the area planted at the standard seed rate. The mean tuber size (mu) was similar in both the standard and modified areas.

N rate comparison

The previous crop in this field was a cereal and the field had also received 25 t/ha of pig FYM. Using this information together with variety and intended yield (42 t/ha), a comparison between the standard N application rate (230 kg N/ha) and modified N application rate of 195 kg N/ha was established. The area receiving the reduced N application rate achieved 50 % plant emergence 1 day before the area receiving the standard amount of N. The plant population in the modified N area was close to that intended but slightly more than the plant population in the standard N area (Figure 19). The pattern of ground cover expansion was similar in both the standard and modified crop and both achieved 100 % ground cover. Despite receiving 35 kg N/ha less than the standard area, the crop canopy in the modified area senesced at the same rate as the crop canopy grown in the area receiving the standard amount

of N. At the first sampling (27 July), the average total yield in the standard and modified areas was *c*. 28 t/ha and the yield was numerically larger in the modified N area. The final sampling was taken on 7 September and the total and ware (> 40 mm) yields in the standard were 47.2 and 43.4 t/ha, respectively. The total and ware yields in the modified area were 39.2 and 36.6 t/ha and thus reducing the N application rate by 35 kg N/ha was apparently associated with a total and ware yield penalty of *c*. 7 t/ha. These data are surprising since the ground cover data would suggest that the yields in both areas should be similar. The estimates of yield in both the standard and modified N areas were associated with relatively large standard errors and it is probable that the numerical difference in yield is largely a consequence of crop variability than of the effect of N fertilizer (see later section on crop modelling).

Westgarth, Hermes (Field 16)

Seed rate comparison

Information supplied by the grower showed that the Hermes seed used to plant Field 16 originated from a seed crop that emerged on 28 May 2009. The Hermes ware crop was planted in Field 16 on 15 April 2010 and thus the interval between seed crop emergence and replanting of the progeny tubers was 322 days. Both the modified and standard Hermes crops reached 50 % plant emergence on 22 May (37 days after planting). The intended plant population in the standard area was 36 600/ha (equivalent to an average within-row spacing of 30 cm), whilst the intended plant population in the modified seed rate area was 27 100/ha (40.3 cm spacing). Crop sampling showed that, for both the standard and modified crops, the achieved plant population was close to that intended. Initial ground cover expansion was similar in both crops, although expansion in the crop grown at the wider spacing was slightly slower than the standard crop and this is consistent with the achieved difference in plant population (Figure 20). Both the standard and modified crops reached 100 % ground cover and this was maintained for several weeks. The onset of senescence in the standard crop was slightly earlier in the standard crop and, again, this difference was consistent with the difference in achieved plant population. The final sampling of the Hermes crop was on 7 September and at this date average total and ware (> 40 mm) yields in the standard and modified areas were 57.1 and 54.2 t/ha, respectively. Total and ware yields in the modified seed rate area were numerically larger than those in the standard seed rate. Consistent with the differences in yield and tuber population in the standard and modified areas, the mean tuber size was *c*. 3.5 mm larger in the modified crop grown at 40 cm spacing than in standard crop grown at 30 cm spacing.

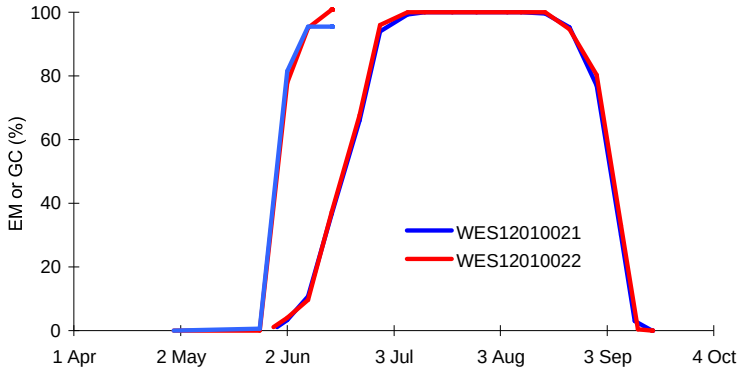
N rate comparison

Field 16 was defined as a medium textured soil with a limited rooting depth (*c*. 40 cm), the previous crop was a cereal and the field also received an application of broiler litter at a rate of 7.5 t/ha. The standard N application rate for this field was 175 kg N/ha and using information on variety and expected yield (42 t/ha), a modified N application rate of 140 kg N/ha was calculated. The standard and modified N area were both planted on 15 April, however the date of 50 % plant emergence was one week later in the reduced N area (Figure 21). This delay is unusually large and unexpected and possible reasons for this delay may include increased depth of planting or reduced soil moisture content and poor seed/soil contact at the time of emergence. Both the standard and modified crops achieved plant populations close to those

intended. The general pattern of ground cover was similar in both standard and modified crops although, due to the delayed emergence, the development of the ground cover curve for the modified was delayed by 1 week. The standard and modified crops were sampled on two occasions (21 July and 7 September) and the total and ware (> 40 mm) averaged *c*. 54 and 51 t/ha, respectively. Both the total and ware yields in the area that received the standard amount of N fertilizer were larger than those in the modified areas. However, all yield measurements were associated with large standard errors suggesting that this field was unusually variable. Because of the large delay in emergence of the modified crop and the displacement of its ground cover curve, this comparison was excluded from the summary tables.

Figure 18. Cockerills, Westgarth Saturna seed rate comparison, Field 35.

Grower:	Tim Westgarth	Tim Westgarth
Field name:	Field 35	Field 35
Unique ID:	WES12010021	WES12010022
Part Field Name:	Seed and N standard	Seed modified and N
Variety:	Saturna	standard Saturna
Intended yield:	42 t/ha	42 t/ha
Planting date (start):	28 Apr	28 Apr
Date of 50 % emergence:	30 May	29 May
Total N applied:	230 kg N/ha	230 kg N/ha
Seed size:	45-60 mm	45-60 mm
Seed count:	627 per 50 kg	627 per 50 kg
Planned density:	29.7 000/ha	28.6 000/ha
Planned spacing:	36.5 cm	38.3 cm
Achieved density:	28.3 000/ha	28.6 000/ha
Achieved spacing:	38.7 cm	38.3 cm

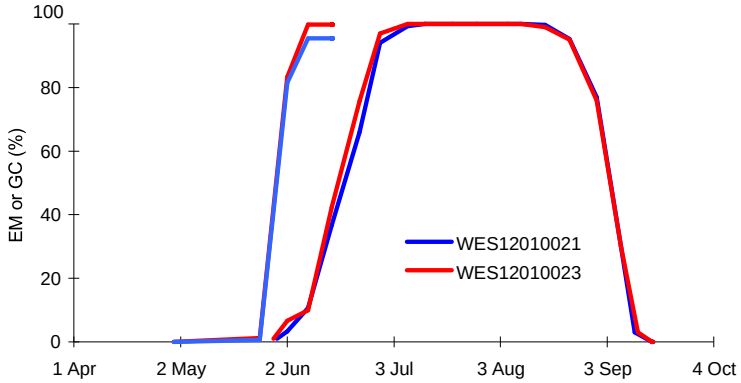


Yield Samples (S.E. in italics)

		Seed and N standard			Seed modified and N standard	
		27 Jul	7 Sep		27 Jul	7 Sep
Plants (000/ha)		27.9	28.6		27.9	29.2
		0.77	*1.12*		*1.22*	*2.10*
Stems (000/ha)		136.7	141.6		137.3	147.6
		6.01	*17.69*		*4.86*	*10.78*
Stems/plant		4.9	4.9		4.9	5.1
		0.16	*0.47*		*0.35*	*0.27*
Tubers (000/ha)		599	634		563	607
		22.2	*41.5*		*13.5*	*45.0*
Tubers (000/ha)	> 10 mm	316	473		275	472
		21.6	*37.2*		*21.9*	*29.1*
Tuber yield (t/ha)	> 40 mm	26.9	47.2		23.5	44.4
		1.04	*3.32*	> 10 mm	*1.08*	*3.00*
Tuber yield (t/ha)	> 10 mm	19.5	43.4		15.8	40.8
		1.51	*3.66*	> 40 mm	*1.85*	*2.67*
DM (%)	> 40 mm	18.0	25.1			
		0.12	*0.55*	> 10 mm		
Mean tuber size (mm)		42.9	51.7		42.5	52.2
		0.53	*0.90*	> 40 mm	*0.85*	*1.25*

Figure 19. Cockerills, Westgarth Saturna N rate comparison, Field 35.

Grower:	Tim Westgarth	Tim Westgarth
Field name:	Field 35	Field 35
Unique ID:	WES12010021	WES12010023
Part Field Name:	Seed and N standard	Seed standard and N modified
Variety:	Saturna	Saturna
Intended yield:	42 t/ha	42 t/ha
Planting date (start):	28 Apr	28 Apr
Date of 50 % emergence:	30 May	29 May
Total N applied:	230 kg N/ha	195 kg N/ha
Seed size:	45-60 mm	45-60 mm
Seed count:	627 per 50 kg	627 per 50 kg
Planned density:	29.7 000/ha	29.7 000/ha
Planned spacing:	36.5 cm	36.5 cm
Achieved density:	28.3 000/ha	30.1 000/ha
Achieved spacing:	38.7 cm	36.4 cm

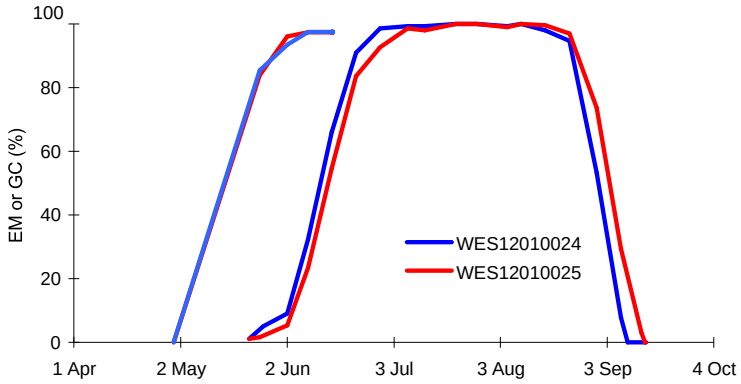


Yield Samples (S.E. in italics)

		Seed and N standard			Seed standard and N modified	
		27 Jul	7 Sep		27 Jul	7 Sep
Plants (000/ha)		27.9	28.6		32.8	27.3
		0.77	*1.12*		*2.10*	*2.35*
Stems (000/ha)		136.7	141.6		193.2	130.3
		6.01	*17.69*		*35.15*	*14.69*
Stems/plant		4.9	4.9		5.9	4.8
		0.16	*0.47*		*0.85*	*0.51*
Tubers (000/ha)		599	634		684	542
		22.2	*41.5*		*64.5*	*82.0*
Tubers (000/ha)	> 10 mm	316	473		277	419
		21.6	*37.2*		*38.3*	*61.8*
Tuber yield (t/ha)	> 40 mm	26.9	47.2		28.4	39.2
		1.04	*3.32*	> 10 mm	*1.16*	*3.88*
Tuber yield (t/ha)	> 10 mm	19.5	43.4		17.9	36.6
		1.51	*3.66*	> 40 mm	*2.09*	*3.59*
DM (%)	> 40 mm	18.0	25.1			
		0.12	*0.55*	> 10 mm		
Mean tuber size (mm)		42.9	51.7		41.7	52.4
		0.53	*0.90*	> 40 mm	*0.47*	*0.61*

Figure 20. Cockerills, Westgarth Hermes seed rate comparison, Field 16.

Grower:	Tim Westgarth	Tim Westgarth
Field name:	Field 16	Field 16
Unique ID:	WES12010024	WES12010025
Part Field Name:	Seed and N standard	Seed modified and N
Variety:	Hermes	standard
Intended yield:	42 t/ha	Hermes
		42 t/ha
Planting date (start):	15 Apr	
Date of 50 % emergence:	22 May	15 Apr
Total N applied:	175 kg N/ha	22 May
Seed size:	45-60 mm	175 kg N/ha
Seed count:	530 per 50 kg	45-60 mm
Planned density:	36.6 000/ha	530 per 50 kg
Planned spacing:	30.0 cm	27.1 000/ha
Achieved density:	36.1 000/ha	40.3 cm
Achieved spacing:	30.3 cm	27.6 000/ha
		39.6 cm

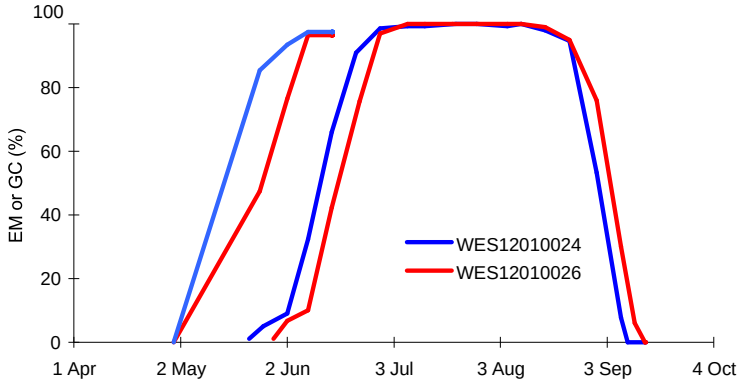


Yield Samples (S.E. in italics)

		Seed and N standard			Seed modified and N standard	
		21 Jul	7 Sep		21 Jul	7 Sep
Plants (000/ha)		36.5	35.8		27.9	27.3
		1.33	*2.38*		*1.22*	*2.35*
Stems (000/ha)		121.5	121.5		86.3	101.2
		4.95	*8.45*		*4.86*	*12.66*
Stems/plant		3.4	3.4		3.1	3.7
		0.19	*0.19*		*0.04*	*0.28*
Tubers (000/ha)		699 > 10 mm	697		521	591
		32.9	*41.1*		*20.7*	*76.5*
Tubers (000/ha)	> 0 mm	699 > 40 mm	440		354	428
		32.9	*27.1*		*9.6*	*51.1*
Tuber yield (t/ha)	> 0 mm	33.2 > 10 mm	55.8		30.5	58.4
		1.03	*3.66*	> 10 mm	*1.36*	*3.60*
Tuber yield (t/ha)	> 0 mm	33.2 > 40 mm	52.5		27.4	55.8
		1.03	*3.62*	> 40 mm	*1.27*	*3.30*
DM (%)	> 0 mm	17.3	24.7			
		0.03	*0.76*	> 10 mm		
Mean tuber size (mm)		48.7	57.5		50.0	60.9
		0.30	*0.44*	> 40 mm	*0.47*	*2.16*

Figure 21. Cockerills, Westgarth Hermes N rate comparison, Field 16.

Grower:	Tim Westgarth	Tim Westgarth
Field name:	Field 16	Field 16
Unique ID:	WES12010024	WES12010026
Part Field Name:	Seed and N standard	Seed standard and N modified
Variety:	Hermes	Hermes
Intended yield:	42 t/ha	42 t/ha
Planting date (start):	15 Apr	15 Apr
Date of 50 % emergence:	22 May	29 May
Total N applied:	175 kg N/ha	140 kg N/ha
Seed size:	45-60 mm	45-60 mm
Seed count:	530 per 50 kg	530 per 50 kg
Planned density:	36.6 000/ha	36.6 000/ha
Planned spacing:	30.0 cm	30.0 cm
Achieved density:	36.1 000/ha	35.5 000/ha
Achieved spacing:	30.3 cm	30.8 cm



Yield Samples (S.E. in italics)

		Seed and N standard			Seed standard and N modified	
		21 Jul	7 Sep		21 Jul	7 Sep
Plants (000/ha)		36.5	35.8		35.2	35.8
		1.33	*2.38*		*3.21*	*2.19*
Stems (000/ha)		121.5	121.5		126.4	136.1
		4.95	*8.45*		*10.38*	*7.69*
Stems/plant		3.4	3.4		3.6	3.8
		0.19	*0.19*		*0.07*	*0.16*
Tubers (000/ha)		699 > 10 mm	697		543	666
		32.9	*41.1*		*111.2*	*62.8*
Tubers (000/ha)	> 0 mm	699 > 40 mm	440		284	430
		32.9	*27.1*		*20.7*	*41.5*
Tuber yield (t/ha)	> 0 mm	33.2 > 10 mm	55.8		24.7	51.6
		1.03	*3.66*	> 10 mm	*1.47*	*4.20*
Tuber yield (t/ha)	> 0 mm	33.2 > 40 mm	52.5		20.8	48.6
		1.03	*3.62*	> 40 mm	*0.47*	*4.08*
DM (%)	> 0 mm	17.3	24.7			
		0.03	*0.76*	> 10 mm		
Mean tuber size (mm)		48.7	57.5		49.3	57.9
		0.30	*0.44*	> 40 mm	*1.52*	*0.71*

Cockerills, Fridlington Farms, Hermes (Field 81)

Seed rate comparison

Information supplied by the grower showed that the Hermes seed used to plant Field 81 had a count of 925/50 kg and originated from a seed crop that emerged on 27 May 2009. The Hermes ware crop was planted in Field 81 on 24 April 2010 so that the interval between seed crop emergence and re-planting of the progeny tubers was 332 days (Figure 22). The average interval between planting and 50 % plant emergence was 37 days but the crop grown at the modified seed rate emerged earlier than the standard crop (28 May and 3 June, respectively). The intended plant population in the standard crop was 58 000/ha (equivalent to an average within-row spacing of 18.9 cm) and harvest data showed that the achieved plant population in the standard area was slightly smaller than intended (55 300/ha, 19.8 cm spacing). For the modified crop, the intended and achieved plant populations were 43 400 and 45 100, respectively, equivalent to within-row spacings of 25.2 and 24.3 cm. Overall, the difference in plant population between the standard and modified areas was slightly less than that intended. As a consequence of emerging 6 days earlier than the standard crop, ground cover expansion in the modified crop was consistently ahead. However, both crops achieved 100 % ground cover and both crops started to senesce in early September. When compared with the standard crop, the crop planted at the modified spacing senesced slightly earlier. The Hermes crop was sampled on three occasions during the season and, as expected from the plan populations, the stem population in the modified area was consistently less than that in standard area. Despite having a smaller stem population, the tuber population in the modified area was larger and this was a consequence of it having an average of 4.7 tuber/stem compared with 2.8 tubers/stem in the standard area. The reason for this difference is not certain but may have been due to standard and modified crops initiating tubers under different environmental conditions. When averaged over the standard and modified crops, the average total yields at the first, second and third harvests were 22, 53, and 61 t/ha, respectively. Numerically, total and ware (> 40 mm) yields were consistently larger in the area grown at the modified spacing. The target yield for this crop was 47 t/ha and both the standard and modified crop exceeded this and in consequence both crops had large mean tuber sizes at final harvest. Due to the relatively large difference in emergence dates and ground cover development, this comparison has been excluded from the summary tables shown on page 48.

N rate comparison

Field 81 was a relatively sandy-textured soil that had been in grass for five years and had also received an application of pig FYM at a rate of 37 t/ha. The standard N application rate for the Hermes crop was 225 kg N/ha and this was reduced to 185 kg N/ha in the modified crop. These comparisons were done between two areas of crop that had both been planted at the modified spacing but one received the standard rate of N and the other the reduced rate. For the standard and modified N areas, the date of 50 % plant emergence was similar (Figure 23). The achieved plant population in the modified N area was slightly less than that in the standard area. Ground cover development was similar in both the standard and modified areas of the crop and both crops reached 100 % ground cover which was then maintained for several weeks. The pattern of canopy senescence was also similar in both the standard and modified areas.

When averaged over the two crops, the total yield at the first, second and final samplings was 25, 59 and 66 t/ha, respectively, and there was little difference in either total or ware yield between those areas that had received 225 or 185 kg N/ha.

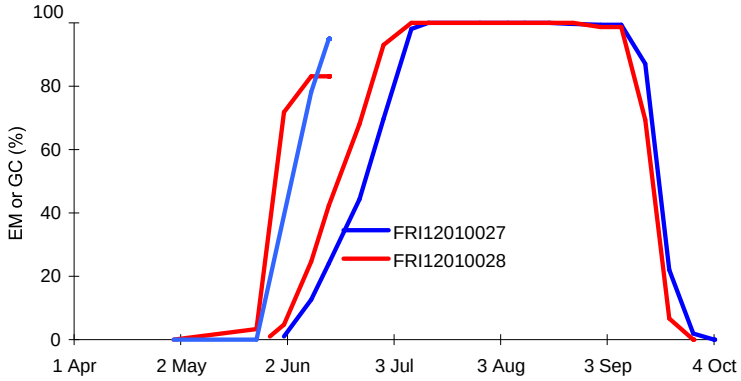
Analysis of crop performance using the CUF yield model

For the Saturna and Hermes crops grown by Tim Westgarth in County Durham, forecasts of yield at final harvest on 7 September tended to overestimate from the sample digs (Figure 24 and Figure 25). This systematic overestimation may be a consequence of the model relying on values of incident radiation measured 60 km to the south at Fridlington Farms. For the Standard Saturna crop (WES12010021) and the Saturna grown with a reduced seed rate (PEP12010022), model forecasts and observed yields were within 10 % of one another. However, for the Saturna crop grown with a reduced amount of N fertilizer (PEP12010023) the discrepancy between the predicted and observed yield was much larger (*c.* 13 t/ha). This difference in yields suggests that the measurements of yield at final harvest may be underestimates and in consequence the apparent yield penalty associated with a reduction in N application rate may not be real. For the three Hermes crops grown by Tim Westgarth, there was generally good agreement between modelled and observed yield at final sampling on 7 September. The data suggest that these crops were not overly stressed during the course of the season and their yields were largely explicable in terms of ground cover persistence and radiation absorption. The three Hermes crops monitored at Fridlington Farms were sampled on three occasions and there was good agreement between modelled and observed yields at the second and third samplings. When weighted for the area planted to each comparison, the average yield of the Fridlington crops at the final sampling was 55.1 t/ha and the average modelled yield was 56.4 t/ha. The average, gross commercial yield (estimated from the number of 1 t boxes filled and then increased by 5 % to allow for unharvested small potatoes and other losses) was 53.8 t/ha but the small areas used to test modified agronomy compromised comparisons of commercial yield with standard practice.

These data suggest that, on average, there was good agreement between the measured gross commercial yield and estimates obtained from sampling or modelling, although there were some differences between sampled, modelled and commercial yield within individual comparisons. In common with the Westgarth crops, the data suggest that through the course of the season, these crops were well supplied with water, were relatively disease-free and in consequence were not stressed.

Figure 22. Cockerills. Fridlington Farms Hermes seed rate comparison, Field 81.

Grower:	Fridlington Farms	Fridlington Farms
Field name:	Field 81	Field 81
Unique ID:	FRI12010027	FRI12010028
Part Field Name:	Seed and N standard	Seed modified & N
Variety:	Hermes	standard Hermes
Intended yield:	47 t/ha	47 t/ha
Planting date (start):	24 Apr	24 Apr
Date of 50 % emergence:	3 Jun	28 May
Total N applied:	225 kg N/ha	225 kg N/ha
Seed size:	35-45 mm	35-45 mm
Seed count:	925 per 50 kg	925 per 50 kg
Planned density:	58.0 000/ha	43.4 000/ha
Planned spacing:	18.9 cm	25.2 cm
Achieved density:	55.3 000/ha	45.1 000/ha
Achieved spacing:	19.8 cm	24.3 cm

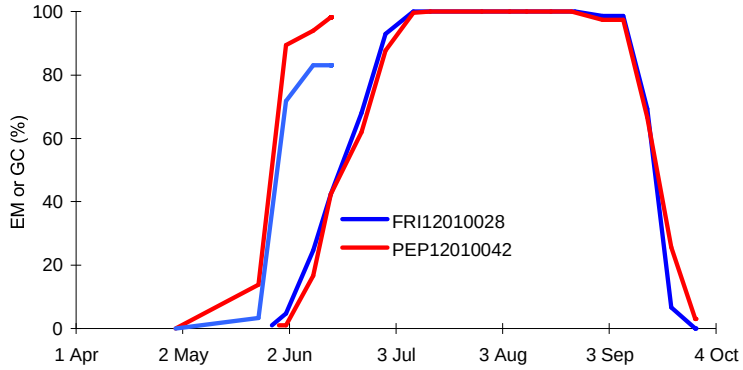


Yield Samples (S.E. in italics)

		Seed and N standard			Seed modified & N standard	
		28 Jul	7 Sep		28 Jul	7 Sep
Plants (000/ha)		67.4	46.2		48.6	42.8
		4.39	*2.03*		*1.22*	*1.75*
Stems (000/ha)		171.3	154.3		133.7	118.5
		7.99	*10.34*		*3.21*	*3.16*
Stems/plant		2.6	3.4		2.8	2.8
		0.11	*0.33*		*0.09*	*0.15*
Tubers (000/ha)		436	492		644	603
		40.5	*56.3*		*27.8*	*58.0*
Tubers (000/ha)	> 10 mm	190	306		293	379
		20.9	*28.5*		*15.9*	*17.0*
Tuber yield (t/ha)	> 40 mm	17.3	47.0		26.8	58.8
		1.55	*2.62*	> 10 mm	*0.79*	*4.78*
Tuber yield (t/ha)	> 10 mm	13.5	44.3		22.6	56.0
		1.34	*2.40*	> 40 mm	*0.80*	*4.22*
DM (%)	> 40 mm	16.3	20.0			
		0.17	*0.14*	> 10 mm		
Mean tuber size (mm)		47.1	64.0		50.1	64.9
		0.36	*1.59*	> 40 mm	*0.36*	*0.47*

Figure 23. Cockerills, Fridlington Farms Hermes N rate comparison, Field 81.

Grower:	Fridlington Farms	Fridlington Farms
Field name:	Field 81	Field 81
Unique ID:	FRI12010028	PEP12010042
Part Field Name:	Seed modified & N standard	Seed and N modified
Variety:	Hermes	Hermes
Intended yield:	47 t/ha	47 t/ha
Planting date (start):	24 Apr	24 Apr
Date of 50 % emergence:	28 May	30 May
Total N applied:	225 kg N/ha	185 kg N/ha
Seed size:	35-45 mm	34-45 mm
Seed count:	925 per 50 kg	925 per 50 kg
Planned density:	43.4 000/ha	43.4 000/ha
Planned spacing:	25.2 cm	25.2 cm
Achieved density:	45.1 000/ha	41.1 000/ha
Achieved spacing:	24.3 cm	26.6 cm



Yield Samples (S.E. in italics)

		Seed modified & N standard			Seed and N modified	
		28 Jul	7 Sep		28 Jul	7 Sep
Plants (000/ha)		48.6	42.8		43.7	41.9
		1.22	*1.75*		*3.65*	*1.05*
Stems (000/ha)		133.7	118.5		123.9	120.3
		3.21	*3.16*		*10.52*	*5.37*
Stems/plant		2.8	2.8		2.8	2.9
		0.09	*0.15*		*0.13*	*0.13*
Tubers (000/ha)	> 10 mm	644	603		537	622
		27.8	*58.0*		*54.1*	*52.2*
Tubers (000/ha)	> 40 mm	293	379		267	373
		15.9	*17.0*	> 10 mm	*9.5*	*26.4*
Tuber yield (t/ha)	> 10 mm	26.8	58.8		24.0	60.0
		0.79	*4.78*	> 40 mm	*1.21*	*4.11*
Tuber yield (t/ha)	> 40 mm	22.6	56.0		20.6	56.7
		0.80	*4.22*	> 10 mm	*0.96*	*3.80*
Mean tuber size (mm)		50.1	64.9		51.1	65.6
		0.36	*0.47*	> 40 mm	*0.57*	*1.04*

Figure 24. Comparison of model output (red line) and yield samples (blue symbol ± 1 S.E.) for Cockerills, Westgarth Saturna Field 35 (*a*) standard crop, (*b*) modified seed rate and (*c*) modified N rate.

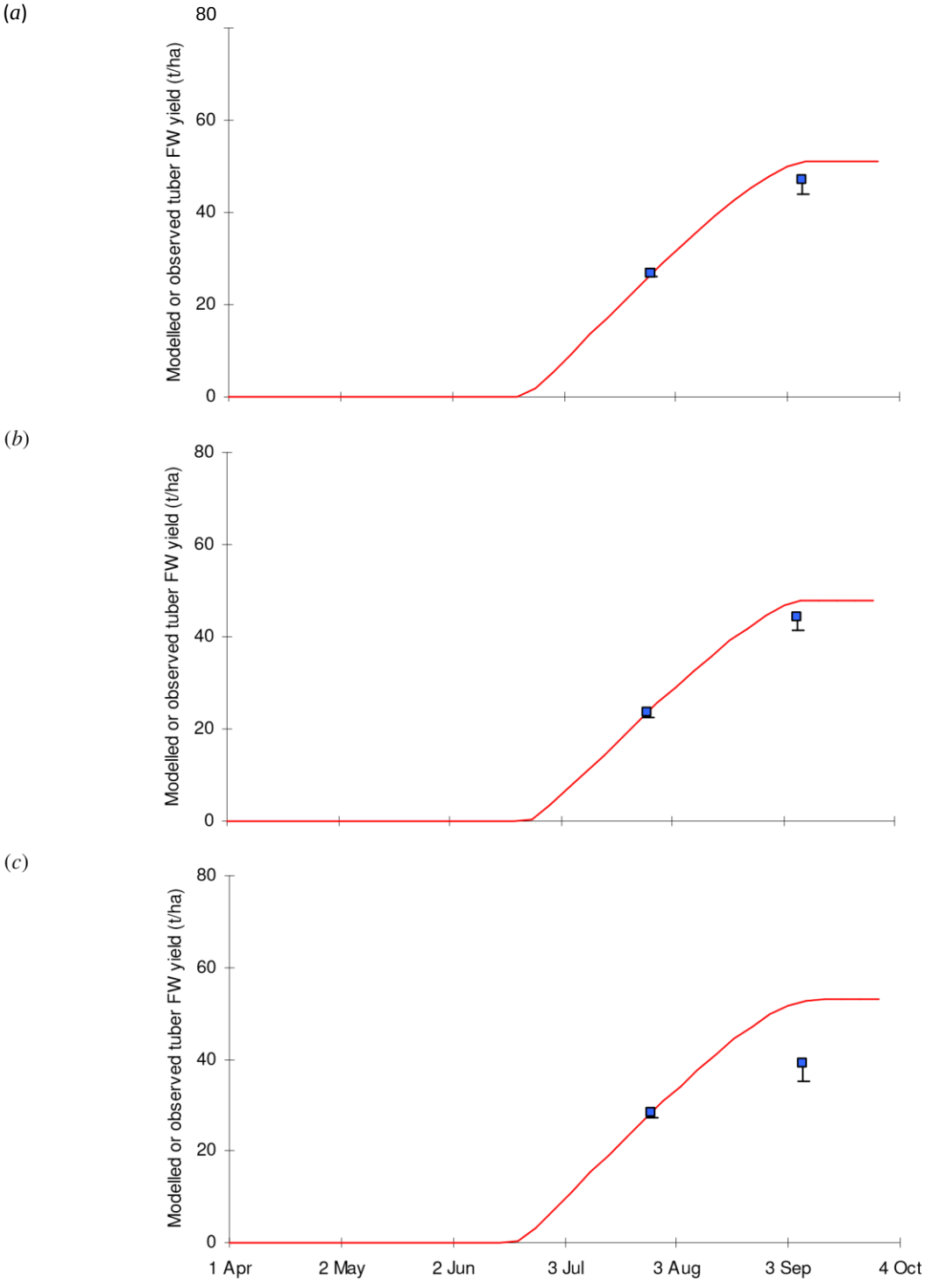
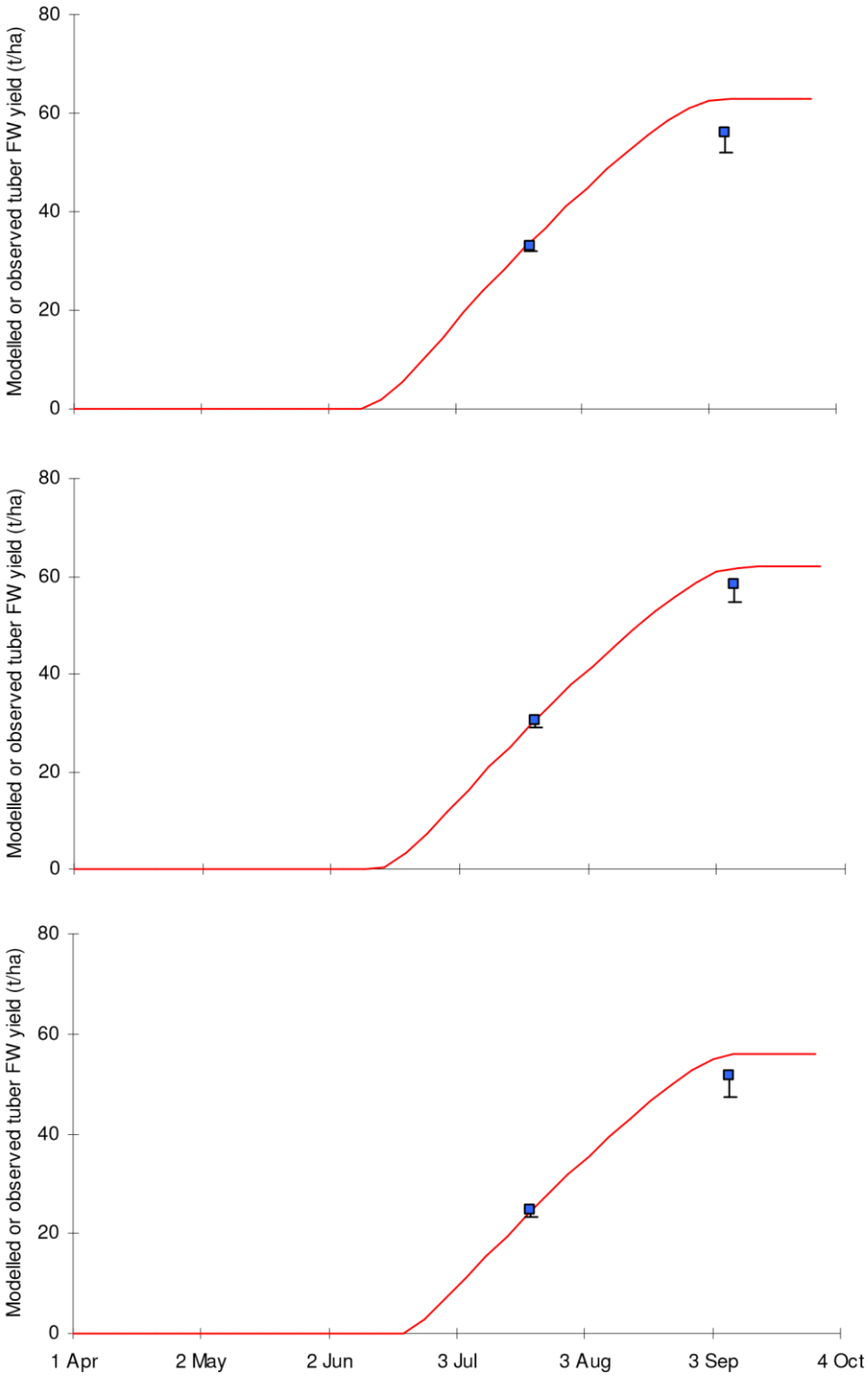


Figure 25. Comparison of model output (red line) and yield samples (blue symbol ± 1 S.E.) for Cockerills, Westgarth Hermes Field 16 (*a*) standard crop, (*b*) modified seed rate and (*c*) modified N rate. (*a*)



(*b*)

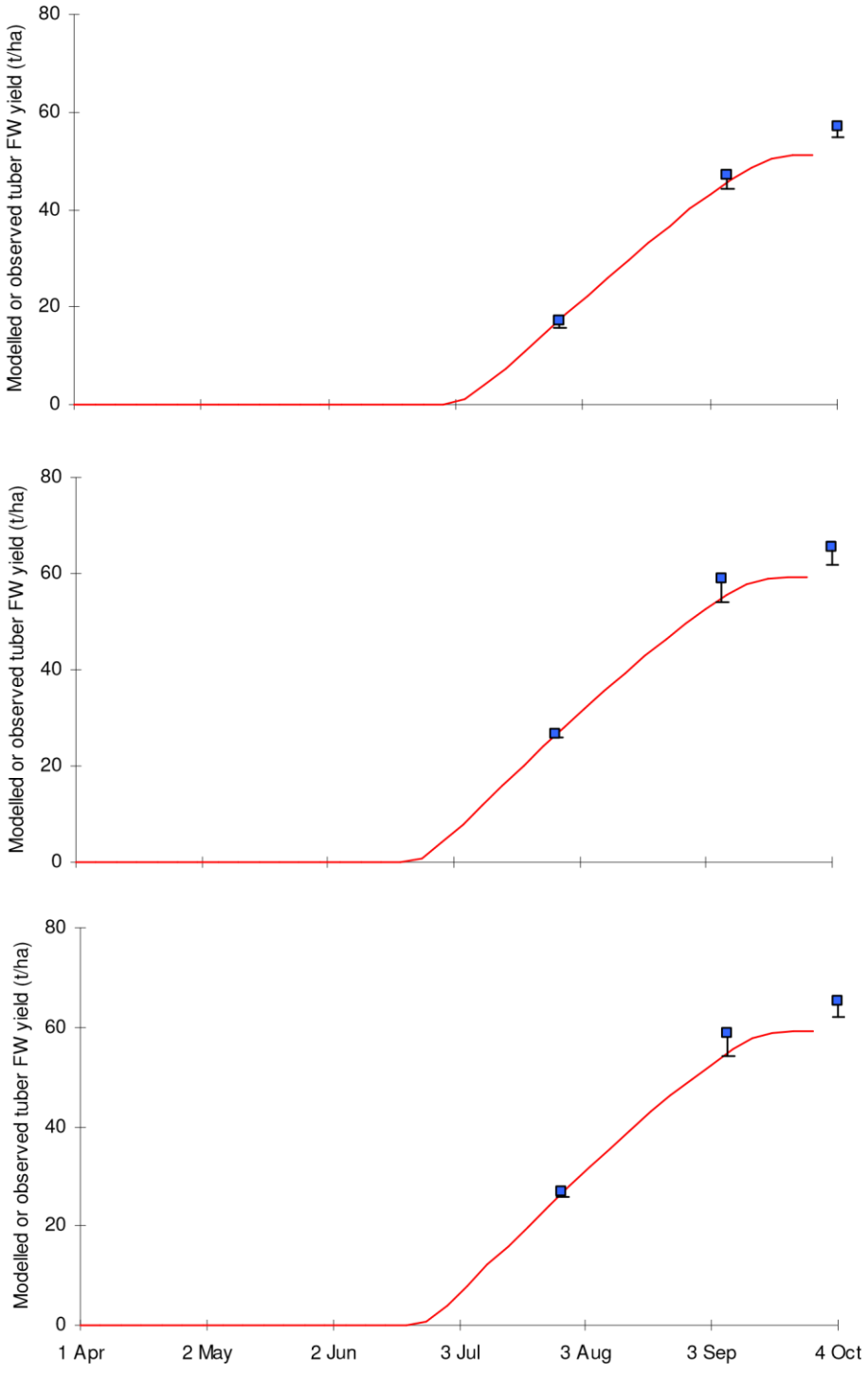
(*c*)

Figure 26. Comparison of model output (red line) and yield samples (blue symbol ± 1 S.E.) for Cockerills, Fridlington Hermes Field 81 (*a*) standard crop, (*b*) modified seed rate and (*c*) modified seed and N rate.

(*a*)

(*b*)

(*c*)



Summary

A summary of the 2010 crop comparisons is given in Table 3.

Table 3. Summary of crop comparisons in 2010

Comparison	Number of crops	Difference in fertilizer (kg N/ha) or seed (t/ha)	Difference in total yield (t/ha)	Difference in yield > 40 mm (t/ha)
N reduced	6	-29	+1.6	+1.4
Seed rate reduced	4	-0.48	+3.3	+3.9
Seed rate increased	n.a.	n.a	n.a	n.a

Note: Comparisons of monitored crops were excluded from this summary where:
Excessive difference in date of 50 % emergence (n=1) and achieved seed rates were smaller than planned and close to modified seed rates (n=1)

Table 4 summarises the effects of changes in agronomy on total and marketable tuber yields during 2007 to 2010. The proposed programme of work in 2011 is expected to be on a similar scale to previous seasons and will include some new collaborators to explore further opportunities to identify where inputs may be reduced without reducing marketable yields.

Table 4. Combined summary of crop comparisons in 2007-2010

Comparison	Number of crops	Difference in fertilizer (kg N/ha) or seed (t/ha)	Difference in total yield (t/ha)	Difference in yield > 40 mm (t/ha)
N reduced	18	-35	+1.6	+1.2
Seed rate reduced	23	-0.56	-0.1	+0.9
Seed rate increased	3	+0.25	+1.6	+0.4

Note: Comparisons of monitored crops were excluded from this summary where:
Achieved seed rates in the standard crops were smaller than planned and were close to modified seed rates (n=7) Nitrogen applications were smaller than planned (n=1), PCN affected crop growth (n=1) or large differences between dates of 50 % emergence (n=1)

References

STALHAM, M.A., ALLEN, E. J., ROSENFIELD, A. B. & HERRY, F. X. (2007). Effect of soil compaction in potato (*Solanum tuberosum*) crops. *Journal of Agricultural Science*, *Cambridge* **145**, 219-312.

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Appendix 1.

Table 5. Summary of all N rate comparison data collected in PCL/CUF grower collaboration project 2007-2010. Yield data are hand-dug samples taken at defoliation

Year	Grower	Field	Variety	Standard N applied (kg N/ha)	Modified N applied (kg N/ha)	Change in N applied (kg N/ha)	Standard yield > 10 mm (t FW/ha)	Modified yield > 10 mm (t FW/ha)	Change in yield > 10 mm (t FW/ha)	Standard yield > 40 mm (t FW/ha)	Modified yield > 40 mm (t FW/ha)	Change in yield > 40 mm (t FW/ha)
2008	Strawson†	Bower 8	Hermes	193	169	-24	66.2	60.6	-5.6	63.8	58.2	-5.6
2008	MVP/TVP††	MFL B	Russet Burbank	200	160	-40	69.1	52.8	-16.3	64.5	46.8	-17.7
2010	Cockerills#	Field 16	Hermes	175	140	-35	55.8	51.6	-4.3	52.5	48.6	-3.9
2007	MVP/TVP	Upper Trent	Russet Burbank	220	165	-55	59.5	67.6	8.1	56.4	64.1	7.7
2007	NNPG	Market Style	Saturna	240	175	-65	40.2	51.0	10.8	29.9	36.4	6.5
2008	A H Worth	Field 13	Maris Piper	180	140	-40	56.0	50.9	-5.1	53.3	47.9	-5.3
2008	NNPG	Malthouse	Saturna	240	180	-60	45.2	48.6	3.4	42.1	45.4	3.3
2008	NNPG	Horseshoes	Hermes	224	175	-49	50.4	53.6	3.2	47.4	50.9	3.6
2009	A H Worth	F38	Maris Piper	180	155	-25	71.4	72.6	1.1	69.8	70.7	0.9
2009	MVP/TVP	Curborough	Markies	150	130	-20	56.4	55.7	-0.7	51.7	50.9	-0.9
2009	MVP/TVP	Deercote Barn	Maris Piper	220	200	-20	64.5	54.4	-10.1	59.9	48.6	-11.3
2009	Strawson	Wood 10	Hermes	210	185	-25	37.6	44.0	6.4	35.3	41.4	6.1
2009	Strawson	Godfrey 13	Saturna	220	195	-25	63.1	58.9	-4.2	60.5	55.9	-4.6
2009	NNPG	Bakers 27	Saturna	240	180	-60	48.8	52.0	3.2	46.4	49.4	3.1
2009	NNPG	Long Lions	Hermes	191	181	-10	57.0	61.0	4.0	54.7	58.1	3.4
2010	Co-op	3/5/7/ B	Estima	230	205	-25	35.9	43.1	7.2	33.8	39.7	5.9
2010	Branston	Pit Field	Desiree	140	120	-20	74.3	75.8	1.5	70.7	72.2	1.6
2010	AH Worth	Field 26/27	Marfona	180	150	-30	54.8	60.9	6.1	53.4	59.5	6.0
2010	AH Worth	JEP28	Melody	180	155	-25	44.2	46.5	2.3	40.1	41.3	1.2
2010	Cockerill	Field 35	Saturna	230	195	-35	47.2	39.2	-8.0	43.4	36.6	-6.8
2010	Cockerills	Field 81	Hermes	225	185	-40	65.4	65.9	0.5	62.9	63.8	0.8
			Average (n=18)	206	171	-35	54.0	55.6	1.6	50.6	51.8	1.2

Not included in averages and summaries since: †, N rates smaller than intended; ††, crop severely affected by potato cyst nematode and #, large difference in emergence dates of crops

Table 6. Summary of all seed rate comparison data (seed rate increased) collected in PCL/CUF grower collaboration project 2007-2010. Yield data are hand-dug samples taken at defoliation

Year	Grower	Field	Variety	Standard seed rate (t/ha)	Modified seed rate (t/ha)	Change in seed rate (t/ha)	Standard yield > 10 mm (t FW/ha)	Modified yield > 10 mm (t FW/ha)	Change in yield > 10 mm (t FW/ha)	Standard yield > 40 mm (t FW/ha)	Modified yield > 40 mm (t FW/ha)	Change in yield > 40 mm (t FW/ha)
2007	MVP/TVP	Thorpe 41	Saturna	1.38	1.59	0.22	54.2	50.1	–4.1	51.8	46.1	–5.7
2007	Strawson	Godfrey	Saturna	2.42	2.73	0.31	69.0	72.4	3.4	67.4	70.7	3.3
2009	NNPG	Bakers 27	Saturna	1.53	1.76	0.23	48.8	54.2	5.4	46.4	50.0	3.7
			Average (n=3)	1.78	2.03	0.25	57.3	58.9	1.6	55.2	55.6	0.4

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Table 7. Summary of all seed rate comparison data (seed rated decreased) collected in PCL/CUF grower collaboration project 2007-2010. Yield data are handdug samples taken at defoliation

Year	Grower	Field	Variety	Standard seed rate (t/ha)	Modified seed rate (t/ha)	Change in seed rate (t/ha)	Standard yield > 10 mm (t FW/ha)	Modified yield > 10 mm (t FW/ha)	Change in yield > 10 mm (t FW/ha)	Standard yield > 40 mm (t FW/ha)	Modified yield > 40 mm (t FW/ha)	Change in yield > 40 mm (t FW/ha)
2008	A H Worth†	Field 69	Estima	2.04	1.68	-0.37	59.0	59.6	0.6	56.5	56.1	-0.5
2008	A H Worth†	Field 69	Estima	2.71	2.80	0.09	59.2	69.8	10.6	56.1	67.1	10.9
2008	Strawson†	Hoggard 6	Saturna	2.21	2.03	-0.18	67.6	60.1	-7.5	62.6	56.5	-6.1
2008	NNPG†	Millfield	Hermes	4.60	1.81	-2.79	53.9	59.4	5.6	49.0	56.6	7.5
2009	A H Worth†	JEP44	Estima	2.25	2.12	-0.13	60.1	55.2	-4.9	58.7	54.0	-4.7
2009	MVP/TVP†	Marsh Barn	Lady Rosetta	1.48	1.23	-0.25	57.6	51.1	-6.5	52.3	48.5	-3.8
2009	NNPG†	Long Lions	Hermes	2.66	2.82	0.16	57.0	62.2	5.2	54.7	59.6	4.9
2009	Strawson†	Sansom Wood 14	Hermes	5.28	4.99	-0.29	42.3	39.1	-3.1	38.7	36.1	-2.5
2010	A H Worth†	Field 26/27	Marfona	2.56	2.27	-0.29	54.8	63.3	8.5	53.4	62.2	8.7
2010	Cockerills†	Field 35	Saturna	2.25	2.28	0.02	47.2	44.4	-2.8	43.4	40.8	-2.6
2007	MVP/TVP	Ellis B	Hermes	2.74	1.77	-0.97	64.4	75.8	11.4	60.5	71.9	11.4
2007	MVP/TVP	Thorpe 41	Saturna	3.59	3.54	-0.05	58.8	51.4	-7.4	56.0	46.5	-9.5
2007	Strawson	Knights Narborough	Saturna	2.36	2.17	-0.19	51.0	49.8	-1.1	48.2	47.8	-0.4
2007	Strawson	Shammar Creake	Hermes	2.98	2.45	-0.53	47.5	46.8	-0.7	46.9	46.4	-0.5

2007	Strawson	Bower Carburton	Hermes	3.58	2.67	-0.91	55.5	58.6	3.1	52.3	56.7	4.3
2007	NNPG	X1	Saturna	2.47	2.21	-0.26	68.7	62.8	-5.9	64.7	59.9	-4.8
2007	NNPG0	X2	Hermes	3.14	2.03	-1.10	49.8	54.0	4.2	45.5	51.0	5.5
2008	A H Worth	Field 13	Maris Piper	1.49	1.13	-0.36	64.4	56.0	-8.4	59.9	53.3	-6.7
2008	Strawson	Bower 8	Hermes	3.19	2.49	-0.70	66.2	57.9	-8.3	63.8	56.2	-7.6
2008	Strawson	Godfrey 8	Saturna	2.46	2.36	-0.10	50.6	52.0	1.5	46.8	48.5	1.6
2008	NNPG	Millfield	Hermes	4.60	3.01	-1.59	53.9	59.3	5.5	49.0	56.8	7.7
2008	NNPG	Horseshoes	Hermes	2.46	2.00	-0.46	50.4	53.6	3.2	47.4	51.7	4.3
2008	NNPG	Malthouse	Saturna	1.82	1.65	-0.17	45.2	43.3	-1.9	42.1	41.3	-0.8

Table 7. (continued). Summary of all seed rate comparison data (seed rated decreased) collected in PCL/CUF grower collaboration project 2007-2010. Yield data are hand-dug samples taken at defoliation

2008	MVP/TVP	Bowling Alley	Lady Rosetta	3.45	3.04	-0.41	66.9	64.7	-2.1	62.2	60.9	-1.2
2008	MVP/TVP	Packington Quarry	Hermes	4.00	2.72	-1.29	57.8	55.0	-2.8	51.8	49.9	-1.9
2009	A H Worth	JEP44	Estima	3.51	2.91	-0.60	67.8	66.2	-1.6	65.8	65.1	-0.7
2009	MVP/TVP	Marsh Barn	Lady Rosetta	2.27	1.87	-0.39	54.5	52.2	-2.3	46.2	48.5	2.3
2009	Strawson	Sansom Wood 14	Hermes	5.28	4.78	-0.50	42.3	39.6	-2.6	38.7	37.5	-1.1
2009	NNPG	Bakers 55	Hermes	2.99	2.50	-0.49	56.6	58.2	1.6	52.1	55.8	3.7
2010	Co-op	3/5/7/ B	Estima	2.84	2.45	-0.39	35.9	39.5	3.6	33.8	38.0	4.2
2010	Branston	Hall Field	King Edward	2.02	1.86	-0.16	67.2	66.0	-1.1	60.6	61.3	0.7
2010	Cockerills	Field 16	Hermes	3.41	2.61	-0.80	55.8	58.4	2.6	52.5	55.8	3.2
2010	Fridlington	Field 81	Hermes	2.99	2.44	-0.55	57.1	65.4	8.3	55.6	62.9	7.3
			Average (n=23)	3.03	2.46	-0.56	56.0	56.0	-0.1	52.3	53.2	0.9

Excluded from averages and summaries since: † achieved seed rates different from intended

Appendix 2

Table 8. Summary statistics comparing standard seed and N rates with modified for all comparison and restricted to valid comparisons. P is the probability that the difference between standard and modified agronomy is zero

Comparison		Tuber yield > 10 mm (t/ha)		Tuber yield > 40 mm (t/ha)	
		Standard	Reduced	Standard	Reduced
N rate	All data (n=21)	55.4 (± 2.43)	55.6 (± 2.08)	52.0 (± 2.54)	51.7 (± 2.27)
	Difference	+0.2 (± 1.46) t/ha; P = 0.914		-0.3 (± 1.42) t/ha; P = 0.842	
	Summary (n=18)	54.0 (± 2.64)	55.6 (± 2.40)	50.7 (± 2.79)	51.8 (± 2.62)
	Difference	+1.6 (± 1.32); P = 0.229		+1.2 (± 1.22); P = 0.349	
Seed rate	All data (n=33)	56.0 (± 1.43)	56.1 (± 1.54)	52.4 (± 1.40)	53.4 (± 1.51)
	Difference	+0.1 (± 0.94) t/ha; P = 0.894		+1.0 (± 0.93) t/ha; P = 0.291	
	Summary (n=23)	56.0 (± 1.84)	56.0 (± 1.85)	52.3 (± 1.78)	53.2 (± 1.78)
	Difference	–0.1 (± 1.05) t/ha; P = 0.953		+0.9 (± 1.06) t/ha; P = 0.394	

Grower Collaboration Project Report for 2011

M F Allison & D M Firman

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Introduction

This was the fifth year of the project and its objectives were to collaborate with growers in planning the agronomic components of their potato production systems utilising current agronomic knowledge and documenting the process and differences from previous practice. The project aimed to examine the accuracy of the agronomic decisions in relation to crop growth, yield potential and timing of harvest, meeting irrigation requirements and other criteria. Collaboration was undertaken with the following growers and grower groups: Branston Holdings Ltd, The Co-operative Farms, South West Agronomy Group (SWAG), RS Cockerill Ltd and McCain Foods Ltd.

Materials and Methods

Information on cropping plans, including varieties, seed stocks, intended planting date and yield, target tuber size, seed rates, soil data and fertilizer application rates, was obtained from collaborating growers. Fertilizer and seed rate recommendations were calculated for some of the crops using the information supplied. The dates of seed crop emergence and ware crop planting were factors accounted for in determining CUF seed rate recommendations but these were not used by growers to determine their 'standard' seed rates (except for SWAG growers already using CUF advice). Cases where the current 'standard' grower's plans differed substantially (*i.e*. by at least 10 %) from recommendations based on the best information available to CUF were identified and opportunities for making comparisons of 'standard' with 'CUF modified' recommendations discussed. In each case, generally a width of *c.* 24 m within a field received modified agronomy whilst standard agronomy was applied to the rest of the field. These unreplicated comparisons are not experiments and their limitations must be appreciated in regard to any confounding influences on the results and the variation associated with estimates of the variates recorded, particularly of crop samples from limited areas. In other cases, even where there were no substantial differences between 'standard' and 'CUF-modified' recommendations, crops were identified with a view to recording performance in relation to agronomic inputs and environmental conditions. Opportunities for additional experiments and data collection were discussed and a nitrogen fertilizer experiment was conducted at one site. A set of protocols and templates for data recording were sent to growers for recording the appropriate data on the crops so that each grower could collect data and send updates to CUF during the season. Staff from CUF visited most of the crops following establishment and some data were collected during these visits to complement data collected by growers. Emergence (EM), ground cover (GC) and yield data were usually collected from three or four replicate areas. To complement data available for the sites, data from a calibrated

pyranometer (Campbell CS300) installed at each site was collected on a logger (Tiny-Tag RE-ED) to provide daily total incident radiation data.

Acknowledgements

The authors would like to than the following people for making this program possible: Tony Bambridge (B&C Farming Ltd, McCain grower); Matt Bere (B&B Potatoes, SWAG grower); Philip Bradshaw (Potato Council Ltd); Philip Burgess (Co-operative Farms); James Daw (Tame Valley Potatoes, McCain grower); Graeme Ditty (Tame Valley Potatoes); Ashley Dunn (Branston Ltd); David Nelson (Branston Ltd); Jack Parsons (Co-operative Farms); James Pullen (Perrin Hill Farm, SWAG grower); Andrew Spinks (B&C Farming Ltd); Mark Taplin (Tame Valley Potatoes); Ben Tyreman (RS Cockerill Ltd); Mathew Wallace (Fridlington Farms, Cockerill grower); Tim Westgarth (Westgarth Farms, Cockerill grower). Thanks are also due to the technical staff at CUF and PepsiCo UK field staff that collected ground cover data and assisted with harvesting the Cockerill crops

Results and Discussion

Sites and monitored crops

In 2011, a total of 30 crops were monitored and key details for these crops are shown Table 1. For some crops the 'standard' was used for comparisons against both modified seed and modified N rates.

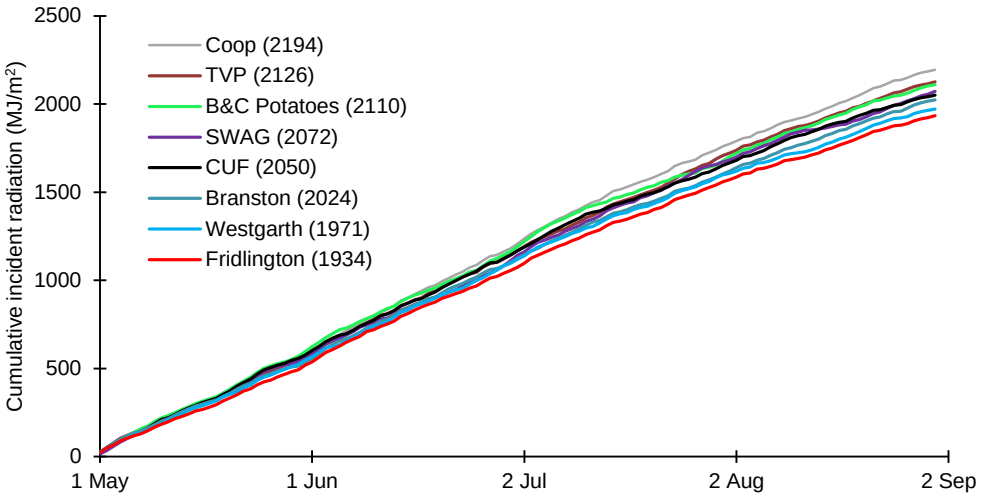
Table 1. Summary of crops monitored as part of PCL/CUF grower collaboration program in 2011

Grower group	Sector	Varieties in program	Number of seed rate comparisons	Number of N rate comparisons
McCain (James Daw, TVP)	Processing	Russet Burbank	4	0
McCain (B&C Farming)	Processing	Russet Burbank	15	0
Co-operative Farms	Fresh	Maris Piper	2	2
SWAG Bere	Fresh	Sante	3	0
SWAG Pullen	Fresh	Estima	No comparisons	
Branston Ltd	Processing	Maris Piper	1	0
R S Cockerill Ltd (Westgarth)	Processing	Saturna	0	1
R S Cockerill Ltd (Fridlington Farms)	Processing	Hermes	1	1

Cumulative (May to August) incident radiation for CUF and seven grower collaboration sites is shown in Figure 1. Missing data (caused by the logger overwriting previous records or not logging by 1 May) were replaced with data from the nearest available sites. No data were available for the Cockerills site in County Durham or the B&C site in Norfolk and these data were replaced with local readings collected as part of other projects. Cumulative, May to August total incident radiation at CUF in 2011 was 2050 MJ/m^2. For comparison, total

incident radiation in 2008, 2009 and 2010 was 2005, 2135 and 2122 MJ/m^2, respectively. In 2011, the difference between the brightest Grower Collaboration site (Cooperative Farms, Goole) and the dullest (Fridlington Farms, York) was 260 MJ/m^2 and this was the same as the range found in 2009. The variation in incident radiation was unlikely to have had much effect on yield potential since the rate of crop establishment, canopy expansion and persistence tend to have much larger effects on yield.

Figure 1. Cumulative incident radiation May-August 2010 at Cambridge and collaboration sites.



McCain Ltd

McCain Ltd joined the grower collaboration program in 2011 and nominated two host growers (B&C Farming Ltd, Norfolk and James Daw of Tame Valley Potatoes, Staffordshire). The main objective of work in the first year of the program was to test new seed rate recommendations for Russet Burbank that had been derived from recent work at CUF (Potato Council Project R296). At B&C Farming Ltd comparisons were made between McCain seed rate recommendation, CUF seed recommendation and an intermediate, B&C recommendation for two stocks of Russet Burbank. Whilst all the data have been presented in this report, the analysis will concentrate on the comparisons between the McCain and CUF plant populations. The seed rate comparisons with James Daw tested grower (standard) and CUF recommendations on two stocks of Russet Burbank. Seed and cropping details for all sites and stocks are given in Table 2. In all cases, the objective of the seed rate recommendation was, for a given target yield, to maximise the yield of potatoes > 90 mm in length and to keep the ware tuber count < 61/10kg for tubers > 45 mm diameter.

Table 2. Details of seed and ware crops for McCain seed rate comparisons and B&C Farming and James Daw of Tame Valley Potatoes

Grower	B&C	B&C	B&C	B&C	B&C	TVP	TVP
Field name	Grove Farm 89	Grove Farm 91	Grove Farm 91	Medler Melton	Medler Melton	29 Acres	29 Acres
Seed crop							
Stock number	54735	54735	54782	54735	54782	54722	54769
Seed size (mm)	30-35	30-35	30-35	30-35	30-35	35-45	35-45
Count (no./50 kg)	1835	1835	1854	1835	1854	910	990
Seed emergence	6 Jun 10	6 Jun 10	30 May	6 Jun 10	30 May	3 Jun 10	5 Jun 10
Certification grade	SE3	SE3	SE3	SE3	SE3	SE2	SE2
Ware crop							
Intended yield (t/ha)	55	55	55	55	55	50	50
Intended planting	1 Apr 11	1 Apr 11	1 Apr 11	1 Apr 11	1 Apr 11	10 Apr 11	10 Apr 11
Intended plant populations (no./ha) and within row spacing (cm)							
McCain population	54 700	54 700	54 700	54 700	54 700	-	-
McCain spacing	20	20	20	20	20	-	-
Grower population	48 000	48 000	48 000	48 000	48 000	31 400	33 300
Grower spacing	22	22	22	22	22	35	33
CUF population	38 500	38 500	37 600	38 500	37 600	26 000	27 500
CUF spacing	28	28	29	28	29	42	40

B&C Farming Ltd, Norfolk, Russet Burbank (54735), Grove Farm 89

Crops with the McCain and CUF spacings were planted on 4 April and both achieved 50 % plant emergence on 3 May (29 days after planting, DAP). The initial rate of ground cover expansion was similar for the McCain and CUF spacings and both achieved complete ground cover (on *c*. 15 June). Complete ground cover was maintained until the end of July although detailed observation of ground cover in each area were not made after mid-June (Figure 2). When based on a sample taken on 7 September (127 days after emergence, DAE), the achieved, plant population in the McCain area was smaller than intended whilst the achieved population for the CUF area was larger than intended. The ware yield (> 45 mm) and fraction of yield > 90 mm length in the McCain area was 55.8 t/ha and 47.7 %, respectively. In the CUF areas the corresponding values were 59.6 t/ha and 52.4 %, respectively. The tuber counts > 45 mm in the McCain and CUF area were 57 and 59/10 kg, respectively. There was little effect of plant population on tuber DM concentration which averaged 23.3 %. Since the differences between the achieved populations were so small, this comparison has been excluded from the summary tables at the end of this report. The comparison between crops grown with the McCain and B&C populations is given in Figure 3.

B&C Farming Ltd, Norfolk, Russet Burbank (54735), Grove Farm 91

The McCain and CUF comparisons at Grove Farm 91 were planted on 4 April and both reached 50 % plant emergence after 30 days. The achieved plant population in the McCain area was smaller than planned, whereas the achieved plant population in the CUF area was larger than planned (Figure 4). However, the difference in achieved plant populations between the two areas permitted a valid comparison. After emergence, initial ground cover expansion in both areas was similar and although no data were recorded, both comparisons were reported to have reached complete ground cover and this was maintained for several weeks. The CUF area had fewer stems and fewer tubers > 10 mm than the McCain area and this is consistent with the difference in plant population. Ware (> 45 mm) yields in McCain and CUF areas were 70.0 and 62.4 t/ha, respectively and the proportion of yield >90 mm length was 49 % in the area planted at the McCain spacing compared with 53 % in CUF area. Both of these estimates of yield > 90 mm were associated with large standard errors and it probable that the marketable yield in both areas was very similar. The tuber count in the McCain area was 57/10 kg compared with 54/10 kg in the CUF area. For both crops planted at the McCain and CUF spacings the tuber DM concentration was identical (21.8 %). The comparison between the McCain and B&C area is shown in Figure 5.

B&C Farming Ltd, Norfolk, Russet Burbank (54782), Grove Farm 91

The seed rate comparison using stock 54782 was planted in Grove Farm 91 on 4 April and, like the 54735 stock, reached 50 % plant emergence on *c*. 4 May. For the McCain area the intended plant population was 54 700/ha and the achieved plant population was 50 100/ha (Figure 6). In the CUF area the intended plant population was 37 600/ha and the achieved was 41 000/ha. Thus, whilst differences in plant population were achieved, these were not as large as originally intended, however they were sufficiently large to provide a valid comparison of two contrasting spacings. In common with the other seed rate comparisons with Russet Burbank, differences in the pattern of initial ground cover expansion due to planting density were negligible. A crop sample was taken on 30 August (*c.* 119 DAE) and in accordance with the smaller plant population, the stem and tuber populations were smaller in the CUF area when compared with the McCain area. Tuber yields > 45 mm were 65.0 and 59.8 t/ha in the McCain and CUF areas, respectively, but differences in the proportion of tubers > 90 mm in length were small and averaged *c*. 47 %. The tuber count > 45 mm in the McCain area was 57/10 kg compared with 59/10 kg in the CUF area. Tuber dry matter concentration differed little between crops grown using McCain and CUF seed spacings and averaged 22.7 %.

B&C Farming, Norfolk, Russet Burbank (54735), Medler Melton

The seed rate comparisons with stock 54735 were planted in Medler Melton on 11 April. Plant emergence was rapid and 50 % emergence was on 8 May (27 DAE) for both seed rate comparisons (Figure 8). For the McCain area, the achieved plant population was smaller than that intended whilst for the CUF area the achieved population was larger than intended. However, the achieved difference between the McCain and CUF areas was sufficiently large to make valid comparisons of total and marketable yield under the two regimes. From emergence until mid-June there was no detectable effect of the different plant populations on ground cover expansion and subsequent field-average ground cover data showed that complete ground cover was reached in early-July and was maintained until mid-August. As expected, reducing the plant population reduced the stem and tuber population, although the effect on the number of tubers > 10 mm was relatively small. Ware tuber yields in the McCain area averaged 51.0 t/ha and those in the CUF area were very similar (50.2 t/ha). The fraction of yield > 90 mm long was 56 % in the McCain area and 53 % in the CUF area. The tuber counts > 45 mm in both areas were 57/10 kg. The Tuber DM concentrations in Medler Melton were greater than those in Grove Farm 89 and Grove Farm 91 and averaged

25.5 %. A summary of the comparison between the McCain and B&C spacing is given in Figure 9.

B&C Farming Ltd, Norfolk, Russet Burbank (54782), Medler Melton

The 54782 stock of Russet Burbank was planted on the 11 April and for both spacings 50 % emergence was reached on 8 May (27 DAE). In common with the other seed rate comparisons, the achieved McCain plant population was smaller than intended whilst the achieved CUF spacing was larger than intended (Figure 10), but the difference in achieved plant population (6 400/ha) was still large enough to test the effect of plant spacing on total and ware yield. Initial ground cover expansion in the CUF spacing area appeared to be slightly faster than in the McCain spacing and when the final ground cover was recorded (10 June) the ground cover of the CUF area was *c.* 11 % larger than McCain Spacing (43 compared with 32 %). The initial ground cover expansion of the 54782 stock, averaged over both spacings, appeared to be slightly slower than in the 54735 stock. Both stocks emerged on 8 May and on the 10 June the average ground cover for the 54735 stock was 51 % but only 38 % for the 54782 stock. Changing the achieved plant population from 51 000 to 44 700/ha reduced the stem population from 122 100 to 95 700/ha and the total tuber population from 459 000 to 415 000/ha. Numerically, the tuber yield > 45 mm was smaller in the McCain area than in the CUF area (48.6 compared with 54.8 t/ha) as was the proportion of yield > 90 mm long (52 compared with 64 %). In common with the other comparisons, this difference in yield between the CUF and McCain area was unlikely to be a real consequence of the difference in plant populations. The tuber count in the McCain area was 58/10 kg compared with 52/10 kg in the CUF area. The average tuber dry matter for both the McCain and CUF area was 25.4 %. The comparison of the McCain and B&C spacing is given in Figure 11.

In summary, all the crops grown at McCain and CUF spacings, irrespective of stock, had total yields (> 10 mm diameter) exceeding the original target yield of 55 t/ha. This was a general feature of many crops monitored in 2011 as part of this and other projects. Once the errors in measurement are taken into account there appeared to be no disadvantage in decreasing the plant population from the McCain to the CUF recommendation. It is possible, that at smaller yields (e.g. closer to the target yield) the benefit of a smaller plant population would become even more apparent since the McCain seed rate recommendations would tend to result in tubers that were too short or in tuber counts that were too high. A feature in many of these comparisons is that the achieved plant population in the McCain area was smaller than anticipated whilst those in the CUF areas were larger. This

discrepancy was also found when plant populations were estimated from four replicated counts taken from 10 m lengths of row at end of the emergence period (Table 3). This discrepancy between intended and achieved plant population has been found before in the Grower Collaboration program and in other surveys done by CUF staff. Assuming the discrepancy is not solely confined to the fields being monitored implies that many fields may not achieve their intended plant population resulting in wasted seed or ware crops failing to meet their potential.

Table 3. Comparison of intended plant populations and those measured at final harvest and those measured at plant emergence of two stocks of Russet Burbank grown by B&C Farming Ltd

Field	Stock	Spacing	Intended	Yield samples	Emergence counts
Grove Farm 89	54735	McCain	54 700	47 400	47 000
Grove Farm 89	54735	B&C	48 000	42 800	46 300
Grove Farm 89	54735	CUF	38 500	48 300	41 000
Grove Farm 91	54735	McCain	54 700	50 100	53 600
Grove Farm 91	54735	B&C	48 000	46 500	47 200
Grove Farm 91	54735	CUF	38 500	43 700	41 400
Grove Farm 91	54782	McCain	54 700	50 100	49 400
Grove Farm 91	54782	B&C	48 000	44 700	46 700
Grove Farm 91	54782	CUF	37 600	41 000	38 100
Medler Melton	54735	McCain	54 700	50 100	44 800
Medler Melton	54735	B&C	48 000	43 700	41 000
Medler Melton	54735	CUF	38 500	43 700	39 200
Medler Melton	54782	McCain	54 700	51 000	34 800
Medler Melton	54782	B&C	48 000	43 700	45 000
Medler Melton	54782	CUF	37 600	44 700	42 300

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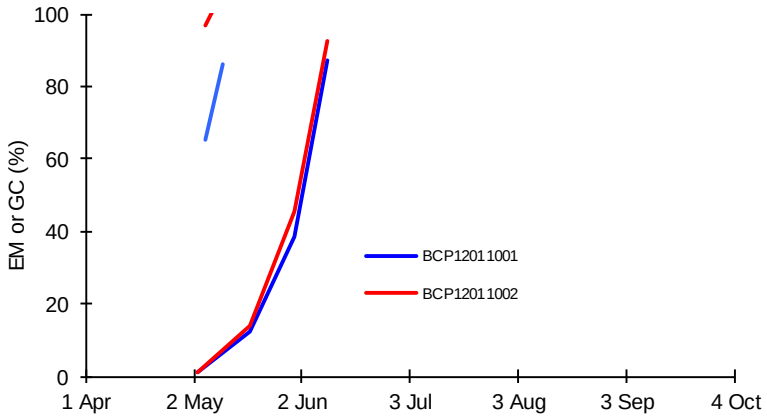
Figure 2. B&C Farming Ltd, Russet Burbank (54735), Grove Farm 89.

Grower:	B&C Farming Ltd	B&C Farming Ltd
Field name:	Grove Farm 89-735	Grove Farm 89-735
Unique ID:	BCP12011001	BCP12011002
Part Field Name:	Seed McCain & N Standard	Seed CUF & N Standard
Variety:	Russet Burbank	Russet Burbank
Intended yield:	55 t/ha	55 t/ha
Intended use:	French-fries	French-fries
Planting date (start):	4 Apr	4 Apr
Date of 50 % emergence:	3 May	3 May
Total N applied:	242 kg N/ha	242 kg N/ha
Seed size:	30-35 mm	30-35 mm
Seed count:	1835 per 50 kg	1835 per 50 kg
Planned density:	54.7 000/ha	38.5 000/ha
Planned spacing:	20.0 cm	28.4 cm
Achieved density:	47.4 000/ha	48.3 000/ha
Achieved spacing:	23.1 cm	22.6 cm



Yield Samples (S.E. in italics)

		Seed McCain & N Standard		Seed CUF & N Standard
		7 Sep		7 Sep
Plants (000/ha)		47.4		48.3
		1.49		*2.73*
Stems (000/ha)		98.4		104.8
		7.87		*13.75*
Stems/plant		2.1		2.2
		0.13		*0.26*
Tubers (000/ha)	> 10 mm	453	> 10 mm	478
		19.8		*38.0*
Tuber yield (t/ha)	> 10 mm	61.6	> 10 mm	65.3
		2.24		*3.83*
Tuber yield (t/ha)	> 45 mm	55.8	> 45 mm	59.6
		3.23		*3.76*
Tuber yield (%)	> 90 mm	47.7	> 90 mm	52.4
		4.23		*1.88*
DM (%)		23.1		23.5
		0.70		*0.33*
Mean tuber size (mm)		57.9		56.6
		1.57		*0.51*

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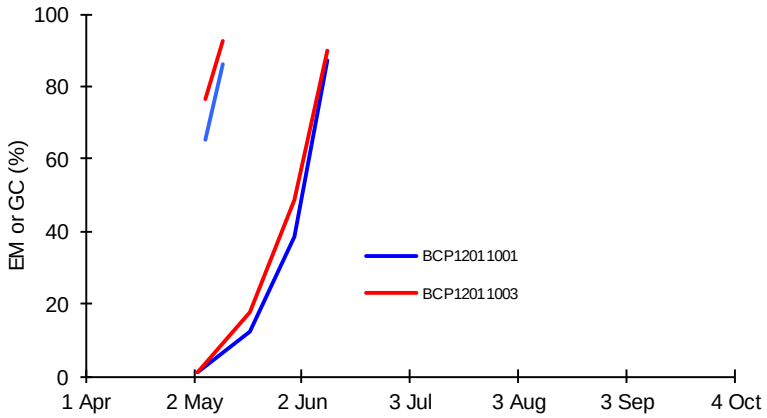
Figure 3. B&C Farming Ltd, Russet Burbank (54735), Grove Farm 89.

Grower:	B&C Farming Ltd	B&C Farming Ltd
Field name:	Grove Farm 89-735	Grove Farm 89-735
Unique ID:	BCP12011001	BCP12011003
Part Field Name:	Seed McCain & N Standard	Seed B&C & N Standard
Variety:	Russet Burbank	Russet Burbank
Intended yield:	55 t/ha	55 t/ha
Intended use:	French-fries	French-fries
Planting date (start):	4 Apr	4 Apr
Date of 50 % emergence:	3 May	3 May
Total N applied:	242 kg N/ha	242 kg N/ha
Seed size:	30-35 mm	30-35 mm
Seed count:	1835 per 50 kg	1835 per 50 kg
Planned density:	54.7 000/ha	48.0 000/ha
Planned spacing:	20.0 cm	21.9 cm
Achieved density:	47.4 000/ha	42.8 000/ha
Achieved spacing:	23.1 cm	25.5 cm



Yield Samples (S.E. in italics)

		Seed McCain & N Standard		Seed B&C & N Standard
		7 Sep		7 Sep
Plants (000/ha)		47.4		42.8
		1.49		*2.73*
Stems (000/ha)		98.4		87.5
		7.87		*5.37*
Stems/plant		2.1		2.0
		0.13		*0.06*
Tubers (000/ha)	> 10 mm	453	> 10 mm	388
		19.8		*12.8*
Tuber yield (t/ha)	> 10 mm	61.6	> 10 mm	61.1
		2.24		*1.35*
Tuber yield (t/ha)	> 45 mm	55.8	> 45 mm	58.2
		3.23		*1.18*
Tuber yield (%)	> 90 mm	47.7	> 90 mm	58.4
		4.23		*5.47*
DM (%)		23.1		22.3
		0.70		*0.05*
Mean tuber size (mm)		57.9		58.3
		1.57		*0.34*

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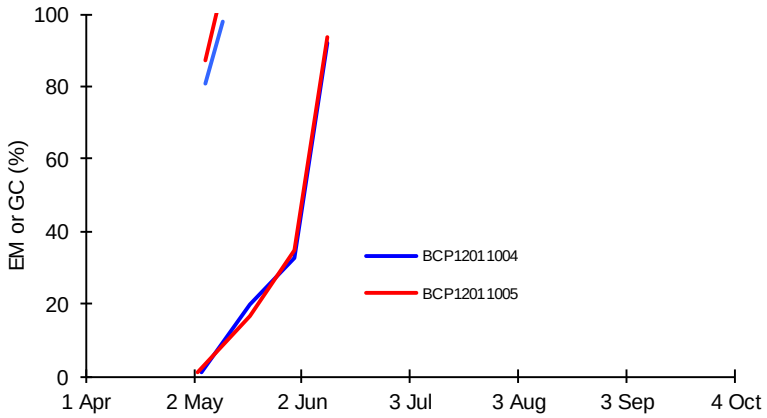
Figure 4. B&C Farming Ltd, Russet Burbank (54735), Grove Farm 91.

Grower:	B&C Farming Ltd	B&C Farming Ltd
Field name:	Grove Farm 91-735	Grove Farm 91-735
Unique ID:	BCP12011004	BCP12011005
Part Field Name:	Seed McCain & N Standard	Seed CUF & N Standard
Variety:	Russet Burbank	Russet Burbank
Intended yield:	55 t/ha	55 t/ha
Intended use:	French-fries	French-fries
Planting date (start):	4 Apr	4 Apr
Date of 50 % emergence:	4 May	3 May
Total N applied:	243 kg N/ha	243 kg N/ha
Seed size:	30-35 mm	30-35 mm
Seed count:	1835 per 50 kg	1835 per 50 kg
Planned density:	54.7 000/ha	38.5 000/ha
Planned spacing:	20.0 cm	28.4 cm
Achieved density:	50.1 000/ha	43.7 000/ha
Achieved spacing:	21.8 cm	25.0 cm



Yield Samples (S.E. in italics)

		Seed McCain & N Standard		Seed CUF & N Standard
		30 Aug		30 Aug
Plants (000/ha)		50.1		43.7
		2.73		*2.98*
Stems (000/ha)		123.0		95.7
		8.20		*10.13*
Stems/plant		2.5		2.2
		0.07		*0.16*
Tubers (000/ha)	> 10 mm	524	> 10 mm	441
		34.3		*20.7*
Tuber yield (t/ha)	> 10 mm	75.6	> 10 mm	67.1
		3.79		*3.69*
Tuber yield (t/ha)	> 45 mm	70.0	> 45 mm	62.4
		5.09		*4.28*
Tuber yield (%)	> 90 mm	49.0	> 90 mm	52.9
		7.96		*4.16*
DM (%)		21.8		21.8
		0.69		*0.77*
Mean tuber size (mm)		58.3		58.1
		1.76		*1.22*

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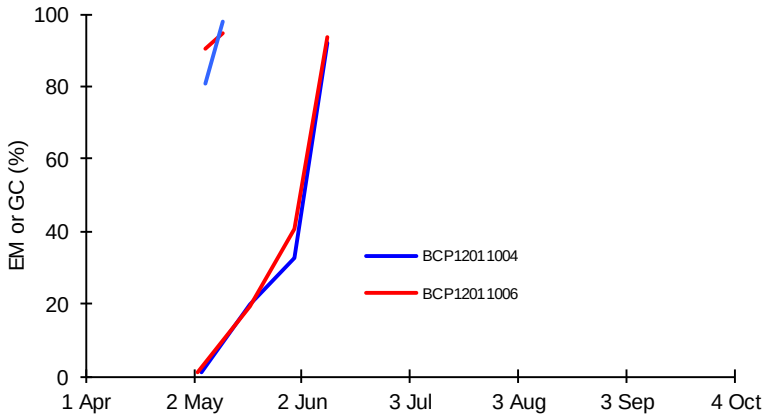
Figure 5. B&C Farming Ltd, Russet Burbank (54735), Grove Farm 91.

Grower:	B&C Farming Ltd	B&C Farming Ltd
Field name:	Grove Farm 91-735	Grove Farm 91-735
Unique ID:	BCP12011004	BCP12011006
Part Field Name:	Seed McCain & N Standard	Seed B&C & N Standard
Variety:	Russet Burbank	Russet Burbank
Intended yield:	55 t/ha	55 t/ha
Intended use:	French-fries	French-fries
Planting date (start):	4 Apr	4 Apr
Date of 50 % emergence:	4 May	3 May
Total N applied:	243 kg N/ha	243 kg N/ha
Seed size:	30-35 mm	30-35 mm
Seed count:	1835 per 50 kg	1835 per 50 kg
Planned density:	54.7 000/ha	48.0 000/ha
Planned spacing:	20.0 cm	21.9 cm
Achieved density:	50.1 000/ha	46.5 000/ha
Achieved spacing:	21.8 cm	23.5 cm



Yield Samples (S.E. in italics)

		Seed McCain & N Standard 30 Aug		Seed B&C & N Standard 30 Aug
Plants (000/ha)		50.1		46.5
		2.73		*2.29*
Stems (000/ha)		123.0		106.6
		8.20		*8.85*
Stems/plant		2.5		2.3
		0.07		*0.18*
Tubers (000/ha)	> 10 mm	524	> 10 mm	502
		34.3		*33.5*
Tuber yield (t/ha)	> 10 mm	75.6	> 10 mm	68.1
		3.79		*2.37*
Tuber yield (t/ha)	> 45 mm	70.0	> 45 mm	60.7
		5.09		*4.27*
Tuber yield (%)	> 90 mm	49.0	> 90 mm	49.5
		7.96		*5.28*
DM (%)		21.8		21.8
		0.69		*0.95*
Mean tuber size (mm)		58.3		57.3
		1.76		*1.76*

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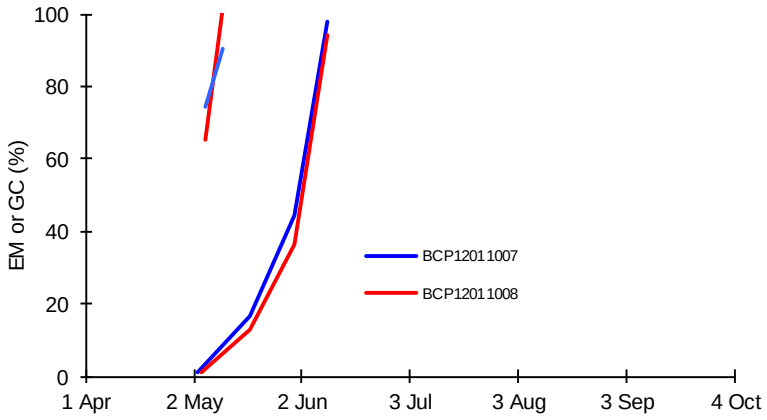
Figure 6. B&C Farming Ltd, Russet Burbank (54782), Grove Farm 91.

Grower:	B&C Farming Ltd	B&C Farming Ltd
Field name:	Grove Farm 91-782	Grove Farm 91-782
Unique ID:	BCP12011007	BCP12011008
Part Field Name:	Seed McCain & N Standard	Seed CUF & N Standard
Variety:	Russet Burbank	Russet Burbank
Intended yield:	55 t/ha	55 t/ha
Intended use:	French-fries	French-fries
Planting date (start):	4 Apr	4 Apr
Date of 50 % emergence:	3 May	4 May
Total N applied:	243 kg N/ha	243 kg N/ha
Seed size:	30-35 mm	30-35 mm
Seed count:	1854 per 50 kg	1854 per 50 kg
Planned density:	54.7 000/ha	37.6 000/ha
Planned spacing:	20.0 cm	29.1 cm
Achieved density:	50.1 000/ha	41.0 000/ha
Achieved spacing:	21.8 cm	26.7 cm



Yield Samples (S.E. in italics)

		Seed McCain & N Standard 30 Aug		Seed CUF & N Standard 30 Aug
Plants (000/ha)		50.1		41.0
		1.75		*2.29*
Stems (000/ha)		123.0		96.6
		4.56		*7.66*
Stems/plant		2.5		2.3
		0.03		*0.09*
Tubers (000/ha)	> 10 mm	541	> 10 mm	499
		33.7		*47.1*
Tuber yield (t/ha)	> 10 mm	72.4	> 10 mm	66.5
		1.43		*2.32*
Tuber yield (t/ha)	> 45 mm	65.0	> 45 mm	59.8
		2.43		*1.77*
Tuber yield (%)	> 90 mm	47.2	> 90 mm	47.1
		5.94		*7.87*
DM (%)		22.8		22.6
		0.43		*0.32*
Mean tuber size (mm)		56.0		56.5
		1.17		*1.29*

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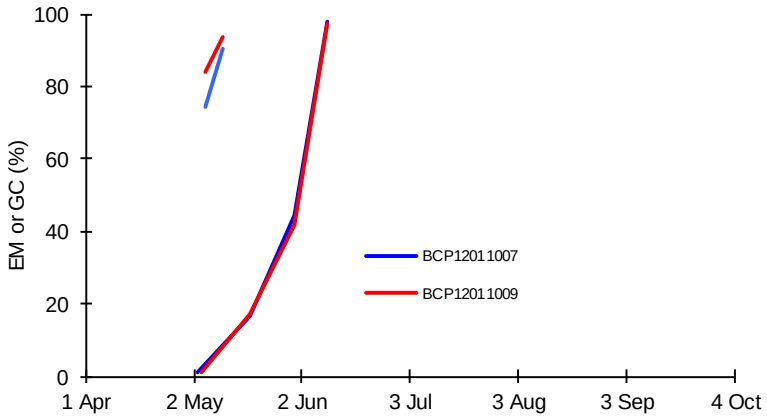
Figure 7. B&C Farming Ltd, Russet Burbank (54782), Grove Farm 91.

Grower:	B&C Farming Ltd	B&C Farming Ltd
Field name:	Grove Farm 91-782	Grove Farm 91-782
Unique ID:	BCP12011007	BCP12011009
Part Field Name:	Seed McCain & N Standard	Seed B&C & N Standard
Variety:	Russet Burbank	Russet Burbank
Intended yield:	55 t/ha	55 t/ha
Intended use:	French-fries	French-fries
Planting date (start):	4 Apr	4 Apr
Date of 50 % emergence:	3 May	4 May
Total N applied:	243 kg N/ha	243 kg N/ha
Seed size:	30-35 mm	30-35 mm
Seed count:	1854 per 50 kg	1854 per 50 kg
Planned density:	54.7 000/ha	48.0 000/ha
Planned spacing:	20.0 cm	21.9 cm
Achieved density:	50.1 000/ha	44.7 000/ha
Achieved spacing:	21.8 cm	24.5 cm



Yield Samples (S.E. in italics)

		Seed McCain & N Standard		Seed B&C & N Standard
		30 Aug		30 Aug
Plants (000/ha)		50.1		44.7
		1.75		*0.91*
Stems (000/ha)		123.0		87.5
		4.56		*4.46*
Stems/plant		2.5		2.0
		0.03		*0.12*
Tubers (000/ha)	> 10 mm	541	> 10 mm	468
		33.7		*28.5*
Tuber yield (t/ha)	> 10 mm	72.4	> 10 mm	69.2
		1.43		*1.36*
Tuber yield (t/ha)	> 45 mm	65.0	> 45 mm	65.0
		2.43		*2.26*
Tuber yield (%)	> 90 mm	47.2	> 90 mm	51.6
		5.94		*4.50*
DM (%)		22.8		22.8
		0.43		*0.21*
Mean tuber size (mm)		56.0		58.1
		1.17		*1.42*

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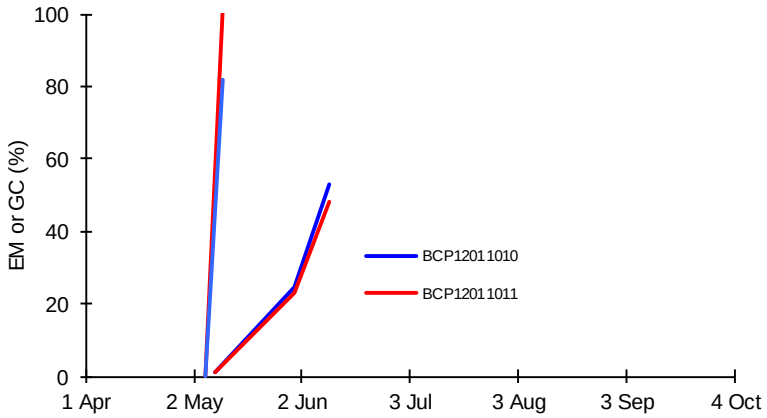
Figure 8. B&C Farming Ltd, Russet Burbank (54735), Medler Melton.

Grower:	B&C Farming Ltd	B&C Farming Ltd
Field name:	Medler Melton-735	Medler Melton-735
Unique ID:	BCP12011010	BCP12011011
Part Field Name:	Seed McCain & N Standard	Seed CUF & N Standard
Variety:	Russet Burbank	Russet Burbank
Intended yield:	55 t/ha	55 t/ha
Intended use:	French-fries	French-fries
Planting date (start):	11 Apr	11 Apr
Date of 50 % emergence:	8 May	8 May
Total N applied:	245 kg N/ha	245 kg N/ha
Seed size:	30-35 mm	30-35 mm
Seed count:	1835 per 50 kg	1835 per 50 kg
Planned density:	54.7 000/ha	38.5 000/ha
Planned spacing:	20.0 cm	28.4 cm
Achieved density:	50.1 000/ha	43.7 000/ha
Achieved spacing:	21.8 cm	25.0 cm



Yield Samples (S.E. in italics)

		Seed McCain & N Standard		Seed CUF & N Standard
		30 Aug		30 Aug
Plants (000/ha)		50.1		43.7
		1.75		*1.49*
Stems (000/ha)		113.0		99.3
		6.49		*5.84*
Stems/plant		2.3		2.3
		0.09		*0.09*
Tubers (000/ha)	> 10 mm	453	> 10 mm	425
		21.3		*17.9*
Tuber yield (t/ha)	> 10 mm	59.8	> 10 mm	57.3
		1.71		*1.65*
Tuber yield (t/ha)	> 45 mm	51.0	> 45 mm	50.2
		1.61		*1.50*
Tuber yield (%)	> 90 mm	56.2	> 90 mm	52.6
		1.44		*1.01*
DM (%)		25.5		25.6
		0.20		*0.18*
Mean tuber size (mm)		54.0		55.1
		0.49		*0.55*

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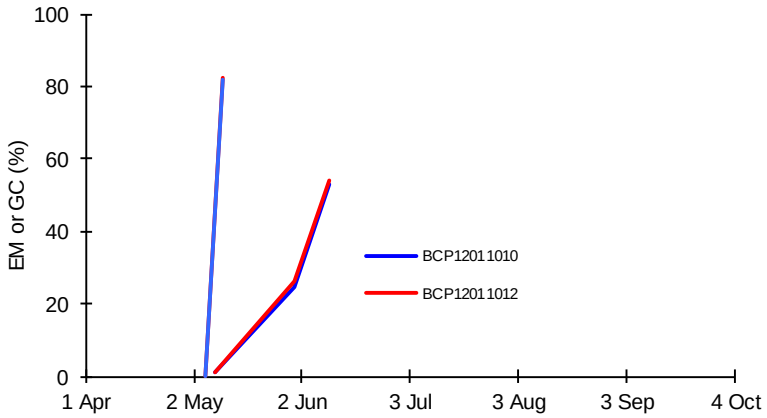
Figure 9. B&C Farming Ltd, Russet Burbank (54735), Medler Melton.

Grower:	B&C Farming Ltd	B&C Farming Ltd
Field name:	Medler Melton-735	Medler Melton-735
Unique ID:	BCP12011010	BCP12011012
Part Field Name:	Seed McCain & N Standard	Seed B&C & N Standard
Variety:	Russet Burbank	Russet Burbank
Intended yield:	55 t/ha	55 t/ha
Intended use:	French-fries	French-fries
Planting date (start):	11 Apr	11 Apr
Date of 50 % emergence:	8 May	8 May
Total N applied:	245 kg N/ha	245 kg N/ha
Seed size:	30-35 mm	30-35 mm
Seed count:	1835 per 50 kg	1835 per 50 kg
Planned density:	54.7 000/ha	48.0 000/ha
Planned spacing:	20.0 cm	21.9 cm
Achieved density:	50.1 000/ha	43.7 000/ha
Achieved spacing:	21.8 cm	25.0 cm



Yield Samples (S.E. in italics)

		Seed McCain & N Standard 30 Aug		Seed B&C & N Standard 30 Aug
Plants (000/ha)		50.1		43.7
		1.75		*1.49*
Stems (000/ha)		113.0		106.6
		6.49		*3.45*
Stems/plant		2.3		2.4
		0.09		*0.04*
Tubers (000/ha)	> 10 mm	453	> 10 mm	507
		21.3		*42.7*
Tuber yield (t/ha)	> 10 mm	59.8	> 10 mm	59.1
		1.71		*2.65*
Tuber yield (t/ha)	> 45 mm	51.0	> 45 mm	47.9
		1.61		*3.78*
Tuber yield (%)	> 90 mm	56.2	> 90 mm	46.5
		1.44		*8.46*
DM (%)		25.5		25.9
		0.20		*0.26*
Mean tuber size (mm)		54.0		52.1
		0.49		*1.04*

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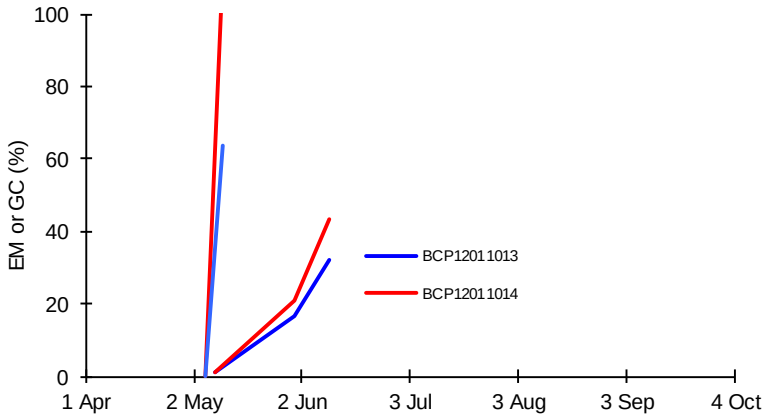
Figure 10. B&C Farming Ltd, Russet Burbank (54782), Medler Melton.

Grower:	B&C Farming Ltd	B&C Farming Ltd
Field name:	Medler Melton-782	Medler Melton-782
Unique ID:	BCP12011013	BCP12011014
Part Field Name:	Seed McCain & N Standard	Seed CUF & N Standard
Variety:	Russet Burbank	Russet Burbank
Intended yield:	55 t/ha	55 t/ha
Intended use:	French-fries	French-fries
Planting date (start):	11 Apr	11 Apr
Date of 50 % emergence:	8 May	8 May
Total N applied:	245 kg N/ha	245 kg N/ha
Seed size:	30-35 mm	30-35 mm
Seed count:	1854 per 50 kg	1854 per 50 kg
Planned density:	54.7 000/ha	37.6 000/ha
Planned spacing:	20.0 cm	29.1 cm
Achieved density:	51.0 000/ha	44.7 000/ha
Achieved spacing:	21.4 cm	24.5 cm



Yield Samples (S.E. in italics)

		Seed McCain & N Standard 30 Aug		Seed CUF & N Standard 30 Aug
Plants (000/ha)		51.0		44.7
		1.49		*1.75*
Stems (000/ha)		122.1		95.7
		4.59		*3.11*
Stems/plant		2.4		2.1
		0.07		*0.02*
Tubers (000/ha)	> 10 mm	459	> 10 mm	415
		11.0		*27.3*
Tuber yield (t/ha)	> 10 mm	58.5	> 10 mm	61.3
		2.24		*2.23*
Tuber yield (t/ha)	> 45 mm	48.6	> 45 mm	54.8
		2.87		*1.44*
Tuber yield (%)	> 90 mm	51.6	> 90 mm	64.4
		1.31		*4.29*
DM (%)		25.0		25.7
		0.07		*0.38*
Mean tuber size (mm)		52.5		56.1
		0.60		*0.84*

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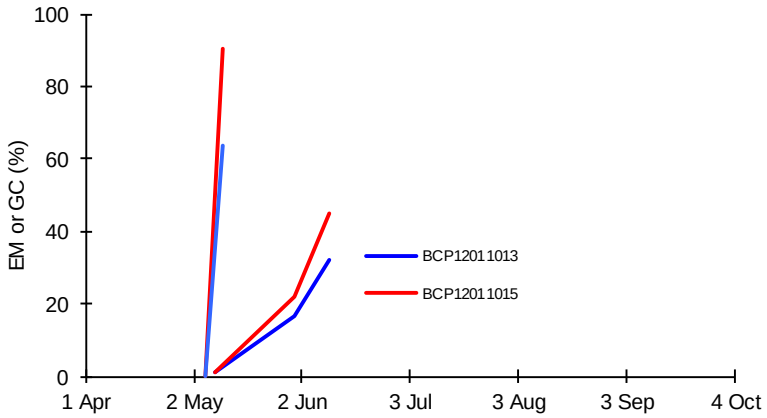
Figure 11. B&C Farming Ltd, Russet Burbank (54782), Medler Melton

Grower:	B&C Farming Ltd	B&C Farming Ltd
Field name:	Medler Melton-782	Medler Melton-782
Unique ID:	BCP12011013	BCP12011015
Part Field Name:	Seed McCain & N Standard	Seed B&C & N Standard
Variety:	Russet Burbank	Russet Burbank
Intended yield:	55 t/ha	55 t/ha
Intended use:	French-fries	French-fries
Planting date (start):	11 Apr	11 Apr
Date of 50 % emergence:	8 May	8 May
Total N applied:	245 kg N/ha	245 kg N/ha
Seed size:	30-35 mm	30-35 mm
Seed count:	1854 per 50 kg	1854 per 50 kg
Planned density:	54.7 000/ha	48.0 000/ha
Planned spacing:	20.0 cm	21.9 cm
Achieved density:	51.0 000/ha	43.7 000/ha
Achieved spacing:	21.4 cm	25.0 cm



Yield Samples (S.E. in italics)

		Seed McCain & N Standard 30 Aug		Seed B&C & N Standard 30 Aug
Plants (000/ha)		51.0		43.7
		1.49		*1.49*
Stems (000/ha)		122.1		99.3
		4.59		*4.56*
Stems/plant		2.4		2.3
		0.07		*0.06*
Tubers (000/ha)	> 10 mm	459	> 10 mm	485
		11.0		*12.2*
Tuber yield (t/ha)	> 10 mm	58.5	> 10 mm	57.7
		2.24		*3.36*
Tuber yield (t/ha)	> 45 mm	48.6	> 45 mm	47.5
		2.87		*4.20*
Tuber yield (%)	> 90 mm	51.6	> 90 mm	48.7
		1.31		*3.57*
DM (%)		25.0		25.6
		0.07		*0.53*
Mean tuber size (mm)		52.5		52.5
		0.60		*0.93*

James Daw, Staffordshire, Russet Burbank (54722), 29 Acres

The seed rate comparisons with stock 54722 were planted on 13 April and 50 % plant emergence was attained on 8 May in the standard seed spacing and 7 May in the modified (Figure 12). For both crops, the final achieved plant population was close to that intended. The initial rate of ground cover expansion was similar in both the standard and modified spacings and both crops produced 100 % ground cover which was then maintained for several weeks. The onset of senescence was slightly earlier in the standard crop but this effect was relatively small. The crop was sampled on two occasions (15 July, 68 DAE and 9 September, 124 DAE) and, when averaged over both harvests, stem and tuber populations were smaller in the crop grown with the modified seed rate but the effects were smaller than expected. At the first sampling, the average total FW yield was 35.7 t/ha and there was little difference in yield between the standard and modified crop. At the second sampling the average total yield was 69 t/ha. The total yield was numerically larger in the crop grown with standard spacing but it is unlikely that these differences were real. The proportion of yield > 90 mm in length in the crop grown at a standard or modified seed spacing was *c.* 70 and 73 %, respectively. The count > 45 mm averaged 46/10 kg for both the standard and modified crops. The tuber dry matter concentration at the final sampling was *c.* 22.7% and was independent of achieved planting density.

James Daw, Staffordshire, Russet Burbank (54769), 29 Acres

The seed rate comparison with the Russet Burbank stock 54769 was planted on 13 April and, for both plant populations 50 % plant emergence was reached 25 days later (8 May). For the crop planted at the standard seed rate, the achieved plant population was close to that intended but for the modified crop, the achieved population was *c.* 6 % larger than intended. Initial ground cover expansion was very similar in both the standard and modified crops and both achieved complete ground cover (Figure 13). The onset on senescence was earlier, and the rate of senescence was faster in the crop planted with modified plant population. Usually, due to increased branching, crops planted at a wider spacing are often more persistent than equivalent crops planted at close spacing and therefore these results are unexpected. It is likely that the early onset of senescence may have been due to the effect of potato cyst nematode (PCN) since this comparison was adjacent to a PCN ‘hot-spot’. When averaged over both harvests the stem population in the standard crop was 99 000/ha compared with 86 000 in the modified crop. Total tuber populations were 459 000 and 424 000/ha in the standard and modified crops, respectively. At the first sampling the yield in the standard crop was 38.9 t/ha compared with 34.0 t/ha in the crop grown with a reduced

plant population. At the final sampling the total yield in the standard crop had increased to 65.0 t/ha whilst the yield in the modified had increased to 60.4 t/ha. The proportion of tuber yield > 90 mm length was also numerically larger in the standard crop when compared with the modified crop (55 *c.f.* 48 %, respectively). The smaller yield in the crops planted with the modified spacing is consistent with the difference in ground cover and is therefore more likely to be a consequence of the effects of PCN rather than the effects of planting density. The tuber counts for both crops averaged 56/10 kg. Tuber DM concentration did not appear to be affected by planting density and averaged 23.5 %.

Analysis of James Daw crop performance using the CUF yield model

In general there was good agreement between observed yields and those forecast by the model (Figure 14 and Figure 15). For all four crops, the average observed yield at final harvest was 65.8 t/ha compared with an average modelled yield of 66.3 t/ha. For both modified seed rate crops the agreement between observed and modelled yields was very close whereas for the standard seed rate cops the model slightly underestimated total yield for the 54722 stock and slightly overestimated the yield for the 54769 stock. Collectively, these data suggest that the achieved yields were largely explicable in terms of ground cover and this suggest that the efficiency of conversion of absorbed radiation to dry matter yield was not substantially affected by water supply or other factors.

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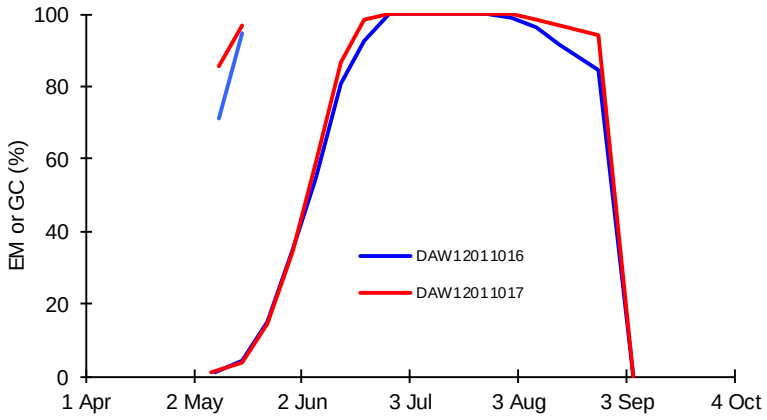
Figure 12. Tame Valley Potatoes Ltd, Russet Burbank (54722), 29 Acre.

Grower:	James Daw	James Daw
Field name:	29 Acre-54722	29 Acre-54722
Unique ID:	DAW12011016	DAW12011017
Part Field Name:	Standard Seed & Standard N	Modified Seed & Standard N
Variety:	Russet Burbank	Russet Burbank
Intended yield:	50 t/ha	50 t/ha
Intended use:	French-fries	French-fries
Planting date (start):	13 Apr	13 Apr
Date of 50 % emergence:	8 May	7 May
Total N applied:	200 kg N/ha	200 kg N/ha
Seed size:	35-45 mm	35-45 mm
Seed count:	910 per 50 kg	910 per 50 kg
Planned density:	31.4 000/ha	26.0 000/ha
Planned spacing:	35.0 cm	42.0 cm
Achieved density:	30.1 000/ha	26.0 000/ha
Achieved spacing:	36.4 cm	42.1 cm



Yield Samples (S.E. in italics)

		Standard Seed & Standard N			Modified Seed & Standard N	
		15 Jul	9 Sep		15 Jul	9 Sep
Plants (000/ha)		30.1	30.1		25.5	26.4
		0.91	*0.91*		*0.00*	*0.91*
Stems (000/ha)		60.1	86.6		65.6	72.9
		5.67	*4.79*		*5.37*	*2.10*
Stems/plant		2.0	2.9		2.6	2.8
		0.17	*0.18*		*0.21*	*0.08*
Tubers (000/ha)	> 10 mm	367	396	> 10 mm	328	368
		28.3	*27.5*		*20.4*	*28.3*
Tuber yield (t/ha)	> 10 mm	36.0	71.5	> 10 mm	35.3	66.4
		1.43	*2.44*		*1.17*	*1.92*
Tuber yield (t/ha)	> 45 mm	24.6	67.7	> 45 mm	25.7	63.5
		1.53	*2.25*		*0.92*	*1.57*
Tuber yield (%)	> 90 mm*		70.4	> 90 mm*		73.1
			3.53			*3.80*
DM (%)		16.2	22.6		16.5	22.8
		0.18	*0.44*		*0.14*	*0.34*
Mean tuber size (mm)		48.5	60.6		49.7	60.6
		1.00	*1.18*		*0.71*	*1.24*

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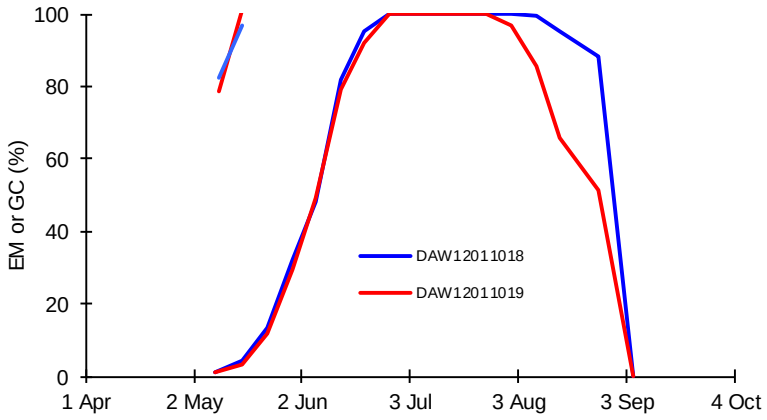
Figure 13. Tame Valley Potatoes Ltd, Russet Burbank (54769), 29 Acre.

Grower:	James Daw	James Daw
Field name:	29 Acre-54769	29 Acre-54769
Unique ID:	DAW12011018	DAW12011019
Part Field Name:	Standard Seed & Standard N	Modified Seed & Standard N
Variety:	Russet Burbank	Russet Burbank
Intended yield:	50 t/ha	50 t/ha
Intended use:	French-fries	French-fries
Planting date (start):	13 Apr	13 Apr
Date of 50 % emergence:	8 May	8 May
Total N applied:	200 kg N/ha	200 kg N/ha
Seed size:	35-45 mm	35-45 mm
Seed count:	910 per 50 kg	910 per 50 kg
Planned density:	33.3 000/ha	27.5 000/ha
Planned spacing:	33.0 cm	40.0 cm
Achieved density:	33.7 000/ha	29.2 000/ha
Achieved spacing:	32.4 cm	37.5 cm

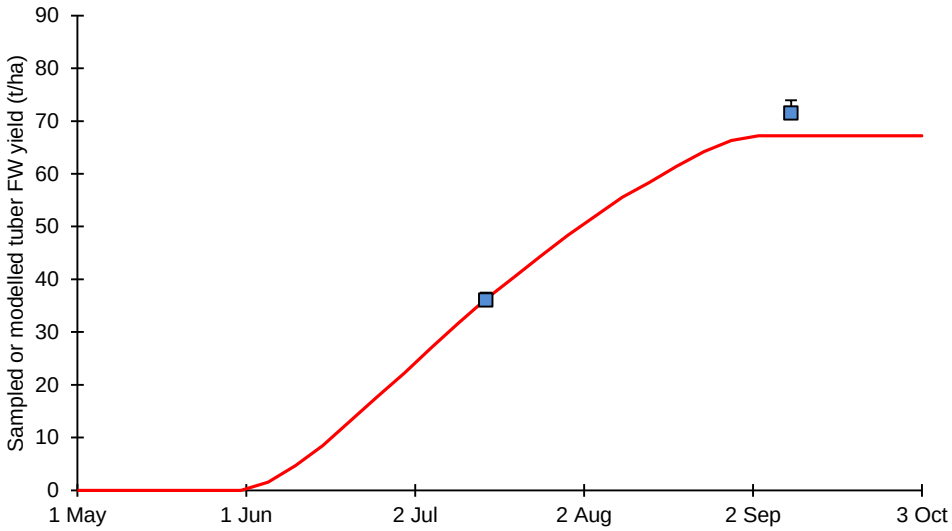


Yield Samples (S.E. in italics)

		Standard Seed & Standard N			Modified Seed & Standard N	
		15 Jul	9 Sep		15 Jul	9 Sep
Plants (000/ha)		32.8	34.6		28.3	30.1
		0.00	*1.05*		*0.91*	*0.91*
Stems (000/ha)		97.5	100.2		83.8	88.4
		7.04	*3.79*		*1.49*	*3.76*
Stems/plant		3.0	2.9		3.0	2.9
		0.21	*0.10*		*0.11*	*0.16*
Tubers (000/ha)	> 10 mm	436	482	> 10 mm	420	427
		34.1	*24.9*		*10.2*	*16.7*
Tuber yield (t/ha)	> 10 mm	38.9	65.0	> 10 mm	34.0	60.4
		2.05	*1.62*		*3.73*	*1.40*
Tuber yield (t/ha)	> 45 mm	24.2	57.8	> 45 mm	19.6	55.0
		1.71	*1.91*		*4.86*	*1.32*
Tuber yield (%)	> 90 mm*		55.4	> 90 mm*		47.6
			4.62			*6.01*
DM (%)		16.8	23.8		17.9	23.2
		1.32	*0.47*		*0.12*	*0.38*
Mean tuber size (mm)		47.2	55.2		46.1	56.5
		0.70	*0.72*		*1.51*	*0.62*

Figure 14. Comparison of modelled yield (red line) and sampled yield (blue symbol ± 1 S.E.) for (*a*) standard see rate and (*b*) modified seed rate. James Daw, Russet Burbank (stock 54722), 29 Acre.

(*a*)



(*b*)

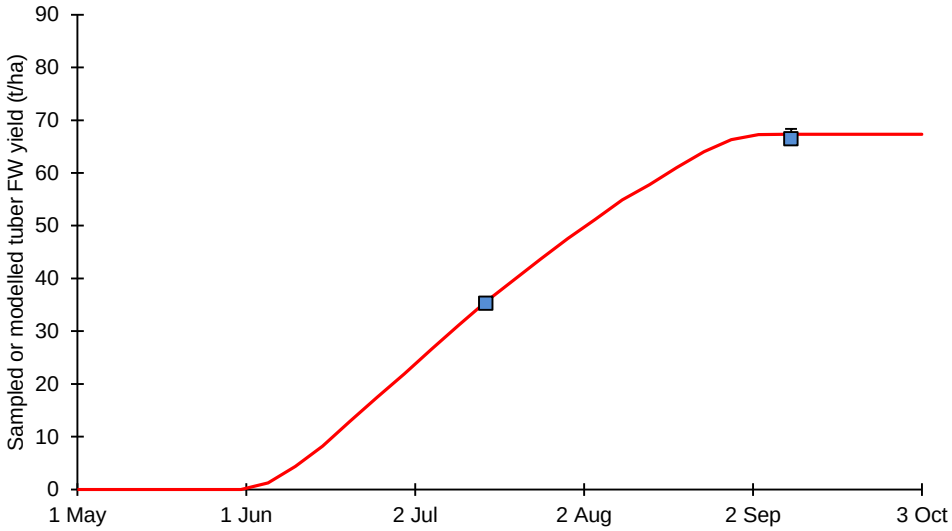
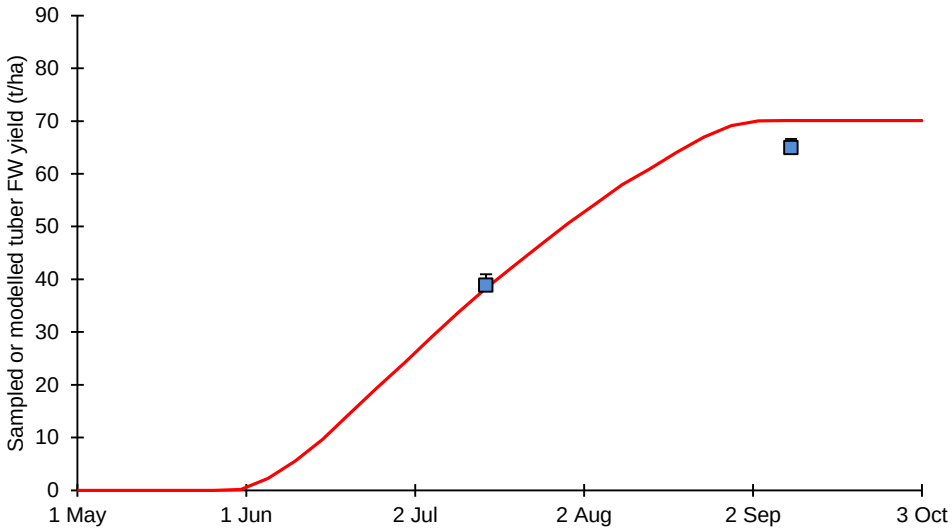
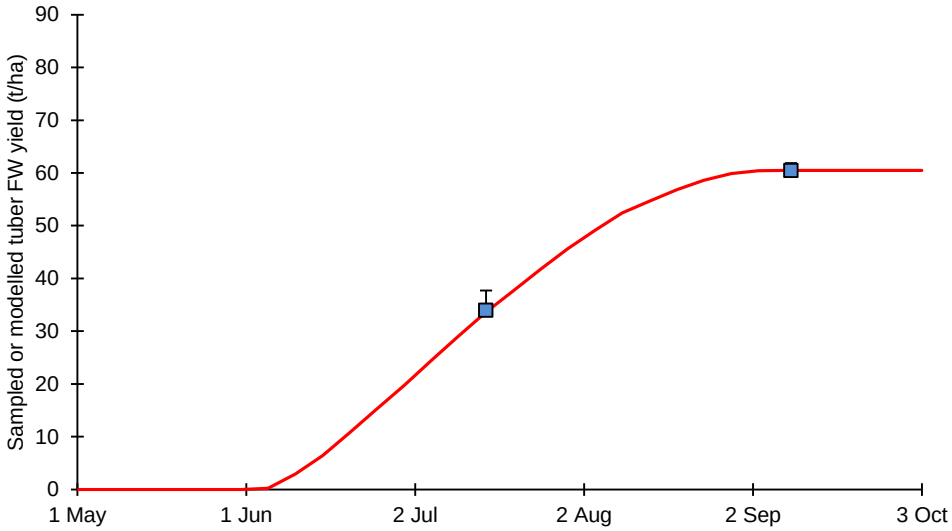


Figure 15. Comparison of modelled yield (red line) and sampled yield (blue symbol ± 1 S.E.) for (*a*) standard see rate and (*b*) modified seed rate. James Daw, Russet Burbank (stock 54769), 29 Acre.

(*a*)



(*b*)



RS Cockerill Ltd

R S Cockerill Ltd joined the Grower Collaboration program in 2010. They are based in Dunnington, Yorkshire and a major component of their business is the supply of processing potatoes to Walkers Snack Foods. Initial discussions with Cockerills identified two of their growers (Westgarth Farms, County Durham and Fridlington Farms, Yorkshire) as potential hosts for comparisons of standard and modified agronomies. Examination of cropping plans showed that at Westgarth's a comparison could be done between standard and reduced N application rates in a crop of Saturna (Stanwick Wall field). At Fridlington comparisons were possible between a Hermes crop (Field 11) grown with standard seed and N application rates and crops grown with either a reduced seed rate or with reduced N application rate. The standard crops at Westgarth and Fridlington Farms were also used as part of a larger PepsiCo program designed to understand the effects of season and agronomy on crop performance, storage, processing quality and sustainable production. The data reported here were collected in collaboration with PepsiCo staff as part of a Pepsico funded project.

Fridlington Farms, Hermes (Field 11)

At the time of planting (5 April) there was relatively little specific information about the Hermes seed apart from its size (50-60 mm). For the purpose of this study it was therefore assumed that the seed was derived from a 'typical' seed crop that emerged on 1 June and had a count of *c*. 500/50 kg. The intended marketable yield of the ware crop was 50 t/ha and the ware crop needed to meet Walker's size criteria. The intended standard plant population was 37 000/ha (equivalent to a within-row spacing of 29.6 cm) and the modified plant population was 26 500/ha (equivalent to 41.3 cm spacing). The crop was grown, following a cereal on a medium soil with between 2-6 % organic matter. The intended season length (from emergence to defoliation) was *c*. 120 days. The standard N application for this crop was a total N application of 220 kg N/ha compared with a modified N application rate of 190 kg N/ha.

Seed rate comparison

Crops grown with the standard and modified seed rate attained 50 % plant emergence on 9 May (34 DAP). For both the standard and modified crops, the achieved plant populations were reasonably close to those intended (Figure 16). The pattern of ground cover expansion, persistence and senescence was also reasonably similar between standard and modified crops, although the modified crop may have started to senesce a few days earlier than the standard. At each sampling (12 July, 64 DAE and 31 August, 114 DAE) plant,

stem and tuber populations (> 10 mm) were consistently smaller in the crop grown with the modified seed rate. At the first sampling, total yields (> 10 mm) were numerically larger in the standard crop but the ware yield (> 40 mm) was numerically larger in the crop grown with the modified seed rate. The second sampling was taken when the crops was almost completely senesced. At this sampling, both total and ware yields were numerically *c.* 12 t/ha larger in the modified crop than in the standard crop. This large difference in yield is unlikely to be real since the ground covers of the modified and standard crops were similar for much of the season. The apparent difference in yield is more likely to be a consequence of the large standard errors associated with yield estimates in the modified crops. At the final sampling, the mean tuber size of the standard crop was 62.5 mm compared with 65.6 mm in the modified crop, however neither crop produced any tubers > 90 mm. The tuber count > 40 mm was 61/10 kg and 50/10 kg for the standard and modified crops, respectively. Both these values are smaller than the Walker's Crisps specification of 72-120/50 kg and this is a consequence of achieved yields being much larger than originally planned. Decreasing the plant density was associated with an increase in tuber DM content from 19.8 to 20.9 %.

Nitrogen rate comparison

Reducing the N application rate from 220 to 190 kg N/ha had no effect on the date of 50 % plant emergence (Figure 17). The achieved plant population in the modified-N crop was slightly smaller than intended (32 800 compared with 37 000) but this was unlikely to affect the interpretation of the results. Ground cover expansion and persistence was similar in the standard and modified N crops but, there was an indication that the reduced N crop may have senesced slightly faster. Total and ware yields were consistently larger in the crop grown with reduced N and at the final sampling ware yield was apparently 18 t/ha larger in the reduced N area. However, as noted in the seed rate comparison, the larger yield in the reduced N area may be a consequence of crop variability since the ground cover curves of the standard and modified crops were very similar. There was no evidence that the modest reduction in N application rate had any detrimental effect on yield. Reducing the N application rate from 220 to 190 kg N/ha had no effect on tuber DM concentration at either harvest.

Westgarth Farms, Saturna (Stanwick Wall)

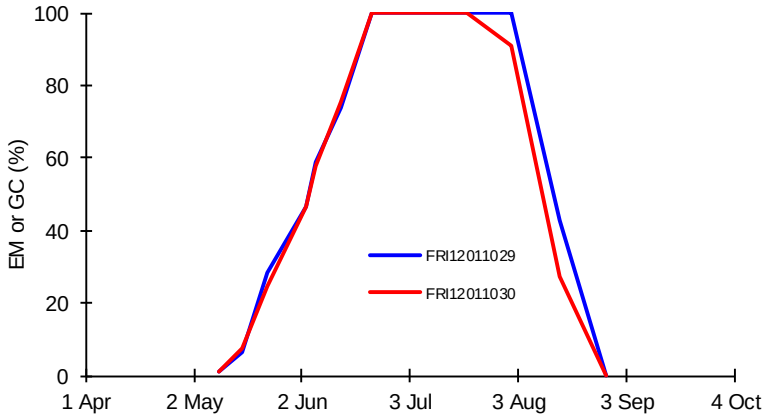
Nitrogen rate comparison

Information supplied by Tim Westgarth showed Stanwick Wall field was a medium textured soil with moderate organic matter content (2-6 %) and the potato crop followed a cereal

crop. The intended season length for the Saturna crop (from emergence to defoliation) was estimated to be *c*. 91 days. Prior to planting (9 April) the field received an application of pig farm yard manure at a rate of 25 t/ha which was incorporated within 2 days of application. The intended, grower N application rate for this field was 175 kg N/ha and this was reduced to 160 kg N/ha in the modified crop. The Saturna seed was from a crop that emerged on 27 May 2010 and had a count of 729/50 kg. The intended marketable yield for this crop was 47 t/ha and the needed to fulfil Walker's Crisps specification. The crop was planted on 21 April and attained 50 % plant emergence on 19 May (28 DAE). In both the standard and modified N crops the achieved plant population was slightly larger than intended (Figure 18). When averaged over both harvests, tuber populations > 10 mm were numerically larger in the reduced N crop but the difference was small. Reducing the N application rate from 175 to 160 kg N/ha had no discernible effect on ground cover expansion or persistence. The first crop sample was taken on 12 July (54 DAE) and at this time both total and ware (> 40 mm) yields were similar in the standard and modified N areas. The second sampling was taken on 30 August (103 DAE) when the crops were senescing but both still had *c*. 60 % ground cover. In the standard area (that received 175 kg N/ha) the total and ware yields were 66.7 and 64.6 t/ha, respectively. In the reduced N area (160 kg N/ha), total and ware yields were 72.1 and 70.4 t/ha, respectively. Estimates of yield in the standard and modified area were both associated with relatively large standard errors and these differences in yield are unlikely to be genuine given the similarities in ground cover although an increase in tuber FW yield in the reduced N area may, in part, be due to differences in tuber DM concentration since reducing the application rate from 175 to 160 kg N/ha was associated with a decrease in tuber DM from 18.7 to 17.7 %. There was no evidence in this comparison that the reduction in N application rate was associated in a reduction in tuber yield. An extra dig (as part of the PepsiCo project) was taken on 13 September from the standard area of crop. At this time tubers yields > 10 mm and > 40 mm were 64.4 (±4.02) and 62.4 (±4.18) t/ha, respectively.

Figure 16. RS Cockerill, Fridlington Farms Hermes seed rate comparison, Field 11.

Grower:	Fridlington Farms	Fridlington Farms
Field name:	Field 11	Field 11
Unique ID:	FRI12011029	FRI12011030
Part Field Name:	Standard seed & Standard N	Modified seed & Standard N
Variety:	Hermes	Hermes
Intended yield:	50 t/ha	50 t/ha
Intended use:	Crisping-Storage	Crisping-Storage
Planting date (start):	5 Apr	5 Apr
Date of 50 % emergence:	9 May	9 May
Total N applied:	220 kg N/ha	220 kg N/ha
Seed size:	55-60 mm	55-60 mm
Seed count:	500 per 50 kg	500 per 50 kg
Planned density:	37.0 000/ha	26.5 000/ha
Planned spacing:	29.6 cm	41.3 cm
Achieved density:	35.8 000/ha	25.5 000/ha
Achieved spacing:	30.5 cm	42.9 cm



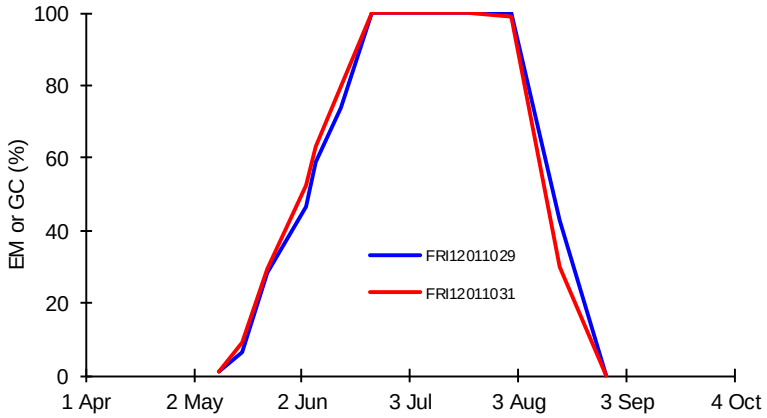
Yield Samples (S.E. in italics)

		Standard seed & Standard N			Modified seed & Standard N	
		12 Jul	31 Aug		12 Jul	31 Aug
Plants (000/ha)		38.9	32.8		23.1	27.9
		1.22	*2.10*		*1.22*	*1.22*
Stems (000/ha)		149.5	119.1		88.7	98.4
		13.14	*15.51*		*17.14*	*9.17*
Stems/plant		3.9	3.6		3.8	3.5
		0.47	*0.25*		*0.67*	*0.19*
Tubers (000/ha)	> 10 mm	571	480	> 10 mm	405	454
		21.5	*34.7*		*96.6*	*39.4*
Tubers (000/ha)	> 40 mm	356	367	> 40 mm	310	360
		26.5	*26.6*		*66.3*	*24.6*
Tuber yield (t/ha)	> 10 mm	45.7	61.9	> 10 mm	44.2	73.5
		2.68	*0.90*		*4.96*	*5.49*
Tuber yield (t/ha)	> 40 mm	42.3	59.9	> 40 mm	42.8	72.1
		3.02	*0.54*		*4.54*	*5.55*
DM (%)		16.7	19.8		17.2	20.9
		0.47	*0.35*		*0.78*	*0.68*
Mean tuber size (mm)		54.1	62.5		59.2	65.6
		0.34	*1.02*		*2.13*	*0.30*

Report for 2011

Figure 17. RS Cockerill, Fridlington Farms Hermes nitrogen rate comparison, Field 11.

Grower:	Fridlington Farms	Fridlington Farms
Field name:	Field 11	Field 11
Unique ID:	FRI12011029	FRI12011031
Part Field Name:	Standard seed & Standard N	Standard seed & Modified N
Variety:	Hermes	Hermes
Intended yield:	50 t/ha	50 t/ha
Intended use:	Crisping-Storage	Crisping-Storage
Planting date (start):	5 Apr	0 Jan
Date of 50 % emergence:	9 May	9 May
Total N applied:	220 kg N/ha	190 kg N/ha
Seed size:	55-60 mm	55-60 mm
Seed count:	500 per 50 kg	500 per 50 kg
Planned density:	37.0 000/ha	37.0 000/ha
Planned spacing:	29.6 cm	29.6 cm
Achieved density:	35.8 000/ha	32.8 000/ha
Achieved spacing:	30.5 cm	33.3 cm



Yield Samples (S.E. in italics)

		Standard seed & Standard N			Standard seed & Modified N	
		12 Jul	31 Aug		12 Jul	31 Aug
Plants (000/ha)		38.9	32.8		32.8	32.8
		1.22	*2.10*		*2.10*	*2.10*
Stems (000/ha)		149.5	119.1		128.8	141.0
		13.14	*15.51*		*9.72*	*7.39*
Stems/plant		3.9	3.6		3.9	4.3
		0.47	*0.25*		*0.15*	*0.05*
Tubers (000/ha)	> 10 mm	571	480	> 10 mm	567	611
		21.5	*34.7*		*50.2*	*14.0*
Tubers (000/ha)	> 40 mm	356	367	> 40 mm	400	433
		26.5	*26.6*		*36.2*	*8.5*
Tuber yield (t/ha)	> 10 mm	45.7	61.9	> 10 mm	52.3	80.7
		2.68	*0.90*		*6.55*	*5.74*
Tuber yield (t/ha)	> 40 mm	42.3	59.9	> 40 mm	49.4	77.8
		3.02	*0.54*		*6.44*	*6.00*
DM (%)		16.7	19.8		16.8	19.8
		0.47	*0.35*		*0.59*	*0.65*
Mean tuber size (mm)		54.1	62.5		54.5	63.1
		0.34	*1.02*		*0.63*	*1.55*

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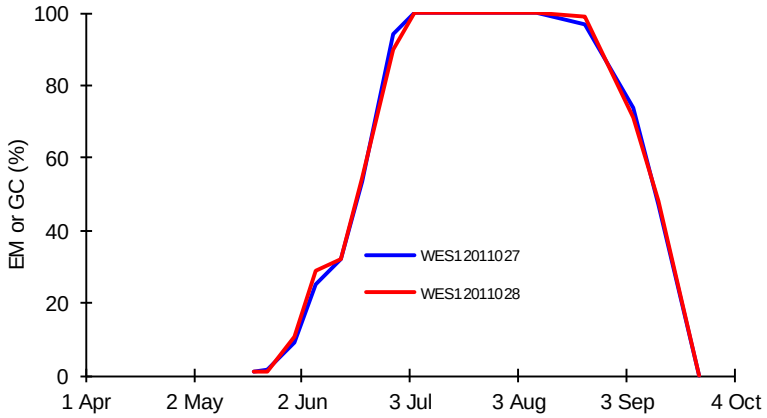
Figure 18. RS Cockerill, Westgarth Farms Saturna N rate comparison, Stanwick Wall.

Grower:	Westgarth	Westgarth
Field name:	Stanwick Wall	Stanwick Wall
Unique ID:	WES12011027	WES12011028
Part Field Name:	Standard seed & Standard N	Standard seed & Modified N
Variety:	Saturna	Saturna
Intended yield:	47 t/ha	47 t/ha
Intended use:	Crisping-Storage	Crisping-Storage

Planting date (start):	21 Apr	21 Apr
Date of 50 % emergence:	19 May	19 May
Total N applied:	175 kg N/ha	160 kg N/ha
Seed size:	45-60 mm	45-60 mm
Seed count:	729 per 50 kg	729 per 50 kg
Planned density:	31.4 000/ha	31.4 000/ha
Planned spacing:	34.8 cm	34.8 cm
Achieved density:	34.8 000/ha	34.0 000/ha
Achieved spacing:	31.4 cm	32.1 cm



Yield Samples (S.E. in italics)

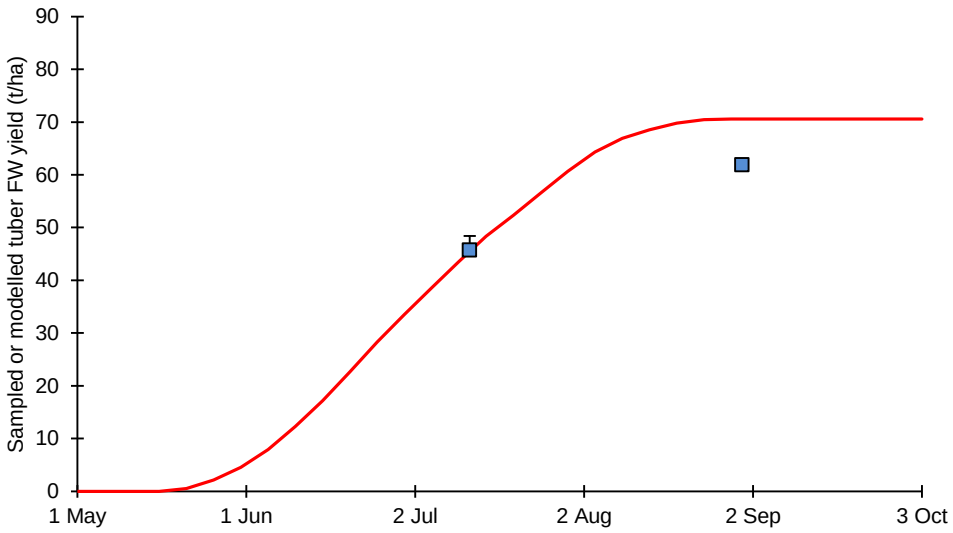
		Standard seed & Standard N			Standard seed & Modified N	
		12 Jul	30 Aug		12 Jul	30 Aug
Plants (000/ha)		31.6	40.1		32.8	35.2
		2.43	*2.10*		*2.10*	*1.22*
Stems (000/ha)		119.1	139.7		113.0	96.0
		8.76	*18.15*		*4.21*	*9.49*
Stems/plant		3.8	3.5		3.5	2.7
		0.24	*0.56*		*0.32*	*0.20*
Tubers (000/ha)	> 10 mm	541	561	> 10 mm	550	597
		59.0	*34.8*		*38.6*	*51.7*
Tubers (000/ha)	> 40 mm	220	463	> 40 mm	221	497
		24.4	*31.0*		*30.7*	*46.8*
Tuber yield (t/ha)	> 10 mm	23.1	66.7	> 10 mm	24.0	72.1
		2.45	*3.84*		*1.88*	*2.98*
Tuber yield (t/ha)	> 40 mm	14.9	64.6	> 40 mm	14.5	70.4
		1.76	*4.05*		*1.95*	*3.03*
DM (%)		15.6	18.7		15.0	17.7
		0.08	*0.92*		*0.20*	*0.36*
Mean tuber size (mm)		41.2	63.1		41.1	64.3
		0.38	*0.25*		*0.65*	*1.00*

Analysis of RS Cockerill crop performance using the CUF yield model

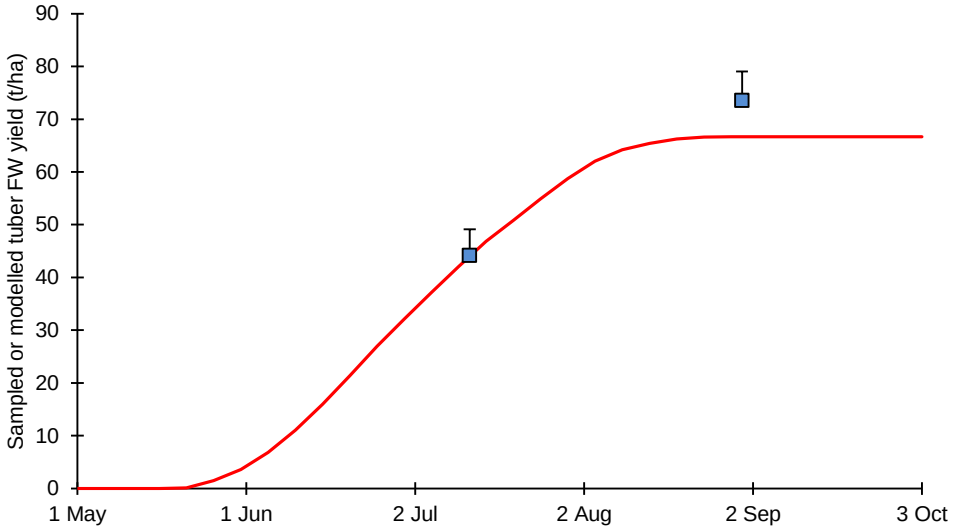
For the standard Hermes, the CUF model forecasted a final, total yield of 70.5 t/ha compared with an observed yield of 61.9 t/ha and thus the observed yield was less than the model predicted (Figure 19a). For the modified seed and N crops the opposite was true: the modelled yields were less than those observed. The average observed tuber yield for the three Saturna crops was 72.1 t/ha and the average modelled tuber yield was 71.2 t/ha. Collectively, these data suggest that the yield in the standard crop may have been underestimated by the samples whilst the yield in the modified seed and N crops may have been overestimated and thus differences in yields between the standard and modified crops were smaller than the sample digs imply. There was reasonably close agreement between the modelled yield and the yield in the extra sample (taken on 13 September) for the standard Saturna crop at Westgarth's (Figure 20a) suggesting that the sample taken on the 30 August may have been an overestimate of the true yield. The modelled yield for the modified N crop was also less than the observed yield (Figure 20b) but again the observed yield may have been overestimated due to variability in the crop. Once they had totally senesced, the modelled yields for the standard and modified N crops were 63.2 and 63.9 t/a respectively. These data suggest that the observed effect of reduced N on tuber FW yield may have been overestimated in the yield samples.

Figure 19. Comparison of modelled yield (red line) and sampled yield (blue symbol ± 1 S.E.) for (*a*) standard crop, (*b*) seed modified and (*c*) N modified. Fridlington Farms, Hermes, Field 11.

(*a*)



(*b*)



(*c*)

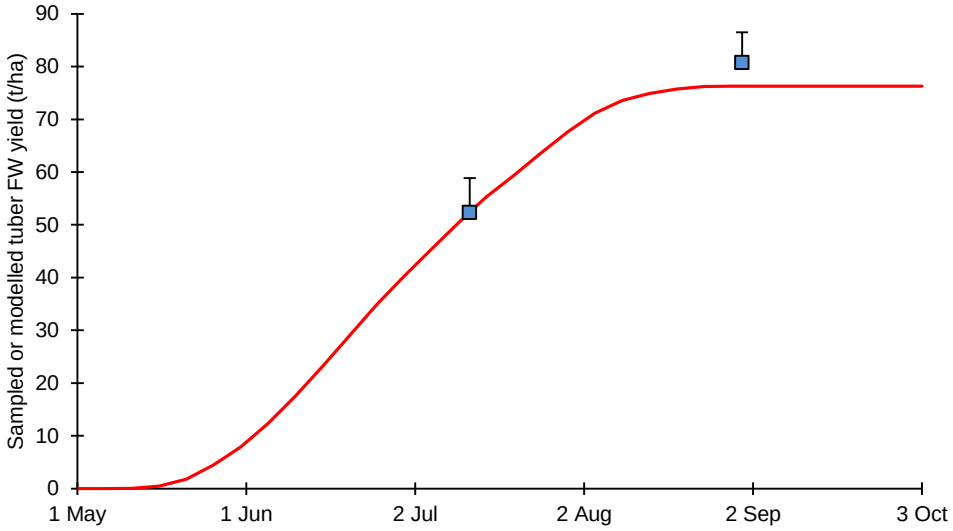
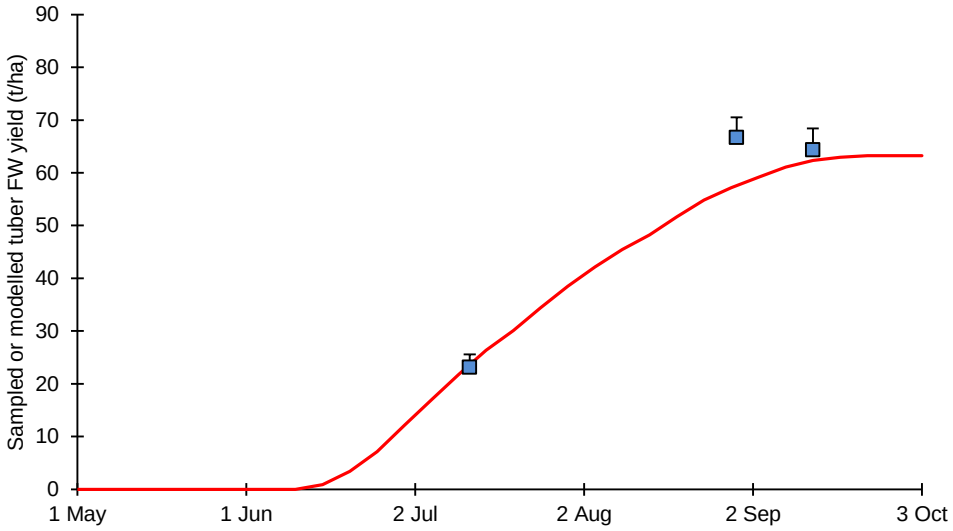
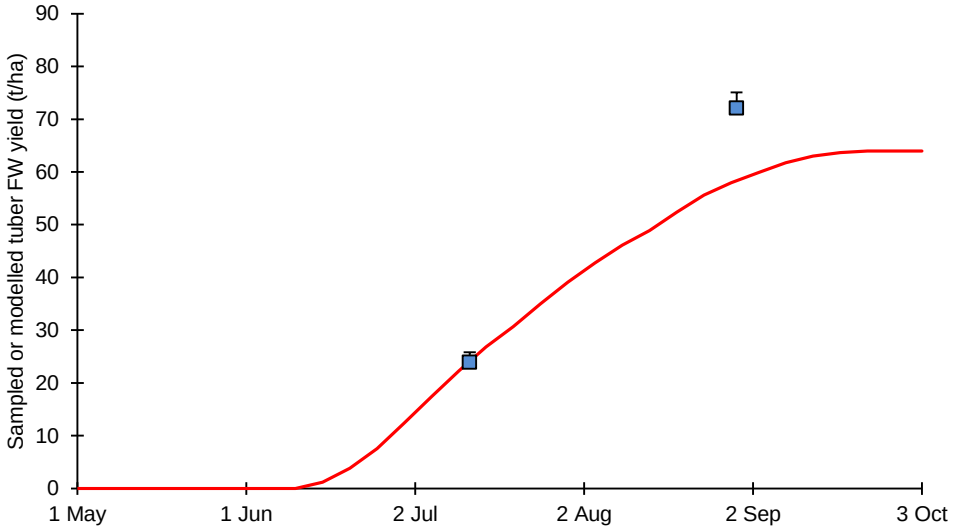


Figure 20. Comparison of modelled yield (red line) and sampled yield (blue symbol ± 1 S.E.) for (*a*) standard crop and (*b*) N modified crop. Westgarth Farms, Saturna, Stanwick Wall.

(*a*)



(*b*)



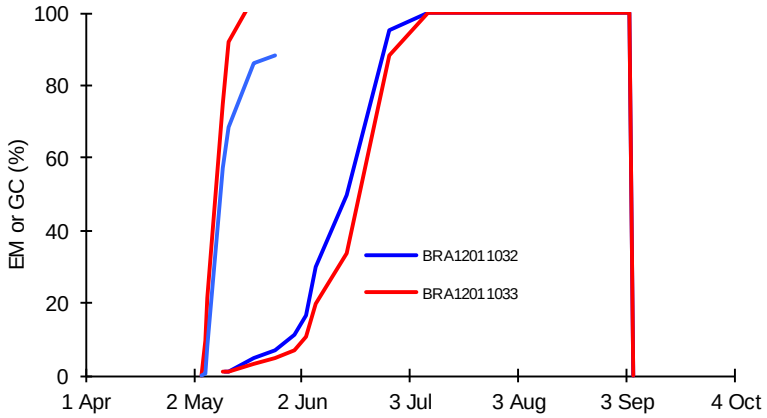
Branston Ltd

Seed rate comparison

Branston initially supplied information on seed and target specification for crops of Saturna and Maris Piper. For the Saturna the proposed modified agronomy would have been within ± 10 % of the standard agronomy and no further action was taken with this crop. The seed count for the Maris Piper seed was 834/50 kg and the date of the seed crop emergence was 28 May 2010. The target yield for the ware crop was 60 t/ha with a specification of 50 % of the total yield between 65 and 85 mm. The intended standard plant population was 29 400/ha (equivalent to a within-row spacing of 37.8 cm). The intended modified plant population and within-row spacing was 25 200/ha and 44.1 cm, respectively. The crop was planted on 5 April, the standard crop attained 50 % plant emergence on the 11 May (35 DAP) compared with 10 May for the modified crop (Figure 21). In the standard crop the achieved plant population was a little less than intended whereas for the modified crop the achieved plant population was greater than intended and thus the achieved difference between the two crops was not as large as originally planned. Ground cover expansion in the modified crop was slightly slower than in the standard crop but both crops achieved complete ground cover which persisted until defoliation on 5 September. The crop was sampled on 8 July (*c*. 59 DAE) and 30 August (*c*. 112 DAE) and over these two harvests, the average stem population was 115 000/ha for the standard crop, compared with 94 000/ha for the modified. Similarly, the average total (> 10 mm) tuber populations in the standard and modified crops were 450 000 and 329 000/ha respectively. Numerically, total and ware yields were larger in the crop grown at the standard spacing at both harvests however these yield differences were small (< 3t/ha) and are unlikely to be real. At the final sampling the mean tuber size was *c.* 6 mm larger in the modified crop and this was largely due to difference in tuber population instead of differences in yield. This increase in mean tuber size was associated with an increase in ware yield (> 60 mm) from 34.8 t/ha in the standard crop to 48.4 t/ha in the crop grown with a reduced seed rate. Calculations using estimates of mean tuber size and the coefficient of tuber size distribution about the mean suggested that in the standard crop the 65-85 mm yield was 20.2 (±3.86) t/ha compared with 30.9 (±6.55) t/ha in the area grown with the reduced seed rate. These data suggest that reducing the actual seed rate from 1.72 to 1.58 t/ha had little effect on total or ware yield but may have increased the proportion of marketable tubers.

Figure 21. Branston, Maris Piper seed rate comparison, Nocton 2

Grower:	David Austin	David Austin
Field name:	Nocton 2	Nocton 2
Unique ID:	BRA12011032	BRA12011033
Part Field Name:	Standard seed & standard N	Modified seed & standard N
Variety:	Maris Piper	Maris Piper
Intended yield:	60 t/ha	60 t/ha
Intended use:	General Ware	General Ware
Planting date (start):	5 Apr	5 Apr
Date of 50 % emergence:	11 May	10 May
Total N applied:	160 kg N/ha	160 kg N/ha
Seed size:	35-50 mm	35-50 mm
Seed count:	834 per 50 kg	834 per 50 kg
Planned density:	29.4 000/ha	25.2 000/ha
Planned spacing:	37.8 cm	44.1 cm
Achieved density:	28.7 000/ha	26.4 000/ha
Achieved spacing:	38.7 cm	42.1 cm



Yield Samples (S.E. in italics)

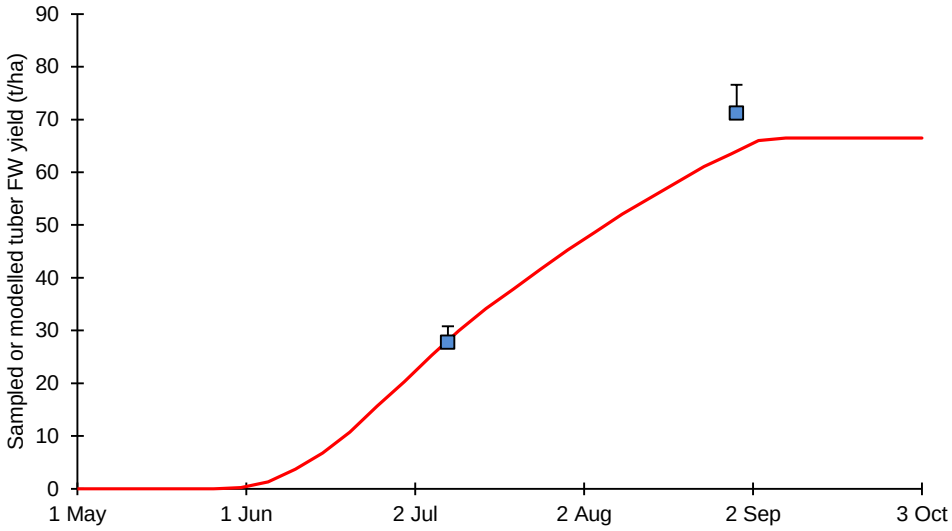
		Standard seed & standard N			Modified seed & standard N	
		8 Jul	30 Aug		8 Jul	30 Aug
Plants (000/ha)		29.6	27.8		26.9	25.9
		1.51	*1.07*		*0.93*	*0.00*
Stems (000/ha)		106.5	123.1		101.9	86.1
		7.91	*7.77*		*8.62*	*7.77*
Stems/plant		3.6	4.4		3.8	3.3
		0.39	*0.18*		*0.23*	*0.30*
Tubers (000/ha)	> 10 mm	442	459	> 10 mm	347	329
		49.7	*62.2*		*51.4*	*54.3*
Tubers (000/ha)	> 60 mm	0	125	> 60 mm	0	146
		0.0	*12.4*		*0.0*	*8.4*
Tuber yield (t/ha)	> 10 mm	27.8	71.2	> 10 mm	25.2	68.3
		3.05	*5.39*		*1.76*	*1.13*
Tuber yield (t/ha)	> 60 mm	0.0	34.8	> 60 mm	0.0	48.4
		0.00	*3.82*		*0.00*	*6.04*
DM (%)		14.8	21.2		15.2	22.3
		0.22	*0.69*		*0.16*	*0.40*
Mean tuber size (mm)		42.8	59.7		44.7	64.9
		0.75	*1.51*		*0.94*	*2.77*

Analysis of Branston crop performance using the CUF yield model

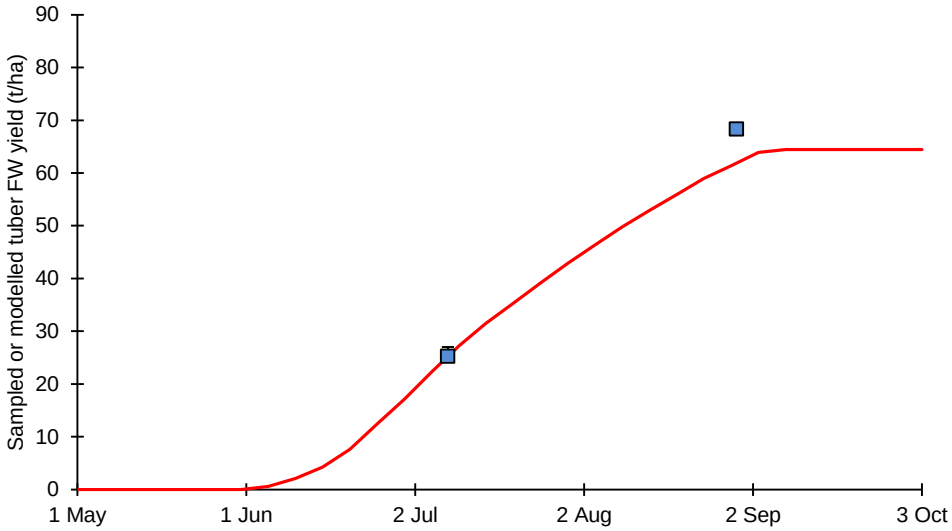
Comparisons of sampled and modelled yield for the standard and seed-rate modified crops are shown in Figure 22*a* and *b*, respectively. For the standard and seed-rate modified crops, the average sampled total FW yield on 30 August was 69.8 t/ha. In comparison the average modelled yield was 62.9 t/ha. The discrepancy may be due to the long interval where the crops was assumed to be at 100 % ground cover (8 July to 30 August) and this may have resulted in an overestimation of the amount of radiation absorbed by the crop and, in turn, yield. However, these data also suggest that this crop was not stressed during the season and yield formation was not limited by lack or water or nutrients.

Figure 22. Comparison of modelled yield (red line) and sampled yield (blue symbol ± 1 S.E.) for (*a*) standard crop and (*b*) seed modified. Branston, Maris Piper, Nocton 2.

(*a*)



(*b*)



Co-operative Farms

The Co-operative Farms, Goole joined the Grower Collaboration program in 2010. In 2011, a crop of Maris Piper was identified as being suitable for inclusion in the program. The Maris Piper seed crop emerged on 25 May 2010 and had a count of 600/50 kg. The expected yield was 55 t/ha and the intended mean tuber size was 56.4 mm which would maximise the proportion of the yield in the 45-70 mm grades. The intended standard plant population was 28 800/ha (38 cm within-row spacing) and using the above information a modified plant population of 25 000/ha (43.7 cm spacing) was calculated. The potato crop followed a cereal and was grown on a deep fertile silt soil with an organic matter content of between 2 and 6 %. The intended season length (from emergence to defoliation) was estimated at 116 days. The standard N application rate was 200 kg N/ha and this was compared with a reduced N application rate of 175 kg N/ha. In addition, a further comparison was planted that tested the reduced seed and N rate in combination. All seed and N rate comparisons were planted on 8 April.

Seed rate comparison

Both the standard and modified seed rate crops reached 50 % plant emergence on 10 May (32 DAP). The achieved plant population in the standard seed rate crop was 29 200/ha (compared with an intended population of 28 800/ha). However, in the modified seed rate crop the achieved plant population was slightly greater than intended (26 900 compared with 25 000/ha). Ground cover expansion was slightly slower in the modified seed rate crop, but both crops attained complete ground cover which was maintained until the field was defoliated on 16 August (Figure 23). When averaged over both samplings, the stem population was 116 000/ha in the standard seed rate crop compared with 102 000/ha in the modified. The crops were sampled twice (11 July and 25 August). At the first sampling, total (> 10 mm) and ware (> 40 mm) yields were 63.9 and 62.2 t/ha, respectively, in the crop grown with the standard seed rate compared with 61.0 and 59.7 t/ha, respectively, in the crop grown with the modified seed rate. The mean tuber size was *c*. 1.3 mm larger in the crop grown at the wider seed spacing.

Nitrogen rate comparison

Reducing the N application rate from 200 to 175 kg N/ha had no effect on the date of 50 % plant emergence or on plant population (Figure 24). Ground cover expansion, maximum ground cover and ground cover persistence were similar irrespective of the amount of N applied and thus both crops would be expected to absorb a similar amount of solar radiation. Despite having a similar plant population, the stem and tuber population (> 10 mm) were

slightly larger in the Maris Piper crop grown with reduced N rate. Total tuber (> 10 mm) yields at the first sampling (11 July, 62 DAP) were 33.3 t/ha in the area where 200 kg N/ha had been applied and 34.3 t/ha where the N application rate had been reduced to 175 kg N/ha. At the final sampling (25 August, 107 DAP), the total yield had increased to 63.9 t/ha in the standard N rate area and 68.3 t/ha in the modified N rate area.

Seed and N rate comparison

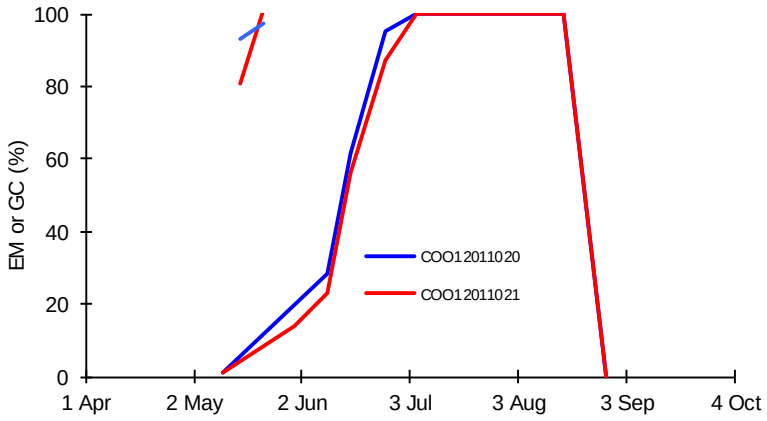
For the purpose of this report, the crop grown with both reduced plant population and reduced N application rate will be compared with the crop grown with a reduced seed rate but a standard N application rate. Thus the comparison investigated the effect of standard and modified N application rates in crops grown with modified spacings. The date of 50 % emergence was the same in both crops as was the overall pattern of ground cover development (Figure 25). Stem populations were numerically larger in the crop grown with reduced N but the total tuber population was similar. The total yield at the first sampling (11 July) was 29.8 t/ha in standard N area compared with 29.3 t/ha in the area grown with reduced N. At the final sampling yields in the area grown with 200 kg N/ha were 61 t/ha compared with 62.8 t/ha where the N application rate had been decreased to 175 kg N/ha.

Analysis of Co-operative crop performance using the CUF yield model

In general there was good agreement between observed yields at final sampling and yields forecasted using the CUF model (Figure 26). The average, observed total yield for the standard, modified seed rate and modified N rate crops was 64.4 t/ha compared with an average forecasted yield of 60.6 t/ha. The data suggest that all crops were adequately supplied with water during the course of the season and yield formation was not limited inefficient conversion of solar radiation to yield as a consequence of stress.

Figure 23. Co-operative Farms, seed rate comparison in standard nitrogen rate crops, Maris Piper Pasture 116.

Grower:	Coop	Coop
Field name:	Pasture 116	Pasture 116
Unique ID:	COO12011020	COO12011021
Part Field Name:	Standard Seed & Standard N	Modified Seed & Standard N
Variety:	Maris Piper	Maris Piper
Intended yield:	55 t/ha	55 t/ha
Intended use:	General Ware	General Ware
Planting date (start):	8 Apr	8 Apr
Date of 50 % emergence:	10 May	10 May
Total N applied:	200 kg N/ha	200 kg N/ha
Seed size:	45-55 mm	45-55 mm
Seed count:	600 per 50 kg	600 per 50 kg
Planned density:	28.8 000/ha	25.0 000/ha
Planned spacing:	38.0 cm	43.7 cm
Achieved density:	29.2 000/ha	26.9 000/ha
Achieved spacing:	37.5 cm	40.7 cm

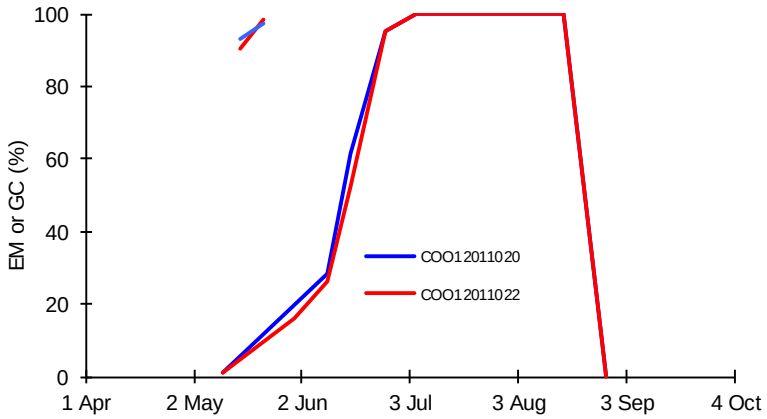


Yield Samples (S.E. in italics)

		Standard Seed & Standard N			Modified Seed & Standard N	
		11 Jul	25 Aug		11 Jul	25 Aug
Plants (000/ha)		28.3	30.1		26.4	27.3
		0.91	*1.75*		*0.91*	*1.05*
Stems (000/ha)		124.9	107.5		100.2	103.9
		13.51	*10.04*		*10.99*	*6.90*
Stems/plant		4.4	3.6		3.8	3.8
		0.46	*0.16*		*0.50*	*0.21*
Tubers (000/ha)	> 10 mm	416	360	> 10 mm	316	337
		7.7	*25.9*		*29.7*	*32.6*
Tubers (000/ha)	> 40 mm	288	308	> 40 mm	238	293
		3.9	*15.2*		*20.7*	*30.4*
Tuber yield (t/ha)	> 10 mm	33.3	63.9	> 10 mm	29.8	61.0
		1.05	*1.46*		*1.58*	*2.99*
Tuber yield (t/ha)	> 40 mm	29.8	62.2	> 40 mm	27.2	59.7
		1.36	*1.31*		*1.30*	*2.81*
DM (%)		16.4	20.3		16.7	21.5
		0.27	*0.40*		*0.12*	*0.44*
Mean tuber size (mm)		47.4	59.6		48.7	60.9
		0.73	*0.83*		*0.77*	*1.12*

Figure 24. Co-operative Farms, nitrogen rate comparison in standard seed rate crop, Maris Piper Pasture 116.

Grower:	Coop	Coop
Field name:	Pasture 116	Pasture 116
Unique ID:	COO12011020	COO12011022
Part Field Name:	Standard Seed & Standard N	Standard Seed & Modified N
Variety:	Maris Piper	Maris Piper
Intended yield:	55 t/ha	55 t/ha
Intended use:	General Ware	General Ware
Planting date (start):	8 Apr	8 Apr
Date of 50 % emergence:	10 May	10 May
Total N applied:	200 kg N/ha	175 kg N/ha
Seed size:	45-55 mm	45-55 mm
Seed count:	600 per 50 kg	600 per 50 kg
Planned density:	28.8 000/ha	28.8 000/ha
Planned spacing:	38.0 cm	38.0 cm
Achieved density:	29.2 000/ha	29.6 000/ha
Achieved spacing:	37.5 cm	36.9 cm



Yield Samples (S.E. in italics)

		Standard Seed & Standard N			Standard Seed & Modified N	
		11 Jul	25 Aug		11 Jul	25 Aug
Plants (000/ha)		28.3	30.1		29.2	30.1
		0.91	*1.75*		*0.00*	*0.91*
Stems (000/ha)		124.9	107.5		141.3	124.9
		13.51	*10.04*		*18.43*	*16.99*
Stems/plant		4.4	3.6		4.8	4.1
		0.46	*0.16*		*0.63*	*0.53*
Tubers (000/ha)	> 10 mm	416	360	> 10 mm	455	401
		7.7	*25.9*		*48.2*	*37.8*
Tubers (000/ha)	> 40 mm	288	308	> 40 mm	293	349
		3.9	*15.2*		*12.4*	*32.1*
Tuber yield (t/ha)	> 10 mm	33.3	63.9	> 10 mm	34.3	68.3
		1.05	*1.46*		*0.95*	*2.25*
Tuber yield (t/ha)	> 40 mm	29.8	62.2	> 40 mm	29.7	66.8
		1.36	*1.31*		*1.75*	*2.16*
DM (%)		16.4	20.3		16.8	21.0
		0.27	*0.40*		*0.30*	*0.38*
Mean tuber size (mm)		47.4	59.6		47.3	60.1
		0.73	*0.83*		*1.60*	*1.60*

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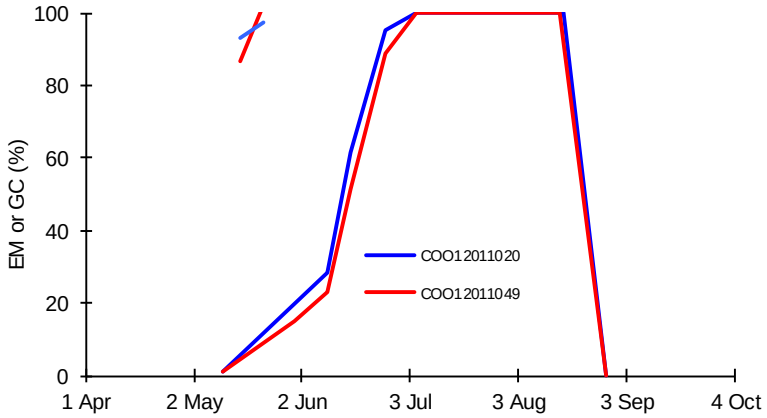
Figure 25. Co-operative Farms, seed and nitrogen rate comparison, Maris Piper Pasture 116.

Grower:	Coop	Coop
Field name:	Pasture 116	Pasture 116
Unique ID:	COO12011020	COO12011049
Part Field Name:	Standard Seed & Standard N	Modified Seed & Modified N
Variety:	Maris Piper	Maris Piper
Intended yield:	55 t/ha	55 t/ha
Intended use:	General Ware	General Ware
Planting date (start):	8 Apr	8 Apr
Date of 50 % emergence:	10 May	10 May
Total N applied:	200 kg N/ha	175 kg N/ha
Seed size:	45-55 mm	45-55 mm
Seed count:	600 per 50 kg	600 per 50 kg
Planned density:	28.8 000/ha	25.0 000/ha
Planned spacing:	38.0 cm	43.7 cm
Achieved density:	29.2 000/ha	25.5 000/ha
Achieved spacing:	37.5 cm	42.9 cm

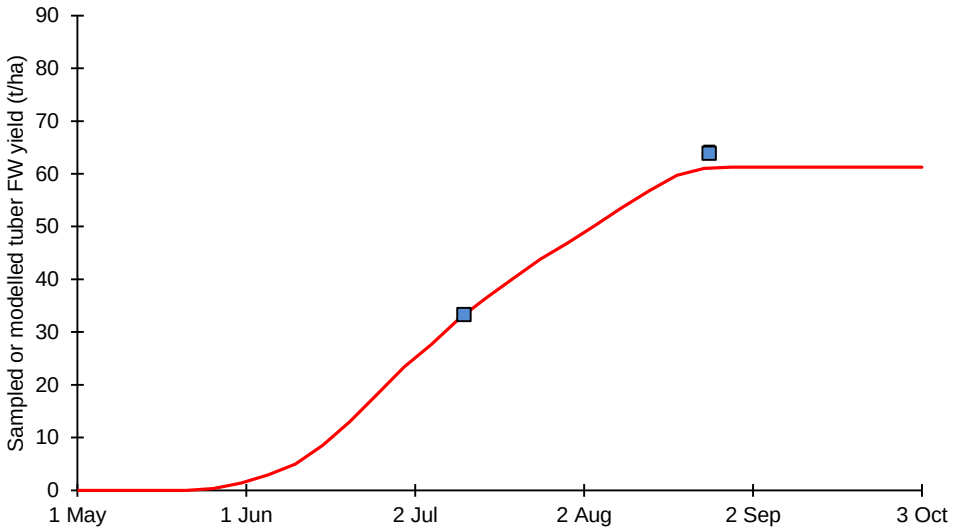


Yield Samples (S.E. in italics)

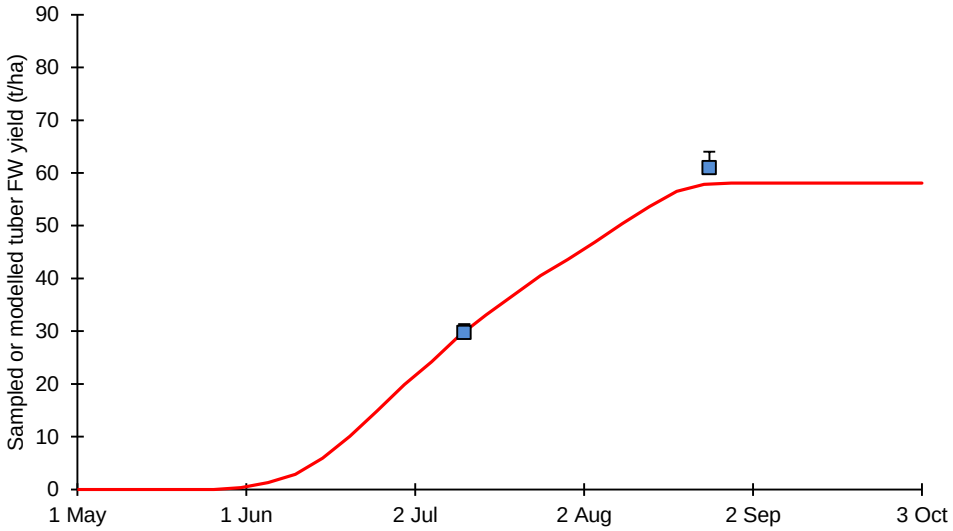
		Standard Seed & Standard N			Modified Seed & Modified N	
		11 Jul	25 Aug		11 Jul	25 Aug
Plants (000/ha)		28.3	30.1		23.7	27.3
		0.91	*1.75*		*1.05*	*1.82*
Stems (000/ha)		124.9	107.5		116.7	136.7
		13.51	*10.04*		*27.96*	*16.34*
Stems/plant		4.4	3.6		5.0	5.0
		0.46	*0.16*		*1.35*	*0.37*
Tubers (000/ha)	> 10 mm	416	360	> 10 mm	320	377
		7.7	*25.9*		*34.9*	*37.2*
Tubers (000/ha)	> 40 mm	288	308	> 40 mm	229	327
		3.9	*15.2*		*12.1*	*25.8*
Tuber yield (t/ha)	> 10 mm	33.3	63.9	> 10 mm	29.3	62.8
		1.05	*1.46*		*0.77*	*3.45*
Tuber yield (t/ha)	> 40 mm	29.8	62.2	> 40 mm	26.5	61.3
		1.36	*1.31*		*1.01*	*3.32*
DM (%)		16.4	20.3		16.5	21.6
		0.27	*0.40*		*0.20*	*0.34*
Mean tuber size (mm)		47.4	59.6		49.8	59.3
		0.73	*0.83*		*1.41*	*1.44*

Figure 26. Comparison of modelled yield (red line) and sampled yield (blue symbol ± 1 S.E.) for (*a*) standard crop, (*b*) seed modified and (*c*) nitrogen modified. Co-operative Farms, Maris Piper, Pasture 116.

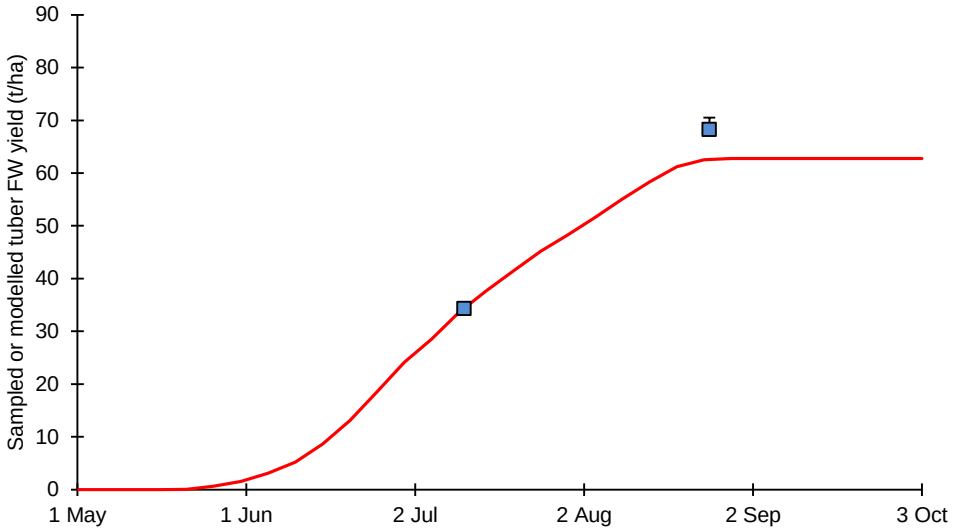
(*a*)



(*b*)



(*c*)



South West Agronomy Group (SWAG)

Since much of the agronomic advice relating to seed and fertilizer used by SWAG could be considered best practice, few comparisons have been done between standard and modified agronomies and activities have mainly been confined to monitoring the growth and performance of these crops. In 2011, this continued for the crop of Estima grown by James Pullen at Tintinhull, Somerset however for the Sante crop grown by Matt Bere (Bridgwater, Somerset) there were opportunities to compare two modified seed rates with a standard seed rate.

James Pullen, Estima, Hungerford

As before, the Estima crop was grown to produce a large proportion of baking potatoes (mean tuber size 65 mm) for the fresh market. The crop was planted on 12 April and 50 % plant emergence was recorded on 6 May (24 DAE). The achieved plant population was close to that intended (Figure 27). Ground cover expansion was rapid and the crop reached 100 % ground cover by early July and this was maintained until the crop was defoliated on 29 July. The first crop sample was taken on 30 June (55 DAE) when the total and baker ware yield (> 60 mm) was 38.7 and 2.1 t/ha, respectively. The total and baker yields had increased to 67.5 and 39.9 t/ha when the second sample was taken on 16 August (102 DAE). When averaged over both harvests, the stem population was 106 200/ha and the total tuber population was 476 000/ha. The mean tuber size was 61.9 mm which is close to that need to ensure a large fraction of baking size potatoes. The yield of potatoes in the 65-85 mm grade was estimated to be 24.6 (±1.97) t/ha.

Matthew Bere, Sante seed rate comparison, Big Mead

Matthew Bere provided seed and cropping details for a crop of Sante to be grown in Big Mead Field, Fordgate Farm, Bridgwater. The Sante seed was from a late-emerging seed crop (emerged 15 July 2010) and had a count of 1220/50 kg. The intended yield of the ware crop was 55 t/ha and the intended mean tuber size was 60 mm. Using this information, a standard target plant population of 56 000/ha (equivalent to a within-row spacing 19.4 cm) was calculated and the majority of this seed stock was planted at this target density. However, since there are relatively few data-sets underpinning seed rate recommendation for Sante, two further target populations were also calculated: 50 500/ha (21.7 cm spacing) and 61 600/ha (17.8 cm spacing). All three seed rates were planted on 4 May and were at 50 % plant emergence on 4 June.

Increased seed rate comparison

The achieved plant populations in both the standard and increased seed rate areas were less than intended and instead of a 10 % increase in plant population the actual increase was *c*. 8 % (Figure 28). Ground cover expansion in the standard crop was normal and the crop reached complete ground cover by 13 July and this was maintained until the 17 August, when the crop started to senesce. Ground covers were not systematically recorded in the modified crops but no differences were noted between treatments in observations made on 19 July and 24 August. When averaged over both samplings, the stem and total tuber population in the standard crop was 126 000 and 433 000/ha, respectively, whilst in the reduced seed rate area the populations were 134 000 and 476 000/ha, respectively. At the first sampling (19 July, 45 DAE), total tuber yields were very similar in the standard and increased plant population areas and total yield averaged 19.1 t/ha. At this harvest the presence of black-leg was noted in all seed rate areas with an average incidence of *c.* 10 % of stems affected. The second sampling was taken on 24 August (81 DAE) immediately before the crop was defoliated. Plant density had little effect on either total or ware yield and these averaged 44.6 and 41.8 t/ha, respectively. The mean tuber size averaged 58.8 mm and was therefore a little less than intended.

Reduced seed rate comparison

The achieved plant populations both the standard crop and reduced seed rate crops were substantially less than that intended (Figure 29) and whilst the planned difference in plant population was 10 % the achieved difference was *c*. 17 %. When averaged over the two samplings, the stem and total tuber populations in the standard crop were 126 000 and 433 000/ha, respectively, whilst in the reduced seed rate area the populations were 112 000 and 423 000/ha, respectively. At the first sampling there was little effect of the plant population on total yield which averaged 20.2 t/ha. On 24 August total and ware (> 40 mm) yields in the standard crop averaged 43.9 and 41.2 t/ha, respectively. In the reduced seed rate crop, the total and ware yields were 53.1 and 51.1 t/ha, respectively. The mean tuber size in the standard crop was 59.0 mm compared with 62.2 mm where the seed rate was decreased. Whilst the reduced seed rate crop had numerically larger yields, the yield estimates in both crops were associated with large errors and the difference are observed differences are unlikely to be real. The large errors are probably a consequence of the blackleg which resulted in very variable yields from plot-to-plot For example in the standard crop total tuber yields varies from 32.2 t/ha (replicate 2) to 50.6 t/ha (replicate 4).

Unfortunately, the effects of blackleg compromised the precision of these comparisons but the data suggest that the smaller population resulted in a ware crop that was a closer match to the specification than either the standard or increased seed rate crops. However, these should be repeated to obtain more robust data.

Analysis of SWAG crops using the CUF yield model

For the Estima crop grown by James Pullen there was good agreement between observed yields and yield predicted by the CUF model on the basis of observed ground cover and incident radiation (Figure 30*a*). These data suggest that this crop was not stressed and absorbed radiation was efficiently converted into tuber yield. When used to model the standard seed rate Sante crop grown by Matt Bere the CUF model slightly overestimated the final yield (Figure 30*b*). This may solely be a consequence of the variability in the crop or may represent the loss of harvested yield due to tuber rotting as a result of blackleg.

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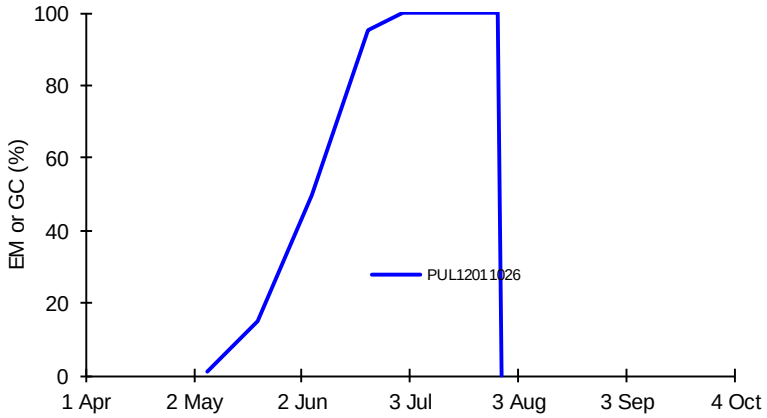
Figure 27. SWAG, James Pullen, Estima, Hungerford Field.

Grower:	James Pullen
Field name:	Hungerford
Unique ID:	PUL12011026
Part Field Name:	Standard seed & Standard N
Variety:	Estima
Intended yield:	60 t/ha
Intended use:	Bakers

Planting date (start):	12 Apr	
Date of 50 % emergence:	6 May	
Total N applied:	160	kg N/ha
Seed size:	45-55	mm
Seed count:	550	per 50 kg
Planned density:	43.8	000/ha
Planned spacing:	25.0	cm
Achieved density:	34.2	000/ha
Achieved spacing:	32.0	cm



Yield Samples (S.E. in italics)

	Standard seed & Standard N	
	30 Jun	16 Aug
Plants (000/ha)	32.8	35.5
	1.49	*1.75*
Stems (000/ha)	106.6	105.7
	3.76	*5.37*
Stems/plant	3.3	3.0
	0.19	*0.16*
Tubers (000/ha) > 10 mm	484	468
	23.5	*8.2*
Tubers (000/ha) > 60 mm	9	137
	3.2	*9.5*
Tuber yield (t/ha) > 10 mm	38.7	67.5
	1.84	*2.40*
Tuber yield (t/ha) > 60 mm	2.1	39.9
	0.66	*3.28*
DM (%)	13.2	17.5
	0.17	*0.37*
Mean tuber size (mm)	48.7	61.9
	0.27	*0.78*

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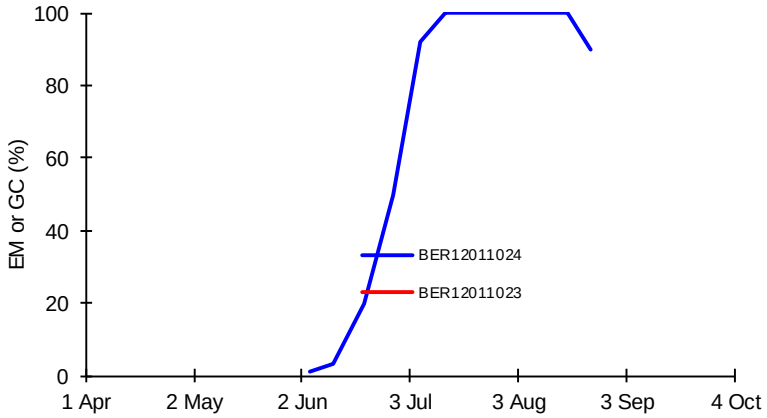
Figure 28. SWAG, Matt Bere, Sante increased seed rate comparison, Big Mead.

Grower:	Matt Bere	Matt Bere
Field name:	Big Mead	Big Mead
Unique ID:	BER12011024	BER12011023
Part Field Name:	Standard Population	Higher Population
Variety:	Sante	Sante
Intended yield:	55 t/ha	55 t/ha
Intended use:	General Ware	General Ware
Planting date (start):	4 May	4 May
Date of 50 % emergence:	4 Jun	4 Jun
Total N applied:	100 kg N/ha	100 kg N/ha
Seed size:	35-45 mm	35-45 mm
Seed count:	1220 per 50 kg	1220 per 50 kg
Planned density:	56.0 000/ha	61.6 000/ha
Planned spacing:	19.5 cm	17.8 cm
Achieved density:	45.1 000/ha	48.8 000/ha
Achieved spacing:	24.2 cm	22.4 cm



Yield Samples (S.E. in italics)

		Standard Population			Higher Population	
		19 Jul	24 Aug		19 Jul	24 Aug
Plants (000/ha)		44.7	45.6		51.0	46.5
		2.29	*3.79*		*1.49*	*2.29*
Stems (000/ha)		132.1	120.3		141.3	126.7
		7.04	*12.00*		*1.75*	*1.75*
Stems/plant		3.0	2.7		2.8	2.7
		0.13	*0.29*		*0.06*	*0.16*
Tubers (000/ha)	> 10 mm	452	415	> 10 mm	478	473
		25.6	*11.3*		*27.1*	*37.4*
Tubers (000/ha)	> 40 mm	165	253	> 40 mm	173	272
		26.6	*17.6*		*16.9*	*31.5*
Tuber yield (t/ha)	> 10 mm	19.0	43.9	> 10 mm	19.3	45.3
		2.22	*4.25*		*1.78*	*3.72*
Tuber yield (t/ha)	> 40 mm	13.1	41.2	> 40 mm	13.1	42.4
		2.25	*4.58*		*1.82*	*3.45*
DM (%)		14.0	20.9		13.7	20.5
		0.23	*0.20*		*0.31*	*0.46*
Mean tuber size (mm)		42.4	59.0		42.9	58.6
		0.92	*1.68*		*1.05*	*0.98*

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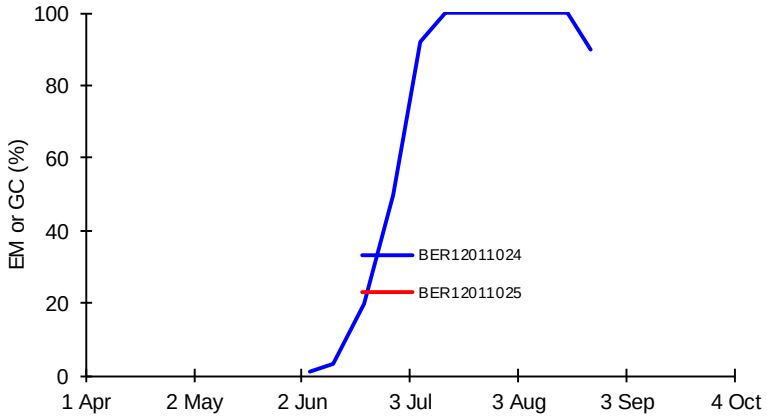
Figure 29. SWAG, Matt Bere, Sante decreased seed rate comparison, Big Mead.

Grower:	Matt Bere	Matt Bere
Field name:	Big Mead	Big Mead
Unique ID:	BER12011024	BER12011025
Part Field Name:	Standard Population	Lowest Population
Variety:	Sante	Sante
Intended yield:	55 t/ha	55 t/ha
Intended use:	General Ware	General Ware
Planting date (start):	4 May	4 May
Date of 50 % emergence:	4 Jun	4 Jun
Total N applied:	100 kg N/ha	100 kg N/ha
Seed size:	35-45 mm	35-45 mm
Seed count:	1220 per 50 kg	1220 per 50 kg
Planned density:	56.0 000/ha	50.5 000/ha
Planned spacing:	19.5 cm	21.7 cm
Achieved density:	45.1 000/ha	37.4 000/ha
Achieved spacing:	24.2 cm	29.3 cm

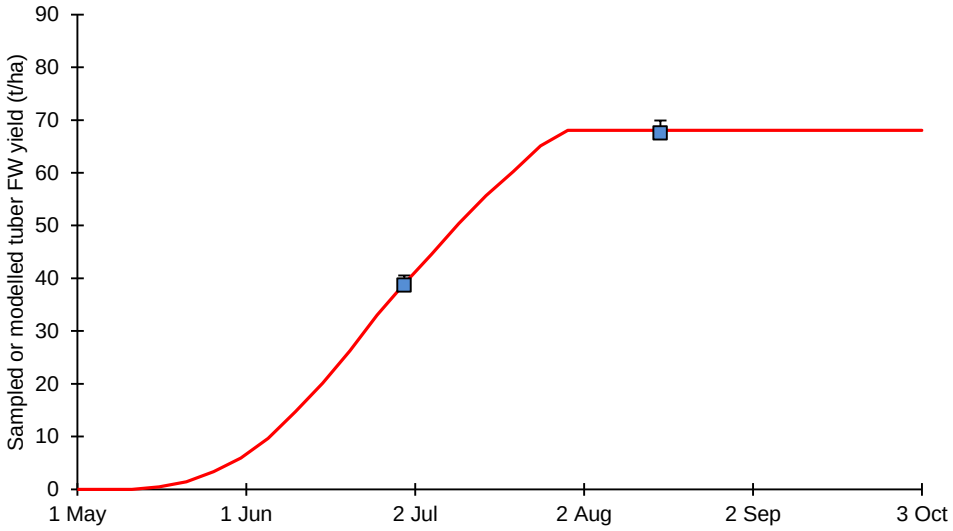


Yield Samples (S.E. in italics)

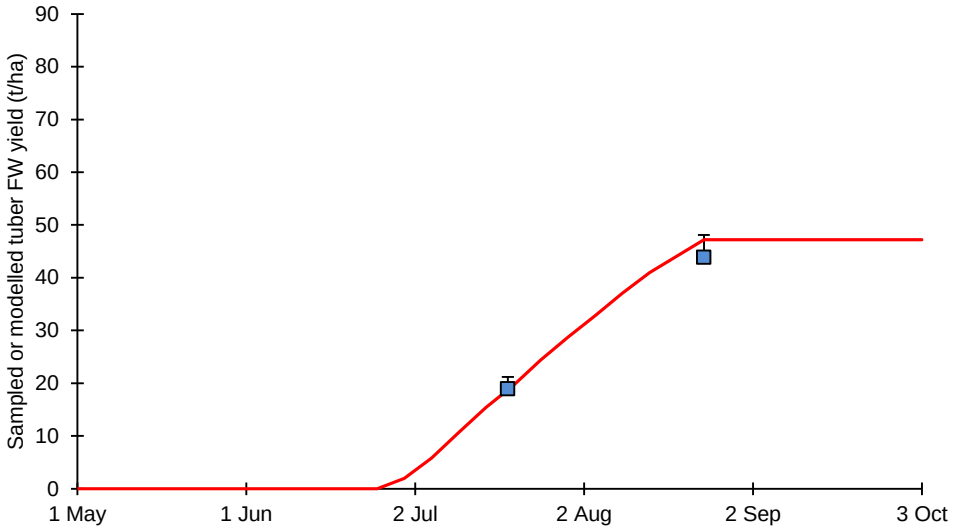
		Standard Population			Lowest Population	
		19 Jul	24 Aug		19 Jul	24 Aug
Plants (000/ha)		44.7	45.6		38.3	36.5
		2.29	*3.79*		*2.35*	*2.98*
Stems (000/ha)		132.1	120.3		125.8	98.4
		7.04	*12.00*		*10.78*	*2.58*
Stems/plant		3.0	2.7		3.3	2.7
		0.13	*0.29*		*0.34*	*0.18*
Tubers (000/ha)	> 10 mm	452	415	> 10 mm	459	386
		25.6	*11.3*		*26.7*	*18.4*
Tubers (000/ha)	> 40 mm	165	253	> 40 mm	199	283
		26.6	*17.6*		*34.4*	*23.4*
Tuber yield (t/ha)	> 10 mm	19.0	43.9	> 10 mm	21.5	53.1
		2.22	*4.25*		*2.86*	*3.05*
Tuber yield (t/ha)	> 40 mm	13.1	41.2	> 40 mm	16.0	51.1
		2.25	*4.58*		*3.17*	*3.12*
DM (%)		14.0	20.9		13.6	20.1
		0.23	*0.20*		*0.18*	*0.33*
Mean tuber size (mm)		42.4	59.0		43.5	62.2
		0.92	*1.68*		*1.05*	*1.40*

Figure 30. Comparison of modelled yield (red line) and sampled yield (blue symbol ± 1 S.E.) for (*a*) James Pullen, Estima, Hungerford Field and (*b*) Matt Bere, Sante standard seed rate, Big Mead Field.

(a)



(b)



Appendix 1

Table 4. Summary of all N rate comparison data collected in PCL/CUF Grower Collaboration Project R295 2007-2011. Yield data are hand-dug-samples taken about the time of defoliation

Year	Grower	Field	Variety	Standard N rate (kg N/ha)	Modified N rate (kg N/ha)	Change in N rate (kg N/ha)	Standard yield > 10 mm (t/ha)	Modified yield > 10 mm (t/ha)	Change in yield > 10 mm (t/ha)	Standard yield > 40 mm (t/ha)	Modified yield > 40 mm (t/ha)	Change in yield > 40 mm (t/ha)
2008	Strawson Farming†	Bower 8	Hermes	193	169	-24	66.2	60.6	-5.6	63.8	58.2	-5.6
2008	Mease Valley Potatoes‡	MFL B	Russet Burbank	200	160	-40	69.1	52.8	-16.3	64.5	46.8	-17.7
2010	RS Cockerill Ltd#	Field 16	Hermes	175	140	-35	55.8	51.6	-4.3	52.5	48.6	-3.9
2011	Co-operative Farms*	Pasture 116	Maris Piper	200	175	-25	61.0	62.8	1.8	59.7	61.3	1.6
2007	Mease Valley Potatoes	Upper Trent	Russet Burbank	220	165	-55	59.5	67.6	8.1	56.4	64.1	7.7
2007	NNPG	Market Style	Saturna	240	175	-65	40.2	51.0	10.8	29.9	36.4	6.5
2008	AH Worth & Co	Field 13	Maris Piper	180	140	-40	56.0	50.9	-5.1	53.3	47.9	-5.3
2008	NNPG	Malthouse	Saturna	240	180	-60	45.2	48.6	3.4	42.1	45.4	3.3
2008	NNPG	Horseshoes	Hermes	224	175	-49	50.4	53.6	3.2	47.4	50.9	3.6
2009	AH Worth & Co	F38	Maris Piper	180	155	-25	71.4	72.6	1.1	69.8	70.7	0.9
2009	Mease Valley Potatoes	Curborough	Markies	150	130	-20	56.4	55.7	-0.7	51.7	50.9	-0.9
2009	Mease Valley Potatoes	Deercote Barn	Maris Piper	220	200	-20	64.5	54.4	-10.1	59.9	48.6	-11.3
2009	Strawson Farming	Wood 10	Hermes	210	185	-25	37.6	44.0	6.4	35.3	41.4	6.1
2009	Strawson Farming	Godfrey 13	Saturna	220	195	-25	63.1	58.9	-4.2	60.5	55.9	-4.6
2009	NNPG	Bakers 27	Saturna	240	180	-60	48.8	52.0	3.2	46.4	49.4	3.1
2009	NNPG	Long Lions	Hermes	191	181	-10	57.0	61.0	4.0	54.7	58.1	3.4
2010	Co-operative Farms	3/5/7/ B	Estima	230	205	-25	35.9	43.1	7.2	33.8	39.7	5.9
2010	Branston Potatoes	Pit Field	Desiree	140	120	-20	74.3	75.8	1.5	70.7	72.2	1.6
2010	AH Worth & Co	Field 26/27	Marfona	180	150	-30	54.8	60.9	6.1	53.4	59.5	6.0
2010	AH Worth & Co	JEP28	Melody	180	155	-25	44.2	46.5	2.3	40.1	41.3	1.2
2010	RS Cockerill Ltd	Field 35	Saturna	230	195	-35	47.2	39.2	-8.0	43.4	36.6	-6.8
2010	RS Cockerill Ltd	Field 18	Hermes	225	185	-40	65.4	65.9	0.5	62.9	63.8	0.8

Table 4. (continued)

Year	Grower	Field	Variety	Standard N rate (kg N/ha)	Modified N rate (kg N/ha)	Change in N rate (kg N/ha)	Standard yield > 10 mm (t/ha)	Modified yield > 10 mm (t/ha)	Change in yield > 10 mm (t/ha)	Standard yield > 40 mm (t/ha)	Modified yield > 40 mm (t/ha)	Change in yield > 40 mm (t/ha)
2011	RS Cockerill Ltd	Field 11	Hermes	220	190	-30	61.9	80.7	18.8	59.9	77.8	17.9
2011	RS Cockerill Ltd	Stanwick Wall	Saturna	175	160	-15	66.7	72.1	5.4	64.6	70.4	5.7
2011	Co-operative Farms	Pasture 116	Maris Piper	200	175	-25	63.9	68.3	4.4	62.2	66.8	4.6
			Average (n=25)	203	170	-33	56.7	58.0	1.3	53.6	54.5	1.0

Not included in summaries because: †, N application rate smaller than intended; ‡, crop severely affected by potato cyst nematode; #, large difference in dates of emergence of standard and modified crops and *, plant populations different to those intended.

Table 5. Summary of all seed rate comparison data (seed rate increased) collected in PCL/CUF Grower Collaboration Project R295 2007-2011. Yield data are hand-dug-samples taken about the time of defoliation

Year	Grower	Field	Variety	Standard seed rate (t/ha)	Modified seed rate (t/ha)	Change in seed rate (t/ha)	Standard yield > 10 mm (t/ha)	Modified yield > 10 mm (t/ha)	Change in yield > 10 mm (t/ha)	Standard yield > 40 mm (t/ha)	Modified yield > 40 mm (t/ha)	Change in yield > 40 mm (t/ha)
2011	SWAG†	Big Mead	Sante	2.30	2.52	0.23	43.9	45.3	1.5	41.2	42.4	1.2
2007	Mease Valley Potatoes	Thorpe 41	Saturna	1.37	1.60	0.23	54.2	50.1	-4.1	51.8	46.1	-5.8
2007	Strawson Farming	Godfrey Blyth	Saturna	2.42	2.72	0.30	69.0	72.4	3.4	67.4	70.7	3.3
2009	NNPG	Bakers 27	Saturna	1.77	2.02	0.25	48.8	54.2	5.4	46.4	50.0	3.7
			Average (n=4)	1.96	2.21	0.25	54.0	55.5	1.5	51.7	52.3	0.6

Not included in summaries because: †achieved seed rates different to those intended.

Table 6. Summary of all seed rate comparison data (seed rate decreased) collected in PCL/CUF Grower Collaboration Project R295 2007-2011. Yield data are hand-dug-samples taken about the time of defoliation

Year	Grower	Field	Variety	Standard seed rate (t/ha)	Modified seed rate (t/ha)	Change in seed rate (t/ha)	Standard yield > 10 mm (t/ha)	Modified yield > 10 mm (t/ha)	Change in yield > 10 mm (t/ha)	Standard yield > 40 mm (t/ha)	Modified yield > 40 mm (t/ha)	Change in yield > 40 mm (t/ha)
2008	A H Worth & Co†	Field 69	Estima	2.33	1.85	-0.48	59.0	59.6	0.6	56.5	56.1	-0.5
2008	A H Worth & Co†	Field 69	Estima	3.00	2.59	-0.41	59.2	69.8	10.6	56.1	67.1	10.9
2008	Strawson Farming†	Hoggard 6	Saturna	2.54	2.18	-0.36	67.6	60.1	-7.5	62.6	56.5	-6.1
2008	NNPG†	Millfield	Hermes	4.57	1.87	-2.70	53.9	59.4	5.6	49.0	56.6	7.5
2009	A H Worth & Co†	JEP44	Estima	2.43	2.17	-0.26	60.1	55.2	-4.9	58.7	54.0	-4.7
2009	Mease Valley Potatoes†	Marsh Barn	Lady Rosetta	1.71	1.40	-0.30	57.6	51.1	-6.5	52.3	48.5	-3.8
2009	Strawson Farming†	S. Wood 14	Hermes	3.14	2.87	-0.27	42.3	39.1	-3.1	38.7	36.1	-2.5
2009	NNPG†	Long Lions	Hermes	3.04	2.40	-0.64	57.0	62.2	5.2	54.7	59.6	4.9
2010	A H Worth & Co†	Field 26/27	Marfona	2.97	2.67	-0.30	54.8	63.3	8.5	53.4	62.2	8.7
2010	RS Cockerill Ltd†	Field 35	Saturna	2.36	2.28	-0.09	47.2	44.4	-2.8	43.4	40.8	-2.6
2011	SWAG†	Big Mead	Sante	2.30	2.07	-0.23	43.9	53.1	9.2	41.2	51.1	9.9
2011	B&C Farming Ltd†	Grove Farm 89	Russet Burbank	1.49	1.05	-0.44	61.6	65.3	3.7	55.8	59.6	3.8
2007	Mease Valley Potatoes	Ellis B	Hermes	2.89	2.44	-0.44	64.4	75.8	11.4	60.5	71.9	11.4
2007	Mease Valley Potatoes	Thorpe 41	Saturna	2.94	2.44	-0.51	58.8	51.4	-7.4	56.0	46.5	-9.5
2007	Strawson Farming	K. Narborough	Saturna	2.30	2.11	-0.20	51.0	49.8	-1.1	48.2	47.8	-0.4
2007	Strawson Farming	S. Creake	Hermes	3.43	2.46	-0.97	47.5	46.8	-0.7	46.9	46.4	-0.5
2007	Strawson Farming	B. Carburton	Hermes	4.39	2.81	-1.58	55.5	58.6	3.1	52.3	56.7	4.3
2007	NNPG	45 acres	Saturna	2.56	2.15	-0.42	68.7	62.8	-5.9	64.7	59.9	-4.8
2007	NNPG	Wrights	Hermes	3.07	2.16	-0.91	49.8	54.0	4.2	45.5	51.0	5.5
2008	A H Worth & Co	Field 13	Maris Piper	1.54	1.13	-0.41	64.4	56.0	-8.4	59.9	53.3	-6.7
2008	Strawson Farming	Bower 8	Hermes	4.47	2.50	-1.96	66.2	57.9	-8.3	63.8	56.2	-7.6
2008	Strawson Farming	Godfrey 8	Saturna	2.45	2.17	-0.29	50.6	52.0	1.5	46.8	48.5	1.6
2008	NNPG	Millfield	Hermes	4.57	2.96	-1.61	53.9	59.3	5.5	49.0	56.8	7.7

Table 6. (continued)

Year	Grower	Field	Variety	Standard seed rate (t/ha)	Modified seed rate (t/ha)	Change in seed rate (t/ha)	Standard yield > 10 mm (t/ha)	Modified yield > 10 mm (t/ha)	Change in yield > 10 mm (t/ha)	Standard yield > 40 mm (t/ha)	Modified yield > 40 mm (t/ha)	Change in yield > 40 mm (t/ha)
2008	NNPG	Horseshoes	Hermes	2.59	2.09	-0.49	50.4	53.6	3.2	47.4	51.7	4.3
2008	NNPG	Malthouse	Saturna	2.02	1.61	-0.41	45.2	43.3	-1.9	42.1	41.3	-0.8
2008	Mease Valley Potatoes	Bowling Alley	Lady Rosetta	3.27	2.98	-0.29	66.9	64.7	-2.1	62.2	60.9	-1.2
2008	Mease Valley Potatoes	P. Quarry	Hermes	3.89	2.53	-1.36	57.8	55.0	-2.8	51.8	49.9	-1.9
2009	A H Worth & Co	JEP44	Estima	3.42	2.89	-0.54	67.8	66.2	-1.6	65.8	65.1	-0.7
2009	Mease Valley Potatoes	Marsh Barn	Lady Rosetta	2.37	1.80	-0.57	54.5	52.2	-2.3	46.2	48.5	2.3
2009	Strawson Farming	S. Wood 14	Hermes	3.14	2.27	-0.86	42.3	39.6	-2.6	38.7	37.5	-1.1
2009	NNPG	Bakers 55	Hermes	3.05	2.40	-0.66	56.6	58.2	1.6	52.1	55.8	3.7
2010	Cooperative Farms	3/5/7/ B	Estima	2.80	2.36	-0.44	35.9	39.5	3.6	33.8	38.0	4.2
2010	Branston Potatoes Ltd	Hall Field	King Edward	2.14	1.88	-0.27	67.2	66.0	-1.1	60.6	61.3	0.7
2010	RS Cockerill Ltd	Field 16	Hermes	3.45	2.56	-0.89	55.8	58.4	2.6	52.5	55.8	3.2
2010	RS Cockerill Ltd	Field 18	Hermes	3.14	2.35	-0.79	57.1	65.4	8.3	55.6	62.9	7.3
2011	Branston Potatoes Ltd	Nocton 2	Maris Piper	1.76	1.51	-0.25	71.2	68.3	-2.9	69.3	67.0	-2.3
2011	RS Cockerill Ltd	Field 11	Hermes	3.70	2.65	-1.05	61.9	73.5	11.6	59.9	72.1	12.1
2011	Co-operative Farms	Pasture 116	Maris Piper	2.40	2.08	-0.32	63.9	61.0	-2.9	62.2	59.7	-2.5
2011	Co-operative Farms	Pasture 116	Maris Piper	2.40	2.08	-0.32	68.3	62.8	-5.5	66.8	61.3	-5.5
2011	Tame Valley Potatoes	29 Acre	Russet Burbank	1.73	1.43	-0.30	71.5	66.4	-5.1	67.7	63.5	-4.2
2011	Tame Valley Potatoes	29 Acre	Russet Burbank	1.83	1.51	-0.32	65.0	60.4	-4.5	57.8	55.0	-2.9
2011	B&C Farming Ltd	Grove Farm 91	Russet Burbank	1.49	1.05	-0.44	75.6	67.1	-8.5	70.0	62.4	-7.6
2011	B&C Farming Ltd	Grove Farm-91	Russet Burbank	1.47	1.01	-0.46	72.4	66.5	-5.9	65.0	59.8	-5.2
2011	B&C Farming Ltd	Medler Melton	Russet Burbank	1.49	1.05	-0.44	59.8	57.3	-2.5	51.0	50.2	-0.8
2011	B&C Farming Ltd	Medler Melton	Russet Burbank	1.47	1.01	-0.46	58.5	61.3	2.8	48.6	54.8	6.2
			Average (n=45)	2.70	2.08	-0.62	58.2	58.1	-0.1	54.3	55.1	0.8

Not included in summaries because: †achieved seed rates different to those intended.

Appendix 2.

Table 7. Summary statistics comparing standard seed and nitrogen application rates with modified for all comparisons and restricted to valid comparisons in 2007-2011. P is the probability that the difference between standard and modified agronomy is zero

		Tuber yield > 10 mm (t/ha)		Tuber yield > 40 mm (t/ha)	
Comparison		Standard	Reduced	Standard	Reduced
N application rate	All data (n=25)	56.7±2.13	58.0±2.16	53.6±2.25	54.5±2.35
	Difference	+1.4±1.45; P=0.36		+1.0±1.41; P=0.51	
	Valid data (n=21)	55.5±2.40	58.2±2.53	52.3±2.55	54.7±2.75
	Difference	+2.8±1.40; P=0.06		+2.4±1.33; P=0.09	
Seed rate	All data (n=45)	58.2±1.35	58.1±1.29	54.3±1.32	55.1±1.27
	Difference	-0.2±0.84; P=0.86		+0.8±0.83; P=0.36	
	Valid data (n=33)	59.3±1.64	58.5±1.52	55.2±1.61	55.4±1.49
	Difference	-0.8±0.92; P=0.41		+0.3±0.94; P=0.78	

Grower Collaboration Project Report for 2012

M F Allison & D M Firman

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Summary

1. In 2012 collaborative work was done with Branston Holdings Ltd, The Co-operative Farms, RS Cockerill Ltd and McCain Foods Ltd and a total of 30 crops were monitored as part of the project.

2. Seed rate comparisons were done with Estima, Harmony, Markies, Piccolo Star, Russet Burbank and VR808 and nitrogen rate comparisons were done with Harmony, Melody and VR808.

3. Measurements of solar radiation at each site showed that 2012 was duller than previous seasons. However, the small yields found in some crops were mainly due to late planting or poor ground cover development.

4. In a few cases, the achieved plant populations were too different from those intended to allow a sensible test of seed rate and these have been excluded from subsequent analysis. One crop was also severely affected by PCN and this crop also been excluded.

5. Since 2007 and where valid comparisons could be made, reducing the seed rate was, on average, associated with a small (0.2 t/ha) reduction in total (> 10 mm) yield. However, ware yield (> 40 mm) was increased by 0.6 t/ha.

6. On average, reducing the nitrogen application rate increased total and ware yield by 3.3 and 3.0 t/ha, respectively. Analysis by paired 'T' test showed that these differences were statistically significant.

Introduction

This project was started in 2007 and its objectives were to collaborate with growers and agronomists in planning the agronomic components of their potato production systems utilising current agronomic knowledge and documenting the process and differences from previous practice. The project aimed to examine the accuracy of the agronomic decisions in relation to crop growth, yield potential and timing of harvest, meeting irrigation requirements and other criteria. Collaboration was undertaken with the following growers and grower groups: Branston Holdings Ltd, The Co-operative Farms, RS Cockerill Ltd and McCain Foods Ltd.

Materials and Methods

Information on cropping plans, including varieties, seed stocks, intended planting date and yield, target tuber size, seed rates, soil data and fertilizer application rates, was obtained from collaborating growers. Fertilizer and seed rate recommendations were calculated for some of

the crops using the information supplied. The dates of seed crop emergence and ware crop planting were factors accounted for in determining CUF seed rate recommendations but these were not used by growers to determine their 'standard' seed rates. Cases where the current 'standard' grower's plans differed substantially (*i.e.* by at least 10 %) from recommendations based on the best information available to CUF were identified and opportunities for making comparisons of 'standard' with 'CUF modified' recommendations discussed. Some seed rate comparisons were set up with varieties for which limited data were available including varieties forming part of part of a project to derived seed rates rapidly (Potato Council Project R446). For these comparisons, the seed rates were experimental rather than representing recommended rates. In each case, generally a width of *c.* 24 m within a field received modified agronomy whilst standard agronomy was applied to the rest of the field. These unreplicated comparisons are not experiments and their limitations must be appreciated in regard to any confounding influences on the results and the variation associated with estimates of the varieties recorded, particularly of crop samples from limited areas. In other cases, even where there were no substantial differences between 'standard' and 'CUF-modified' recommendations, crops were identified with a view to recording performance in relation to agronomic inputs and environmental conditions. When appropriate other comparisons tested the effect of standard and reduced N application rate on growth and yield. A set of protocols and templates for data recording were sent to growers for recording the appropriate data on the crops so that each grower could collect data and send updates to CUF during the season. Staff from CUF visited all of the crops following establishment and some data were also collected during these visits to complement data collected by growers. Emergence (EM), ground cover (GC) and yield data were usually collected from three or four replicate areas. To complement data available for the sites, data from a calibrated pyranometer (Campbell CS300) installed at each site was collected on a logger (Tiny-Tag RE-ED) to provide daily total incident radiation data.

Acknowledgements

The authors would like to than the following people for making this program possible: Tony Bambridge (B&C Farming Ltd, McCain grower); Philip Bradshaw (Potato Council Ltd); Philip Burgess (Co-operative Farms); James Daw (Tame Valley Potatoes, McCain grower); Graeme Ditty (Tame Valley Potatoes); David Nelson (Branston Ltd.); Jack Smith (Co-operative Farms); Charlotte Smith (Branston Ltd.); Andrew Spinks (B&C Farming Ltd); Mark Taplin (Tame Valley Potatoes); Tim Westgarth (Westgarth Farms, Cockerill grower). Thanks are also due to the technical staff at CUF and PepsiCo UK field staff.

Results and Discussion

Sites and monitored crops

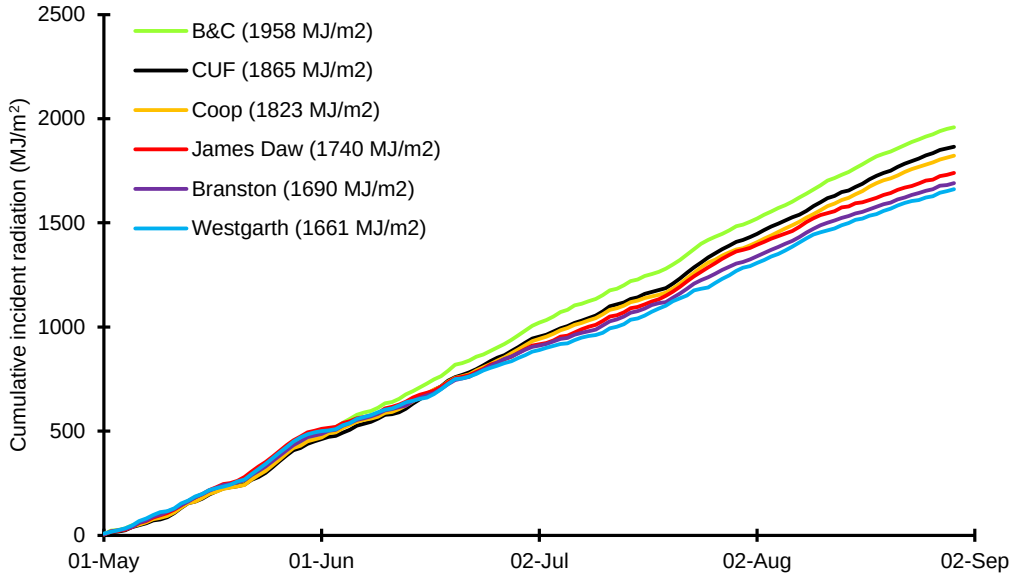
In 2012, a total of 30 crops were monitored and key details for these crops are shown in Table 1. For some crops the 'standard' crop was used for comparisons against crops grown with modified seed or modified N rates.

Table 8. Summary of crops monitored as part of PCL/CUF grower collaboration program in 2012

Grower group	Sector	Varieties in program	Number of seed rate comparisons	Number of N rate comparisons
McCain (James Daw, TVP)	Processing	Russet Burbank	2	0
McCain (James Daw, TVP)	Processing	Markies	2	0
McCain (B&C Farming)	Processing	Russet Burbank	12	0
Co-operative Farms	Fresh	Harmony	2	2
Co-operative Farms	Fresh	Melody	0	2
Branston Ltd.	Fresh	Estima	2	0
Branston Ltd.	Fresh	Piccolo Star	4	0
R S Cockerill Ltd (Westgarth)	Processing	VR808	2	2

Cumulative (May to August) incident radiation for CUF and seven grower collaboration sites is shown in Figure 1. Missing data (caused by the logger overwriting previous records or not logging by 1 May) were replaced with data from the nearest available sites. Cumulative, May to August total incident radiation at CUF in 2012 was 1865 MJ/m^2. For comparison, total incident radiation in 2008, 2009, 2010 and 2011 was 2005, 2135, 2122 and 2050 MJ/m^2, respectively, and therefore radiation receipts in 2012 were substantially less than in previous seasons. In 2012, the difference between the brightest Grower Collaboration site (B&C Farming, Marsham, Norfolk) and the dullest (Tim Westgarth, County Durham) was 297 MJ/m^2 The variation in incident radiation was unlikely to have had much effect on yield potential since the rate of crop establishment, canopy expansion and persistence tend to have much larger effects on yield.

Figure 31. Cumulative incident radiation May-August 2012 at Cambridge and collaboration sites.



McCain Ltd

McCain Ltd joined the grower collaboration program in 2011 and nominated two host growers (B&C Farming Ltd, Norfolk and James Daw of Tame Valley Potatoes, Staffordshire). The main objective of work in the first year of the program was to test new seed rate recommendations for Russet Burbank that had been derived from recent work at CUF (Potato Council Project R296). At B&C Farming Ltd comparisons were made between the standard McCain seed rate recommendation and a reduced (B&C) seed rate recommendation for four stocks of Russet Burbank. The seed rate comparisons with James Daw tested grower (standard) and CUF recommendations on one stock of Russet Burbank and one of Markies. Seed and cropping details for B&C Farming are given in Table 2 whilst those for James Daw are shown in Table 11. In all cases, the objective of the seed rate recommendation was, for a given target yield, to maximise the yield of potatoes > 90 mm in length and to keep the ware tuber count less than 61/10kg for tubers > 45 mm diameter.

Table 9. Details of seed and ware crops for comparison of McCain and B&C seed rates for Russet Burbank

Field name	Grove Farm 82	Fengate	Fengate	Fengate	Fengate	Medler Crow Hall
Seed crop						
Stock number	63197	63254	63207	63197	64512	63197
Seed size (mm)	30-35	30-35	30-35	30-35	30-35	30-35
Count (no./50 kg)	1826	1764	1892	1826	2101	1826
Seed emergence	-	-	-	-	-	-
Certification grade	SE2	SE2	SE2	SE2	-	SE2
Ware crop						
Intended yield (t/ha)	60	60	60	60	60	60
Intended planting	28 March	28 March	28 March	28 March	28 March	28 March
Intended plant populations (no./ha) and within row spacing (cm)						
McCain population	54945	53000	57800	54945	73260	54945
McCain spacing	19.9	20.6	18.9	19.9	14.9	19.9
Grower population	47090	46750	47460	47090	48500	47090
Grower spacing	23.2	23.0	23.0	23.2	22.5	23.2

B&C Farming Ltd, Norfolk, Russet Burbank (63197), Grove Farm 82

Crops with the B&C Farming and McCain spacings were planted on 3 April and both comparisons achieved 50 % plant emergence on the 21 May (48 days after planting, DAP). The 63197 stock was also planted in Fengate and Medler Crow Hall fields. The effect of the different plant spacings on ground cover development was not recorded. A final yield

sample was taken on 8 October (140 days after emergence, DAE). The achieved plant spacing in the B&C area was slightly larger than planned whereas in the McCain area, the population was smaller than planned and, in consequence, the plant populations differed less than originally intended (Figure 32). The total (> 10 mm) yield in the B&C area was 69.9 t/ha compared with 72.5 t/ha in crop planted with the McCain spacing. The proportion of yield > 90 mm length was 60 and 68 % in the B&C and McCain areas, respectively. For both the B&C and McCain crops the tuber count was < 61 tubers/10 kg

Figure 32. McCain, B&C Farming Ltd, Russet Burbank (stock 63197) seed comparison, Grove Farm 82

Grower:	B&C Farming	B&C Farming
Field name:	Grove Farm 82-63197	Grove Farm 82-63197
Unique ID:	BCF12012009	BCF12012010
Part Field Name:	Seed B&C N	Seed McCain
Variety:	Russet Burbank	Russet Burbank
Intended yield:	60 t/ha	60 t/ha
Intended use:	French-fries	French-fries
Planting date (start):	3 Apr	3 Apr
Date of 50 % emergence:	21 May	21 May
Total N applied:	240 kg N/ha	240 kg N/ha
Seed size:	30-35 mm	30-35 mm
Seed count:	1826 per 50 kg	1826 per 50 kg
Planned density:	47.1 000/ha	54.9 000/ha
Planned spacing:	23.2 cm	19.9 cm
Achieved density:	48.3 000/ha	51.9 000/ha
Achieved spacing:	22.6 cm	21.1 cm

Yield Samples (S.E. in italics)

		Seed B&C N	Seed McCain
		8 Oct	8 Oct
Plants (000/ha)		48.3	51.9
		2.73	*0.91*
Stems (000/ha)		128.5	110.3
		14.30	*4.79*
Stems/plant		2.7	2.1
		0.46	*0.12*
Tubers (000/ha)	> 10 mm	532	512
		45.2	*13.7*
Tuber yield (t/ha)	> 10 mm	69.9	72.5
		6.02	*2.21*
Tuber yield (t/ha)	> 45 mm	60.3	62.1
		6.39	*3.26*
Tuber yield (%)	> 90 mm	60	68
		2.6	*4.4*
DM (%)		22.4	23.9
		0.53	*0.76*
Mean tuber size (mm)		53.7	55.5
		0.96	*1.30*
Count (No/10kg)	> 45 mm	57	50
		1.4	*3.5*

B&C Farming Ltd, Norfolk, Russet Burbank (63254), Fengate

Stock 63254 was planted in Fengate field on 30 March and crops planted at the B&C and McCain spacings emerged on 18 May (49 DAP). For both crops the achieved plant spacing was greater than that intended (Figure 33). The crop was sampled on 8 October (143 DAE) and total tuber yields were 58 t/ha in the B&C area and 62 t/ha in the McCain. Whilst yields in the McCain area were numerically larger than those in the B&C area due to the relatively large standard errors associated with the mean yield the differences are unlikely to be statically significant. Numerically, the proportion of yield > 90 mm in length was larger in crops grown with the McCain spacing than the B&C spacing, but the difference was small and the tuber counts for the B&C and McCain crops were within acceptable limits.

B&C Farming Ltd, Norfolk, Russet Burbank (63207), Fengate

The B&C and McCain areas of stock 63207 were planted in Fengate field on 30 March and both seed rate comparisons attained 50 % plant emergence on 18 May (49 DAP). For both seed rate comparisons the achieved plant populations were less than originally intended (Figure 34) and the achieved plant population of the B&C crop was *c*. 13 % less than that of the McCain crop. The crops were sampled on 8 October (143 DAP). Despite having a smaller plant population, the B&C area had a larger stem and total tuber population and this was primarily due to the B&C crop producing more stems per seed tuber than the McCain crop (2.7 compared with 2.1, respectively). Numerically, the total tuber yield in the B&C area was larger than in the McCain area but this difference was small. Conversely, ware yields (> 45 mm) were slightly larger in the crop grown with the intended McCain spacing.

B&C Farming, Norfolk, Russet Burbank (63197), Fengate

Seed stock 63197 was planted at Grove Farm 82 and in Medler Crow Hall. The comparisons in Fengate were planted on 30 March and both the B&C and McCain area were at 50 % plant emergence on *c*. 18 May (49 DAP). Whilst the intended B&C plant population was meant to be 14 % smaller than in the McCain crop the achieved plant spacing differed by only 3 % and, numerically, the achieved B&C plant population was larger than the McCain population (Figure 35). The comparisons were sampled on 8 October (143 DAE). Due to the similarity in plant populations, stem and total tuber population did not differ much between the B&C and McCain areas. Total and ware (> 45 mm) averaged 58.9 and 41.6 t/ha respectively and yields did not vary much between the B&C and McCain areas. Both the B&C and McCain crops had similar tuber counts and had similar percentage of the total yield > 90 mm in length.

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Figure 33. McCain, B&C Farming Ltd, Russet Burbank (stock 63254) seed comparison, Fengate

Grower:	B&C Farming	B&C Farming
Field name:	Fengate-63254	Fengate-63254
Unique ID:	BCF12012011	BCF12012012
Part Field Name:	Seed B&C	Seed McCain
Variety:	Russet Burbank	Russet Burbank
Intended yield:	60 t/ha	60 t/ha
Intended use:	French-fries	French-fries
Planting date (start):	30 Mar	30 Mar
Date of 50 % emergence:	18 May	18 May
Total N applied:	240 kg N/ha	240 kg N/ha
Seed size:	30-35 mm	30-35 mm
Seed count:	1764 per 50 kg	1764 per 50 kg
Planned density:	46.8 000/ha	53.0 000/ha
Planned spacing:	23.4 cm	20.6 cm
Achieved density:	42.8 000/ha	45.6 000/ha
Achieved spacing:	25.5 cm	24.0 cm

Yield Samples (S.E. in italics)

		Seed B&C 8 Oct	Seed McCain 8 Oct
Plants (000/ha)		42.8	45.6
		4.31	*2.35*
Stems (000/ha)		95.7	136.7
		8.60	*5.67*
Stems/plant		2.2	3.0
		0.09	*0.12*
Tubers (000/ha)	> 10 mm	451	504
		18.8	*20.9*
Tuber yield (t/ha)	> 10 mm	57.6	62.1
		3.65	*1.93*
Tuber yield (t/ha)	> 45 mm	44.4	46.6
		3.24	*3.41*
Tuber yield (%)	> 90 mm	67	73
		3.6	*2.9*
DM (%)		23.6	24.4
		0.30	*0.64*
Mean tuber size (mm)		52.3	50.9
		0.80	*0.89*
Count (No/10kg)	> 45 mm	53	55
		1.7	*2.4*

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Figure 34. McCain, B&C Farming Ltd, Russet Burbank (stock 63207) seed comparison, Fengate

Grower:	B&C Farming	B&C Farming
Field name:	Fengate-63207	Fengate-63207
Unique ID:	BCF12012013	BCF12012014
Part Field Name:	Seed B&C	Seed McCain
Variety:	Russet Burbank	Russet Burbank
Intended yield:	60 t/ha	60 t/ha
Intended use:	French-fries	French-fries
Planting date (start):	30 Mar	30 Mar
Date of 50 % emergence:	18 May	18 May
Total N applied:	240 kg N/ha	240 kg N/ha
Seed size:	30-35 mm	30-35 mm
Seed count:	1892 per 50 kg	1892 per 50 kg
Planned density:	47.5 000/ha	57.8 000/ha
Planned spacing:	23.0 cm	18.9 cm
Achieved density:	38.3 000/ha	42.8 000/ha
Achieved spacing:	28.6 cm	25.5 cm

Yield Samples (S.E. in italics)

		Seed B&C 8 Oct	Seed McCain 8 Oct
Plants (000/ha)		38.3	42.8
		4.34	*3.45*
Stems (000/ha)		104.8	88.4
		12.75	*9.34*
Stems/plant		2.7	2.1
		0.17	*0.17*
Tubers (000/ha)	> 10 mm	459	424
		37.7	*39.2*
Tuber yield (t/ha)	> 10 mm	65.2	63.6
		1.99	*3.94*
Tuber yield (t/ha)	> 45 mm	51.5	52.3
		3.46	*5.47*
Tuber yield (%)	> 90 mm	80	78
		1.5	*5.2*
DM (%)		24.6	24.9
		0.43	*0.46*
Mean tuber size (mm)		52.2	52.7
		1.58	*1.37*
Count (No/10kg)	> 45 mm	49	50
		3.1	*4.8*

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Figure 35. McCain, B&C Farming Ltd, Russet Burbank (stock 63197) seed comparison, Fengate

Grower:	B&C Farming	B&C Farming
Field name:	Fengate-63197	Fengate-63197
Unique ID:	BCF12012015	BCF12012016
Part Field Name:	Seed B&C	Seed McCain
Variety:	Russet Burbank	Russet Burbank
Intended yield:	60 t/ha	60 t/ha
Intended use:	French-fries	French-fries
Planting date (start):	30 Mar	30 Mar
Date of 50 % emergence:	18 May	18 May
Total N applied:	240 kg N/ha	240 kg N/ha
Seed size:	30-35 mm	30-35 mm
Seed count:	1826 per 50 kg	1826 per 50 kg
Planned density:	47.1 000/ha	54.9 000/ha
Planned spacing:	23.2 cm	19.9 cm
Achieved density:	50.1 000/ha	51.9 000/ha
Achieved spacing:	21.8 cm	21.1 cm

Yield Samples (S.E. in italics)

		Seed B&C 8 Oct	Seed McCain 8 Oct
Plants (000/ha)		50.1	51.9
		2.29	*2.73*
Stems (000/ha)		133.1	134.0
		15.57	*14.38*
Stems/plant		2.6	2.6
		0.26	*0.24*
Tubers (000/ha)	> 10 mm	527	508
		7.9	*34.6*
Tuber yield (t/ha)	> 10 mm	59.4	58.3
		3.47	*2.89*
Tuber yield (t/ha)	> 45 mm	42.8	40.3
		4.80	*2.57*
Tuber yield (%)	> 90 mm	66	68
		3.9	*2.0*
DM (%)		25.0	26.3
		0.58	*0.35*
Mean tuber size (mm)		49.7	48.7
		1.20	*0.57*
Count (No/10kg)	> 45 mm	58	58
		3.2	*1.6*

B&C Farming Ltd, Norfolk, Russet Burbank (64512), Fengate

The 64512 stock of Russet Burbank planted in Fengate had a large seed count (2101/50 kg) and there was a large difference between the intended B&C and McCain population (48 500 and 73 300/ha, respectively). For the B&C crop, the achieved plant population was larger than intended whereas for the McCain crop the achieved population was smaller than intended (Figure 36). Despite this the B&C plant population was 26 % smaller than the McCain population. The comparisons were planted on 30 March and both were at 50 % plant emergence on 18 May (49 DAP). The B&C and McCain areas were sampled 143 DAE on 8 October. Stem populations in the B&C and McCain areas averaged 117 000 and 163 000/ha, respectively and there were large differences in total tuber population. The crop planted using the McCain spacing had a total yield of 64.0 t/ha compared with 59.5 t/ha in the B&C area. However, due to the reduction in tuber population the yield > 45 mm was numerically larger in the B&C area than in the McCain area (49.0 compared with 44.6 t/ha). The B&C crop had a larger percentage yield > 90 mm length and a smaller tuber count than the McCain crop.

B&C Farming Ltd., Norfolk, Russet Burbank (63197), Medler Crow Hall

The seed rate comparisons in Medler Crow Hall used the same stock of Russet Burbank seed as grown in Grove Farm 82 and Fengate. The comparisons were planted on 16 April and 50 % plant emergence was achieved 35 days later on 21 May (Figure 37). For the crop planted using the B&C spacing the achieved plant population was slightly more than that intended whilst for the area planted with the McCain spacing the achieved plant population was similar to that intended. Overall, the achieved B&C plant population was *c*. 8 % smaller than the crop grow using the McCain plant population. The comparisons were sampled on 8 October (140 DAE) and the McCain crop had a larger stem and tuber (> 10 mm) population than the B&C crop. Numerically, the total tuber yield in the B&C area was slightly less than that in the McCain area (57.4 compared with 61.4 t/ha) but these mean yields are unlikely to be significantly different. Ware yield (> 45 mm) in the B&C and McCain areas were 40.5 and 43.6 t/ha, respectively, but again these differences are unlikely to differ significantly. As a consequence of the smaller tuber population the B&C crop had a larger percentage of its yield > 90 mm in length and it also had a smaller tuber count.

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Figure 36. McCain, B&C Farming Ltd, Russet Burbank (stock 64512) seed comparison, Fengate

Grower:	B&C Farming	B&C Farming
Field name:	Fengate-64512	Fengate-64512
Unique ID:	BCF12012017	BCF12012018
Part Field Name:	Seed B&C	Seed McCain
Variety:	Russet Burbank	Russet Burbank
Intended yield:	60 t/ha	60 t/ha
Intended use:	French-fries	French-fries
Planting date (start):	30 Mar	30 Mar
Date of 50 % emergence:	18 May	18 May
Total N applied:	240 kg N/ha	240 kg N/ha
Seed size:	30-35 mm	30-35 mm
Seed count:	2101 per 50 kg	2101 per 50 kg
Planned density:	48.5 000/ha	73.3 000/ha
Planned spacing:	22.5 cm	14.9 cm
Achieved density:	51.9 000/ha	70.2 000/ha
Achieved spacing:	21.1 cm	15.6 cm

Yield Samples (S.E. in italics)

		Seed B&C 8 Oct	Seed McCain 8 Oct
Plants (000/ha)		51.9	70.2
		3.11	*6.72*
Stems (000/ha)		116.7	163.1
		5.37	*8.98*
Stems/plant		2.3	2.4
		0.14	*0.17*
Tubers (000/ha)	> 10 mm	460	621
		24.1	*40.8*
Tuber yield (t/ha)	> 10 mm	59.5	64.0
		2.95	*3.52*
Tuber yield (t/ha)	> 45 mm	49.0	44.6
		3.41	*3.40*
Tuber yield (%)	> 90 mm	71	59
		2.3	*5.3*
DM (%)		24.5	25.4
		0.42	*0.77*
Mean tuber size (mm)		53.0	49.0
		0.40	*0.42*
Count (No/10kg)	> 45 mm	54	61
		1.0	*1.8*

Figure 37. McCain, B&C Farming Ltd, Russet Burbank (stock 63197) seed comparison, Medler Crow Hall

Grower:	B&C Farming	B&C Farming
Field name:	Medler Crow Hall-63197	Medler Crow Hall-63197
Unique ID:	BCF12012323	BCF12012324
Part Field Name:	Seed B&C	Seed McCain
Variety:	Russet Burbank	Russet Burbank
Intended yield:	60 t/ha	60 t/ha
Intended use:	French-fries	French-fries
Planting date (start):	16 Apr	16 Apr
Date of 50 % emergence:	21 May	24 May
Total N applied:	240 kg N/ha	240 kg N/ha
Seed size:	30-35 mm	30-35 mm
Seed count:	1826 per 50 kg	1826 per 50 kg
Planned density:	47.1 000/ha	54.9 000/ha
Planned spacing:	23.2 cm	19.9 cm
Achieved density:	50.1 000/ha	54.7 000/ha
Achieved spacing:	21.8 cm	20.0 cm

Yield Samples (S.E. in italics)

		Seed B&C	Seed McCain
		8 Oct	8 Oct
Plants (000/ha)		50.1	54.7
		2.29	*1.49*
Stems (000/ha)		126.7	150.4
		10.46	*18.91*
Stems/plant		2.5	2.8
		0.19	*0.43*
Tubers (000/ha)	> 10 mm	573	610
		28.4	*33.5*
Tuber yield (t/ha)	> 10 mm	57.4	61.4
		2.12	*4.55*
Tuber yield (t/ha)	> 45 mm	40.5	43.6
		3.00	*3.70*
Tuber yield (%)	> 90 mm	46	43
		7.2	*5.3*
DM (%)		25.2	24.2
		0.50	*0.41*
Mean tuber size (mm)		49.7	49.8
		0.96	*0.45*
Count (No/10kg)	> 45 mm	61	64
		5.6	*4.4*

Summary of effects of B&C and McCain spacings on total and ware yield

When averaged over all comparisons the achieved plant population in the B&C crops was 46 900/ha compared with 52 900/ha for the McCain crops (Table 10). The B&C crops had a smaller stem and total tuber population than the McCain crops and the total yield was also 2.2 t/ha smaller. However, ware yield (> 45 mm and > 90 mm) and tuber count were almost identical. These data suggest that reducing seed rates from McCain recommended to those used in practice by B&C Farming has no deleterious effect on marketable yield.

Table 10. Average effect of using B&C or McCain plant population on stem and tuber population, total and ware yield and tuber dry matter concentration

	B&C Farming		McCain	
	Mean (n=24)	S.E. (n=24)	Mean (n=24)	S.E. (n=24)
Achieved plant population (000/ha)	46.9	1.56	52.9	2.22
Stem population (000/ha)	118	5.1	130	6.6
Tuber population > 10 mm (000/ha)	500	14.4	530	18.2
Tuber yield > 10 mm (t/ha)	61.5	1.61	63.7	1.50
Tuber yield > 45 mm (t/ha)	48.1	2.05	48.2	2.02
Tuber yield > 90 mm long (% of total)	65	2.6	65	2.8
Tuber count > 45 mm (No/10 kg)	55	1.4	56	1.6
Tuber DM concentration (%)	24.2	0.26	24.9	0.27

James Daw, Tame Valley Potatoes

In 2012, the work with James Daw (who as part of Tame Valley Potatoes grows for McCain) concentrated on testing standard and reduced seed rates for crops of Russet Burbank and Markies. Seed and cropping details for these crops are shown in Table 11.

Table 11. Details of seed and ware crops for comparison of Tame Valley Potatoes and CUF seed rates for Russet Burbank and Markies.

Field name	Green Lane	Green Lane
Variety	Russet Burbank	Markies
Seed crop		
Stock number	63199	65693
Seed size (mm)	35-45	35-45
Count (no./50 kg)	940	747
Seed emergence	7 June 2011	30 May 2011
Certification grade	SE2	SE2
Ware crop		
Intended yield (t/ha)	50	50
Intended planting		
Intended plant populations (no./ha) and within row spacing (cm)		
McCain population	32165	29557
McCain spacing	34.0	37.0
CUF population	26352	24855
CUF spacing	41.5	44.0

James Daw, Staffordshire, Markies, Green Lane

The comparisons of Markies seed rates were planted on 4 May in Green Lane field, near Barton Under Needwood, Staffordshire. Fifty per cent plant emergence was recorded on 4 June (31 DAP) for the standard crop and 5 June for the crop grown at the reduced seed rate (Figure 38). For both the standard and modified seed rate crops, the achieved plant population was similar to that planned and the comparisons tested an achieved plant population of 31 000/ha (standard crop) with 25 500/ha (modified crop). Initial ground cover expansion in the modified crop was slightly slower than in the standard crop and this is probably due to the reduced plant population. The canopies of both the standard and modified seed rate crops had similar persistence but whilst the canopy of the standard crop got to 100 % ground cover this was not the case in the modified crop.

The crops were sampled on two occasions, 31 July (57 DAE) and 10 October (128 DAE). When averaged over both harvests the stem populations in standard and modified areas were 106 000 and 82 000/ha, respectively. The average difference in total (> 10 mm) tuber

population between the standard and modified crops was 354 000/ha and 313 000/ha but at the second sampling on 10 October the standard crop had a numerically larger tuber population. The total yield at the first sampling was 21.6 t/ha in the standard crop compared with 23.5 t/ha in the crop grown with the reduced seed rate. At the second sampling the total yield in the standard area had increased to 43.1 t/ha whereas in the modified seed rate area it had increased to 54.4 t/ha. This large numeric difference in total yield between the two areas was not expected and is not consistent with the observed differences in ground cover. The proportion of tubers > 90 mm was numerically larger in the crop grown with the reduced seed rate but the difference was relatively small when compared with standard errors. The tuber count for both the standard and modified seed rate crops was within acceptable limits.

James Daw, Staffordshire, Russet Burbank, Green Lane

The Russet Burbank seed rate comparisons were also grown in Green Land field. The comparisons were planted on 4 May and the standard and reduced population crops both reached 50 % plant emergence on 31 May (27 DAP). For the standard crop, the achieved plant population was 33 700/ha compared with 26 900/ha for the crop grown at the modified plant spacing. For both the standard and modified crops the achieved plant density was similar to that intended (Figure 39). Initial ground cover development was similar for both comparisons and both crops attained complete ground cover. The canopy of the crop grown at the reduced seed rate was slightly more persistent than the standard crop. Both crops were sampled on the 31 July and 10 October (61 and 13 DAE, respectively). When averaged over both sampling, the standard crop had a larger stem population than the modified crop (175 300 compared with 162 900/ha) however the tuber population > 10 mm were similar for both seed rates (480 000/ha compared with 473 000/ha). The total tuber yield of the standard and modified crops was 41.4 and 46.4 t/ha, respectively and whilst the yield of the reduced seed rate crop was numerically larger, the yield difference is probably not real. Numerically, the percentage of the total yield > 90 mm long was larger in the crop grown at the reduced seed rate but the tuber counts for both crops were very similar and averaged 67 tubers/10 kg.

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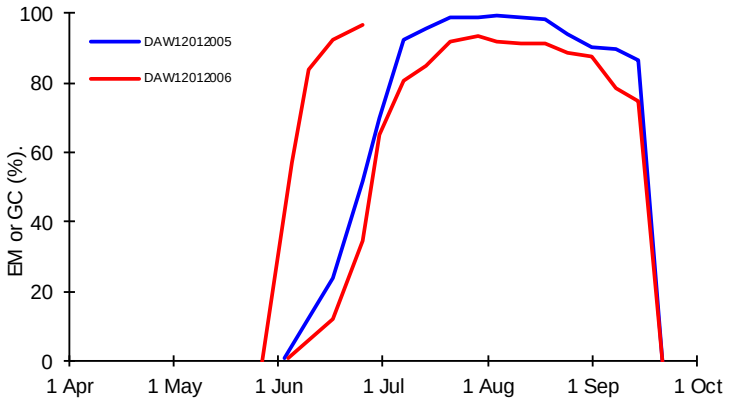
Figure 38. McCain, James Daw, Markies seed rate comparison

Grower:	James Daw	James Daw
Field name:	Green Lane	Green Lane
Unique ID:	DAW12012005	DAW12012006
Part Field Name:	Seed & N standard	Seed modified & N standard
Variety:	Markies	Markies
Intended yield:	50 t/ha	50 t/ha
Intended use:	French-fries	French-fries
Planting date (start):	4 May	4 May
Date of 50 % emergence:	4 Jun	5 Jun
Total N applied:	180 kg N/ha	180 kg N/ha
Seed size:	35-45 mm	35-45 mm
Seed count:	747 per 50 kg	747 per 50 kg
Planned density:	29.6 000/ha	24.9 000/ha
Planned spacing:	37 cm	44 cm
Achieved density:	31.0 000/ha	25.5 000/ha
Achieved spacing:	35.3 cm	42.9 cm



Yield Samples (S.E. in italics)

		Seed & N standard			Seed modified & N standard		
		31 Jul		10 Oct	31 Jul		10 Oct
Plants (000/ha)		32.8		29.2	25.5		25.5
		1.49		*1.49*	*0.00*		*0.00*
Stems (000/ha)		112.1		100.2	83.8		80.2
		19.88		*13.10*	*11.04*		*4.46*
Stems/plant		3.4		3.4	3.3		3.1
		0.60		*0.31*	*0.43*		*0.17*
Tubers (000/ha)	> 10 mm	393	> 10 mm	314	298	> 10 mm	327
		25.1		*26.9*	*18.1*		*13.8*
Tuber yield (t/ha)	> 10 mm	21.6	> 10 mm	43.1	23.5	> 10 mm	54.4
		1.41		*1.84*	*0.32*		*3.85*
Tuber yield (t/ha)	> 45 mm	6.3	> 45 mm	36.0	13.0	> 45 mm	50.1
		2.19		*2.51*	*1.14*		*4.23*
Tuber yield (%)	> 90 mm	0.0	> 90 mm	63.5	0.0	> 90 mm	66.9
		0.00		*8.39*	*0.0*		*4.84*
DM (%)		18.7		23.5	17.4		24.3
		0.39		*0.70*	*0.38*		*0.54*
Mean tuber size (mm)		40.9		53.9	46.0		57.3
		1.59		*1.32*	*0.83*		*1.57*
Count (No/10kg)	> 45 mm	89		56	71		50
		1.8		4.9	*1.9*		*4.9*

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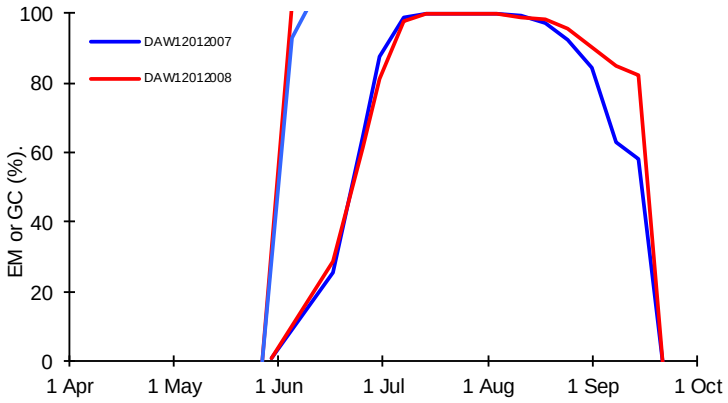
Figure 39. McCain, James Daw, Russet Burbank seed rate comparison

Grower:	James Daw	James Daw
Field name:	Green Lane	Green Lane
Unique ID:	DAW12012007	DAW12012008
Part Field Name:	Seed & N standard	Seed modified & N standard
Variety:	Russet Burbank	Russet Burbank
Intended yield:	50 t/ha	50 t/ha
Intended use:	French-fries	French-fries
Planting date (start):	4 May	4 May
Date of 50 % emergence:	31 May	31 May
Total N applied:	200 kg N/ha	200 kg N/ha
Seed size:	35-45 mm	35-45 mm
Seed count:	940 per 50 kg	940 per 50 kg
Planned density:	32.2 000/ha	26.4 000/ha
Planned spacing:	34.0 cm	41.5 cm
Achieved density:	33.7 000/ha	26.9 000/ha
Achieved spacing:	32.4 cm	40.7 cm



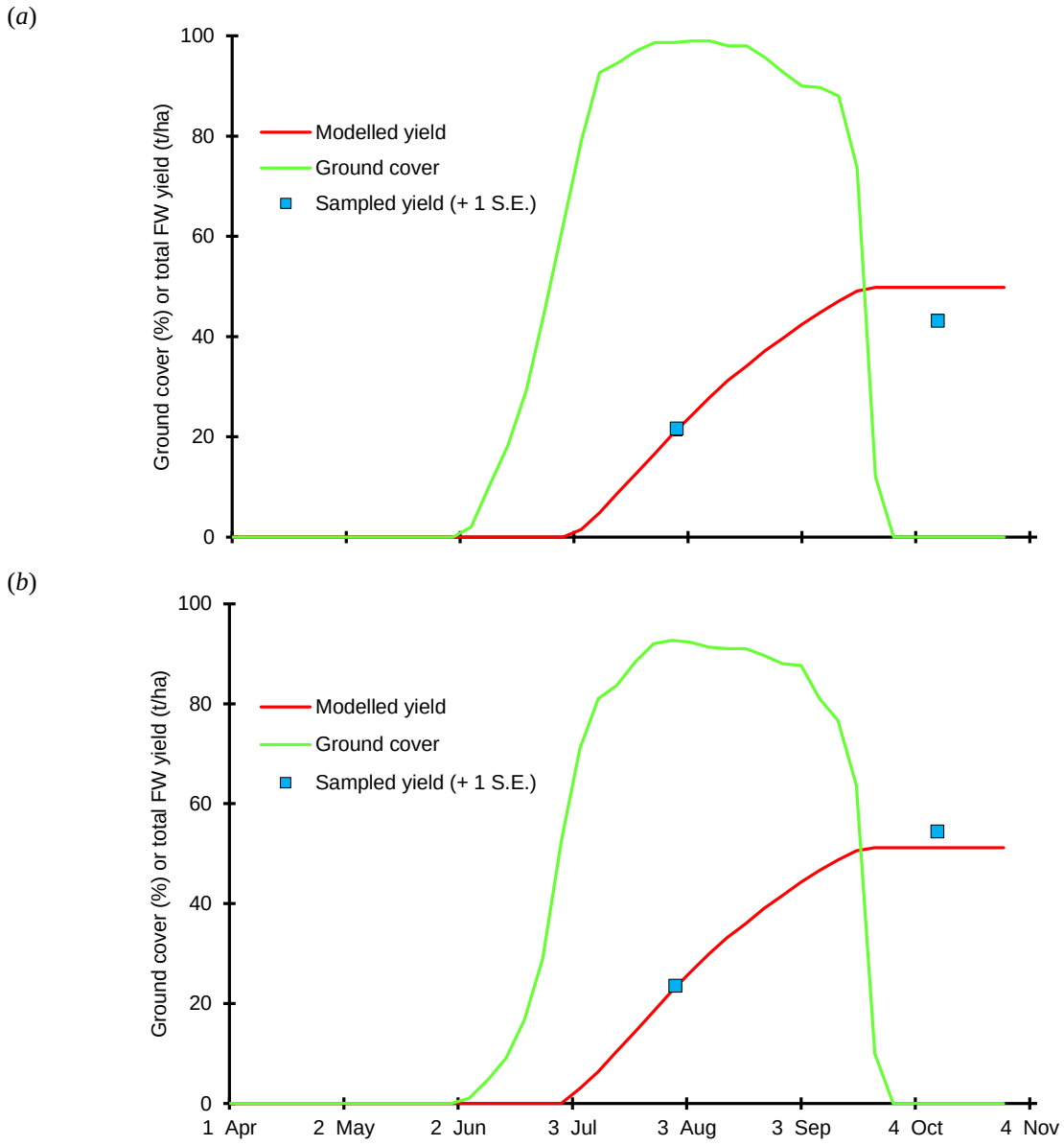
Yield Samples (S.E. in italics)

		Seed & N standard			Seed modified & N standard		
		31 Jul		10 Oct	31 Jul		10 Oct
Plants (000/ha)		32.8		34.6	26.4		27.3
		0.00		*1.05*	*0.91*		*1.05*
Stems (000/ha)		99.3		131.2	82.0		157.7
		11.47		*6.31*	*6.23*		*9.69*
Stems/plant		3.0		3.8	3.1		5.8
		0.35		*0.30*	*0.15*		*0.24*
Tubers (000/ha)	> 10 mm	511	> 10 mm	449	489	> 10 mm	457
		19.8		*27.3*	*13.6*		*26.2*
Tuber yield (t/ha)	> 10 mm	22.0	> 10 mm	41.4	24.6	> 10 mm	46.4
		0.45		*1.30*	*1.22*		*2.26*
Tuber yield (t/ha)	> 45 mm	2.6	> 45 mm	24.3	3.5	> 45 mm	30.9
		0.86		*2.32*	*1.46*		*2.59*
Tuber yield (%)	> 90 mm	0	> 90 mm	49	0	> 90 mm	64.5
		0.0		*9.80*	*0.0*		*5.20*
DM (%)		19.2		25.8	19.2		25.6
		0.14		*1.30*	*0.14*		*0.20*
Mean tuber size (mm)		37.7		47.2	38.2		48.4
		0.82		*1.30*	*1.07*		*0.87*
Count (No/10kg)	> 45 mm	95		68	89		66
		0.9		4.2	*1.4*		*4.2*

Analysis of James Daw crop performance using the CUF yield model

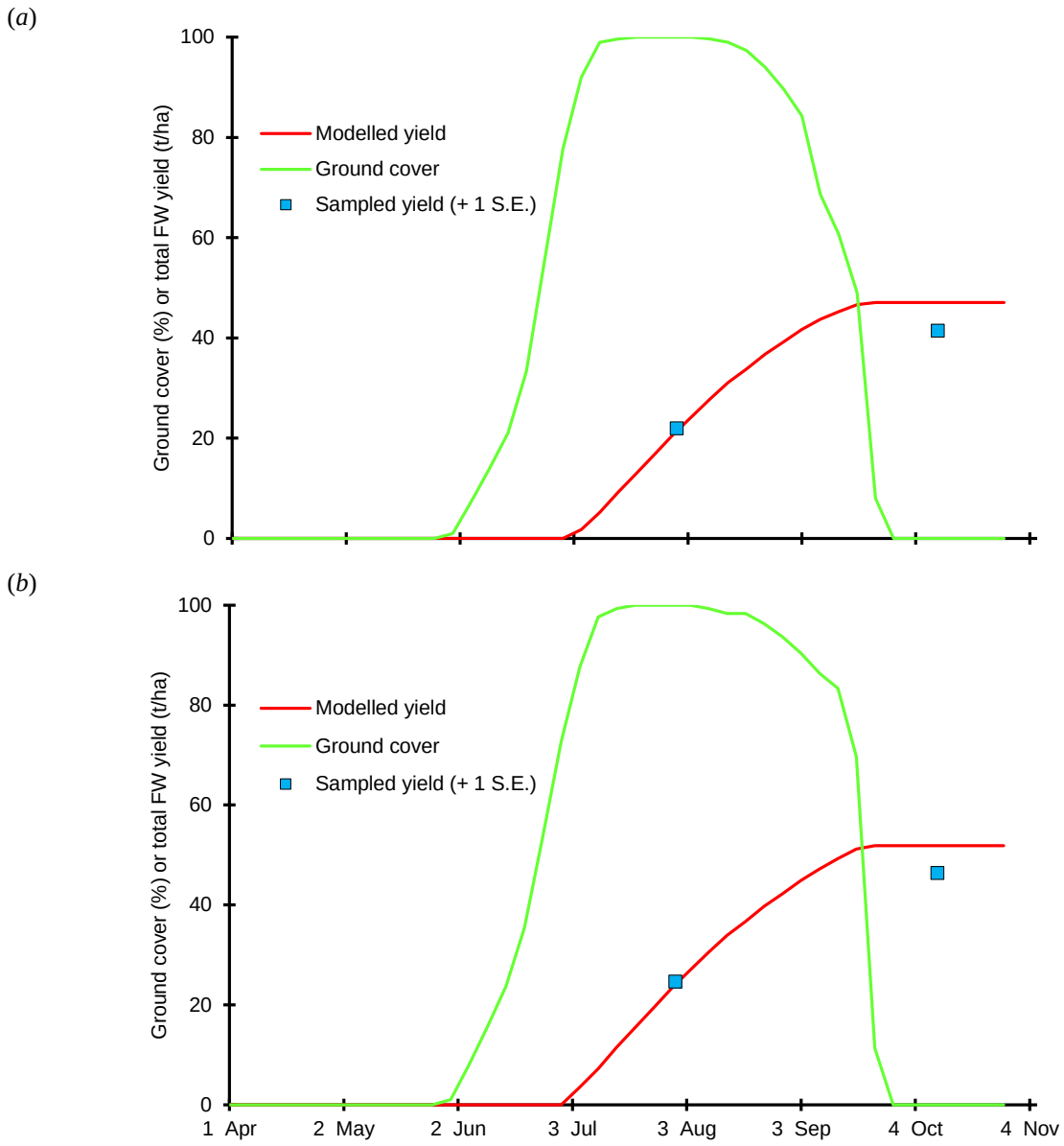
The performance of standard and reduced seed rate Markies and Russet Burbank crops was analysed using the CUF yield model. Based on the observed ground cover curves and daily incident radiation the yield model predicted yields of 50 and 51 t/ha for the Markies crops grown at the standard and reduced seed rates, respectively, (Figure 40). Thus, based on model yields there was little difference in total yields between the seed rate comparisons and the hand-sampled yields taken in October may have underestimated the yield of the standard crop and overestimated the yield of the reduced seed-rate crop.

Figure 40. Comparison of modelled yield and sampled yield for (*a*) Green Lane, Markies standard crop and (*b*) Green Lane, Markies reduced seed rate crop.



For the standard Russet Burbank, the model calculated that a yield of 47 t/ha was achievable compared with 52 t/ha in the crop grown at the reduced seed rate. Whilst, for both crops the model overestimated the sample yield the model output indicated the relative difference in sample yields between the standard and modified crop may be genuine and was a consequence of the slightly more persistent canopy of the modified crop.

Figure 41. Comparison of modelled yield and sampled yield for (*a*) Green Lane, Russet Burbank standard crop and (*b*) Green Lane, Russet Burbank reduced seed rate crop.



Internal Defects in Russet Burbank and Markies

Once grading, yield assessments and tuber dry matter measurements were complete all remaining tubers > 90 mm in length were first assessed for the presence of misshapes and then for internal defects (internal rust spot and hollow heart) by cutting each tuber in half along the long-axis and scoring the severity of any defects. On average, 84 tubers were assessed from each replicate of each treatment. The data for the B&C Russet Burbank and James Daw's Markies and Russet Burbank are given in Table 12. On average c. 3 % of Russet Burbank tubers were misshapen, with more misshapes (7 %) being found in stock 63197 grown at Medler Crow Hall. Stock 63197 was also grown at Grove Farm 82 and Fengate where the incidence of misshapes averaged 2 %. There was no evidence that the proportion of misshapes was affected by reducing the plant population. Overall, 72 % of tubers were free of any internal defect (range 57-86 %). For the standard and reduced seed rate crops, the average percentages of internal defect free tubers was 74 and 69, respectively. An average of 10 % of tuber showed moderate to severe IRS. On average hollow heart was not very common with *c.*1 % of all tuber showing some symptoms. The incidence of internal rust spot and hollow heart did not seem to be affected by plant population. Internal arcs typical of those found in Tobacco Rattle Virus affected tubers were found in Russet Burbank crops grown at Green Lane (James Daw) and at Medler Crow Hall (B&C Farming).

Table 12. Severity of internal rust spot (IRS) and hollow heart (HH) found within Russet Burbank and Markies crops grown by B&C Farming, Norfolk and James Daw, Staffordshire. All values as percentages

Coding	Variety	Stock number	Achieved plant population (000/ha)	Field name	Misshapen (dolls etc.)	No internal defects	IRS slight speckling	IRS obvious staining 2-3 mm spots	IRS large 4-5 mm spots or multiple spots	HH first sign of hollow	HH hollow 5-10 mm	HH hollow > 10 mm
DAW12012005	Markies	65693	31.1	Green Lane	0	86	10	3	0	0	0	0
DAW12012006	Markies	65693	25.5	Green Lane	0	78	15	4	1	0	1	1
DAW12012007	Russet Burbank†	63199	33.7	Green Lane	7	76	7	9	3	0	0	0
DAW12012008	Russet Burbank	63199	26.9	Green Lane	5	66	11	17	5	0	0	0
BCF12012009	Russet Burbank	63197	48.3	Grove Farm 82	2	75	4	8	11	0	1	0
BCF12012010	Russet Burbank	63197	51.9	Grove Farm 82	4	68	5	8	14	0	3	2
BCF12012011	Russet Burbank	63254	42.8	Fengate	2	70	6	10	8	1	2	2
BCF12012012	Russet Burbank	63254	45.6	Fengate	2	71	5	5	17	1	2	0
BCF12012013	Russet Burbank	63207	38.3	Fengate	2	70	3	8	13	1	2	2
BCF12012014	Russet Burbank	63207	42.8	Fengate	2	75	2	9	4	2	5	3
BCF12012015	Russet Burbank	63197	50.1	Fengate	2	73	2	6	15	2	1	0
BCF12012016	Russet Burbank	63197	51.9	Fengate	1	65	4	10	17	1	2	1
BCF12012017	Russet Burbank	64512	51.9	Fengate	0	66	0	1	28	2	3	1
BCF12012018	Russet Burbank	64512	70.2	Fengate	2	77	0	3	17	1	1	0
BCF12012323	Russet Burbank†	63197	50.1	Medler Crow H.	8	57	6	26	4	2	0	1
BCF12012324	Russet Burbank	63197	54.7	Medler Crow H.	6	73	2	17	6	0	1	1

†Evidence of arcs from Tobacco Rattle Virus

RS Cockerill Ltd

Westgarth Farms, Van Rijn 808

R S Cockerill Ltd. joined the Grower Collaboration program in 2010. They are based in Dunnington, Yorkshire and a major component of their business is the supply of processing potatoes to Walkers Snack Foods. In 2012 work was concentrated on optimising the production of a new variety Van Rijn 808 (VR808) and this work was done with Tim Westgarth. Information about the seed, field and cropping plans were supplied by Mr Westgarth in spring 2012 and are summarised in Table 13. Examination of these details showed that the crop of crop of VR808 could be grown at a wider spacing (40.7 compared with 29.5 cm) and with a reduced input of N fertilizer (180 compared with 210 kg N/ha). Anecdotal information suggested that VR808 may respond to N applications in excess of the current recommendation of 210 kg N/ha and to test this an extra comparison was included that tested the effects of 240 kg N/ha on growth and yield. The standard crop of VR808 was also part of lager PepsiCo program designed to understand the effects of season and agronomy on crop performance, storage, processing quality and sustainable production. The data reported here were collected in collaboration with PepsiCo staff as part of this larger project.

Table 13. Field, seed and cropping details for VR808 grown by Tim Westgarth, County Durham in 2012

Variety	VR808
Field name	Richardson
Seed size (mm)	40-50
Seed count (no/50 kg)	725
Seed crop emergence date†	n.a.
Intended ware planting date	15 April 12
Intended ware yield (t/ha)	55
Intended market	Crisping
Intended defoliation date	25 August
Estimated season length (days)*	102
Soil type	Medium
Soil organic matter content	2-6 %
Previous crop	Cereal
Organic manure usage (type; amount)	Poultry manure; 5 t/ha
N from organic manures (kg N/ha)	60
Grower standard plant spacing (cm)	29.5
CUF modified plant spacing (cm)	40.7
Grower standard N application rate (kg N/ha)	210
CUF modified N application rate-1 (kg N/ha)	180
CUF modified N application rate-2 (kg N/ha)	240

†'Average' seed age assumed

*From ware crop emergence to defoliation

Seed rate comparisons

The crop of VR808 was planted on 25 May about 40 days later than originally planned reflecting the challenging meteorological conditions that prevailed for much of 2012. The interval between planting and 50 % plant emergence was about 26 (days) and was not greatly affected by planting density (Figure 42). For crops grown at both the standard and reduced seed rates the achieved spacing was slightly less than that intended but the achieved difference in plant population was still large enough to give valid comparisons. Ground cover expansion was slightly faster in the standard crop and this is consistent with the increased plant population in this comparison. Both the standard and reduced plant population crops achieved complete ground cover and both crops had started to senesce before they were defoliated on 24 September (giving a season length from emergence to defoliation of 96 days).

The first crop sampling was taken on 9 August (50 DAE). Total tuber yield was 15.8 t/ha in the crop grown at the standard spacing and 13.2 t/ha in the crop grown at the increased spacing. This difference in total yield is consistent with the slight delay in ground cover expansion. The standard and reduced seed-rate crops had total tuber populations of 531 and 420 000/ha, respectively. The second sampling was taken on 5 September (77 DAE) and

total tuber yield was 37.2 t/ha in the standard crop compared with 35.6 t/ha in crop grown at the reduced seed rate. However ware yield (> 40 mm) was very similar in both comparisons and averaged 30.9 t/ha. As a consequence of the smaller than anticipated yield (a result of late planting/emergence) the mean tuber size for both comparisons was smaller than that needed to maximise the proportion of marketable yield. However, despite having a slightly smaller total yield, the ware yield in the reduced seed rate was larger as a consequence of the reduced tuber population.

Reduced N rate comparison

Decreasing the N application rate from 210 to 180 kg N/ha had no effect on the interval between planting emergence which averaged about 26 days. The achieved plant populations in both areas were similar (averaging 36 500/ha) and were close to the intended plant populations 34 600/ha (Figure 43). Ground cover expansion in the reduced-N area was slightly slower than that in the standard-N area but the difference was small and may not have been due to the effect of N. Irrespective of N application rate, both areas achieved complete ground cover and both areas were defoliated at near-complete ground cover on 24 September. At the first sampling (9 August, 50 DAE), total tuber yield was numerically larger in the area grown with 180 kg N/ha but the difference in yield was small and averaged 16.3 t/ha. At the second sampling on 5 September (77 DAE), the average total yield had increased to 36.8 t/ha with the area that had received 210 kg N/ha having a numerically larger yield. The effect of N application on ware (> 40 mm) yield was very small (0.4 t/ha) and the average ware yield for the standard and reduced N rate areas of the field was 30.2 t/ha. At the first sampling, crops grown in both areas had similar tuber DM concentration but at the second sampling, increasing the N application rate from 180 to 210 kg N/ha was associated with a decrease in tuber DM from 24.3 to 23.3 %. Decreasing the N application rate by 30 kg N/ha had no effect on tuber population at either sampling.

Increased N rate comparison

The interval between planting and 50 % plant emergence was 26 days and was not affected by an increase in application rate from the standard 210 kg N/ha to 240 kg N/ha (Figure 44). The achieved plant population averaged 36 700/ha and differences between N treatments were small. The pattern of ground cover development for crops grown in both areas was nearly identical and both crops would have absorbed a similar amount of solar radiation. The total tuber yield at the first sampling on 9 August averaged 15.9 t/ha and there was very little difference between yields in the standard or increased-N areas. The second sampling was take at 77 DAE and total tuber yields in the standard and increased-N areas were 37.2

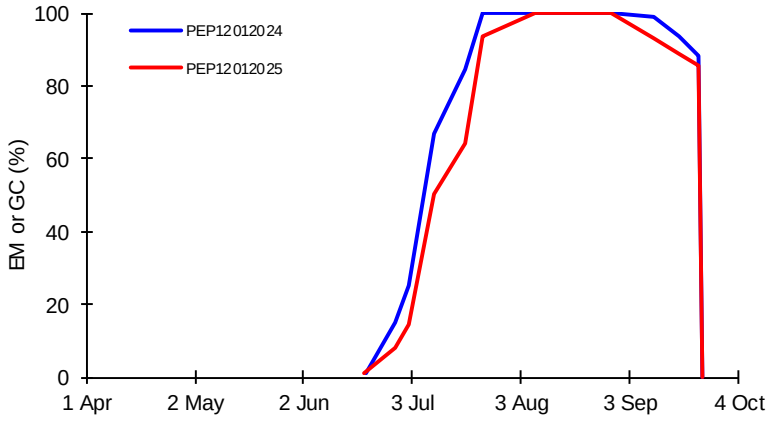
and 32.1 t/ha, respectively. Increasing the N application from 210 to 240 kg N/ha was associated with a reduction in tuber population and in consequence whilst increasing the N application rate reduced total yield by 5.1 t/ha the effect on ware yield was smaller (3.3 t/ha). Collectively, both N comparisons suggest that this crop was not N limited and an N application of 180 kg N/ha was adequate for a season length of 96 days. However, this conclusion should be tested in more 'average' seasons where the yield potential is not so limited by late plantings and crop emergence.

Report for 2012

Figure 42. RS Cockerill, Westgarth VR808 seed rate comparison

Grower:	Cockerills	Cockerills
Field name:	Richardson	Richardson
Unique ID:	PEP12012024	PEP12012025
Part Field Name:	Standard seed & N	Reduced seed & standard N
Variety:	VR808	VR808
Intended yield:	42 t/ha	42 t/ha
Intended use:	Crisping-Storage	Crisping-Storage

Planting date (start):	25 May	25 May
Date of 50 % emergence:	20 Jun	19 Jun
Total N applied:	210 kg N/ha	210 kg N/ha
Seed size:	35-50 mm	35-50 mm
Seed count:	900 per 50 kg	900 per 50 kg
Planned density:	34.6 000/ha	26.9 000/ha
Planned spacing:	31.6 cm	40.7 cm
Achieved density:	37.4 000/ha	27.8 000/ha
Achieved spacing:	29.3 cm	39.3 cm



Yield Samples (S.E. in italics)

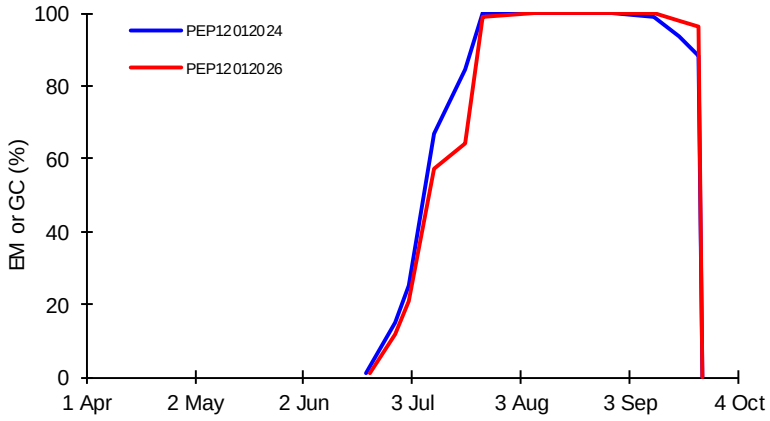
		Standard seed & N			Reduced seed & standard N	
		9 Aug	5 Sep		9 Aug	5 Sep
Plants (000/ha)		39.2	35.5		27.3	28.3
		3.11	*0.91*		*1.05*	*0.91*
Stems (000/ha)		178.6	196.9		161.3	158.6
		13.06	*14.81*		*11.17*	*10.58*
Stems/plant		4.6	5.5		5.9	5.6
		0.37	*0.34*		*0.22*	*0.31*
Tubers (000/ha)	> 10 mm	531	598	> 10 mm	420	528
		22.2	*19.5*		*22.4*	*28.8*
Tubers (000/ha)	> 40 mm	65	368	> 40 mm	26	351
		19.5	*9.3*		*2.6*	*9.5*
Tuber yield (t/ha)	> 10 mm	15.8	37.2	> 10 mm	13.2	35.6
		1.25	*0.37*		*0.49*	*1.16*
Tuber yield (t/ha)	> 40 mm	4.1	30.4	> 40 mm	1.7	31.3
		1.34	*0.62*		*0.21*	*0.89*
DM (%)		20.8	23.3		23.1	24.0
		0.12	*0.30*		*0.61*	*0.41*
Mean tuber size (mm)		35.8	44.6		34.9	46.6
		0.75	*0.42*		*0.33*	*0.35*

Report for 2012

Figure 43. RS Cockerill, Westgarth VR808 reduced N rate comparison

Grower:	Cockerills	Cockerills
Field name:	Richardson	Richardson
Unique ID:	PEP12012024	PEP12012026
Part Field Name:	Standard seed & N	Standard seed & reduced N
Variety:	VR808	VR808
Intended yield:	42 t/ha	42 t/ha
Intended use:	Crisping-Storage	Crisping-Storage

Planting date (start):	25 May	25 May
Date of 50 % emergence:	20 Jun	21 Jun
Total N applied:	210 kg N/ha	180 kg N/ha
Seed size:	35-50 mm	35-50 mm
Seed count:	900 per 50 kg	900 per 50 kg
Planned density:	34.6 000/ha	34.6 000/ha
Planned spacing:	31.6 cm	31.6 cm
Achieved density:	37.4 000/ha	35.5 000/ha
Achieved spacing:	29.3 cm	30.8 cm



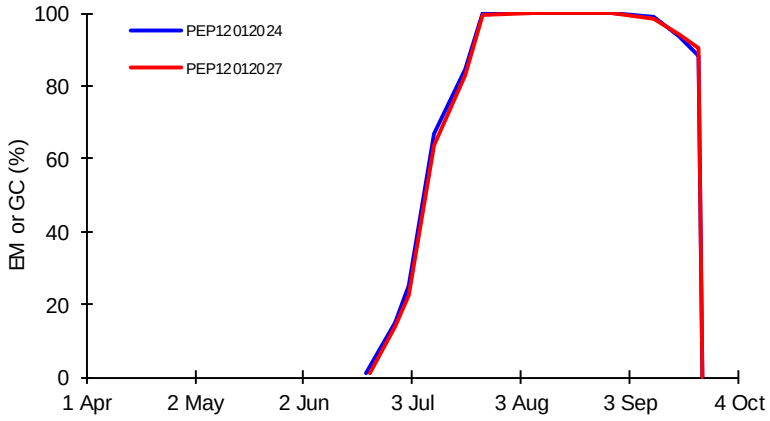
Yield Samples (S.E. in italics)

		Standard seed & N			Standard seed & reduced N	
		9 Aug	5 Sep		9 Aug	5 Sep
Plants (000/ha)		39.2	35.5		36.5	34.6
		3.11	*0.91*		*1.49*	*1.82*
Stems (000/ha)		178.6	196.9		198.7	195.0
		13.06	*14.81*		*10.78*	*11.28*
Stems/plant		4.6	5.5		5.4	5.6
		0.37	*0.34*		*0.17*	*0.14*
Tubers (000/ha)	> 10 mm	531	598	> 10 mm	538	605
		22.2	*19.5*		*43.7*	*32.3*
Tubers (000/ha)	> 40 mm	65	368	> 40 mm	88	362
		19.5	*9.3*		*7.0*	*21.3*
Tuber yield (t/ha)	> 10 mm	15.8	37.2	> 10 mm	16.7	36.3
		1.25	*0.37*		*0.95*	*1.17*
Tuber yield (t/ha)	> 40 mm	4.1	30.4	> 40 mm	5.5	30.0
		1.34	*0.62*		*0.44*	*1.55*
DM (%)		20.8	23.3		20.9	24.3
		0.12	*0.30*		*0.36*	*0.26*
Mean tuber size (mm)		35.8	44.6		36.8	45.7
		0.75	*0.42*		*0.37*	*0.32*

Report for 2012

Figure 44. RS Cockerill, Westgarth VR808 increased N rate comparison

Grower:	Cockerills	Cockerills
Field name:	Richardson	Richardson
Unique ID:	PEP12012024	PEP12012027
Part Field Name:	Standard seed & N	Standard seed & increased N
Variety:	VR808	VR808
Intended yield:	42 t/ha	42 t/ha
Intended use:	Crisping-Storage	Crisping-Storage
Planting date (start):	25 May	25 May
Date of 50 % emergence:	20 Jun	20 Jun
Total N applied:	210 kg N/ha	240 kg N/ha
Seed size:	35-50 mm	35-50 mm
Seed count:	900 per 50 kg	900 per 50 kg
Planned density:	34.6 000/ha	34.6 000/ha
Planned spacing:	31.6 cm	31.6 cm
Achieved density:	37.4 000/ha	36.0 000/ha
Achieved spacing:	29.3 cm	30.4 cm



Yield Samples (S.E. in italics)

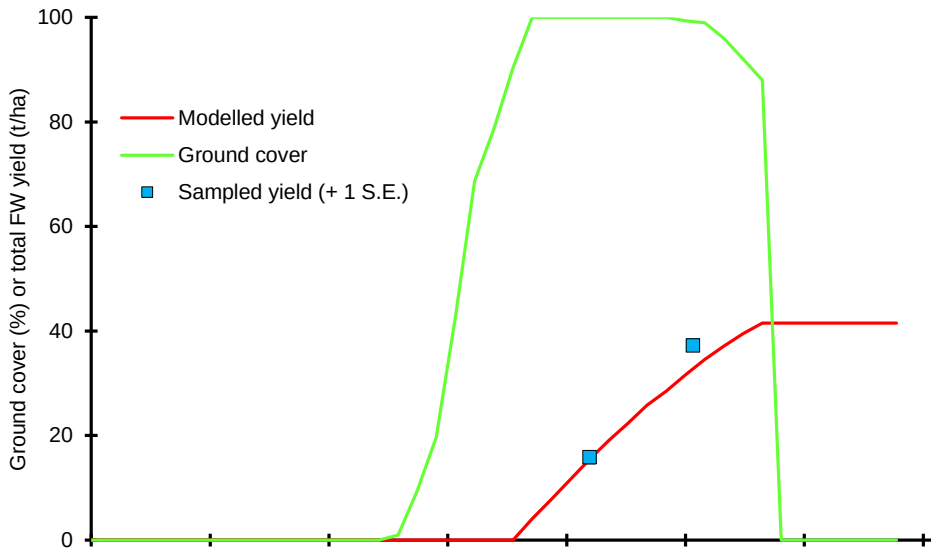
		Standard seed & N			Standard seed & increased N	
		9 Aug	5 Sep		9 Aug	5 Sep
Plants (000/ha)		39.2	35.5		35.5	36.5
		3.11	*0.91*		*1.75*	*1.49*
Stems (000/ha)		178.6	196.9		190.5	169.5
		13.06	*14.81*		*2.29*	*10.58*
Stems/plant		4.6	5.5		5.4	4.7
		0.37	*0.34*		*0.20*	*0.28*
Tubers (000/ha)	> 10 mm	531	598	> 10 mm	514	519
		22.2	*19.5*		*68.6*	*36.2*
Tubers (000/ha)	> 40 mm	65	368	> 40 mm	46	337
		19.5	*9.3*		*13.8*	*15.9*
Tuber yield (t/ha)	> 10 mm	15.8	37.2	> 10 mm	16.0	32.1
		1.25	*0.37*		*1.73*	*0.79*
Tuber yield (t/ha)	> 40 mm	4.1	30.4	> 40 mm	3.0	27.1
		1.34	*0.62*		*0.95*	*0.46*
DM (%)		20.8	23.3		23.6	23.5
		0.12	*0.30*		*1.05*	*0.30*
Mean tuber size (mm)		35.8	44.6		35.5	45.6
		0.75	*0.42*		*0.64*	*0.56*

Analysis of RS Cockerill crop performance using the CUF yield model

For the standard crop of VR808, the yield model predicted a total FW yield of 32.8 t/ha at the time of the final sampling compared with an observed yield of 37.2 and thus the observed yield was slightly larger than that modelled (Figure 45*a*). Similarly for the crop grown with a reduced seed rate, the model predicted a yield of 30.7 t/ha whereas the observed yield was 35.6 t/ha. For the two crops where N applications were reduced or increased by 30 kg N/ha relative to the standard 210 kg N/ha, the agreement between the modelled and observed yield was much closer (Figure 46*a* and *b*). Since the key inputs to the model are crop ground cover and incident radiation, the reasonably close agreement between modelled and observed yields suggest that smaller than expected yields of these crops was mainly a consequence of insufficient radiation absorption. When compared with other, higher yielding crops of VR808, the canopies of the Grower Collaboration crops were fairly typical in terms of their expansion and persistence. The low yields were thus probably due to the crop growing in a dull environment due to the combined effects of late planting and reduced incident radiation due to excesive cloud cover.

Figure 45. Comparison of modelled yield and sampled yield for (*a*) Richardson, VR808 standard crop and (*b*) Richardson, VR808 reduced seed rate crop.

(*a*)



(*b*)

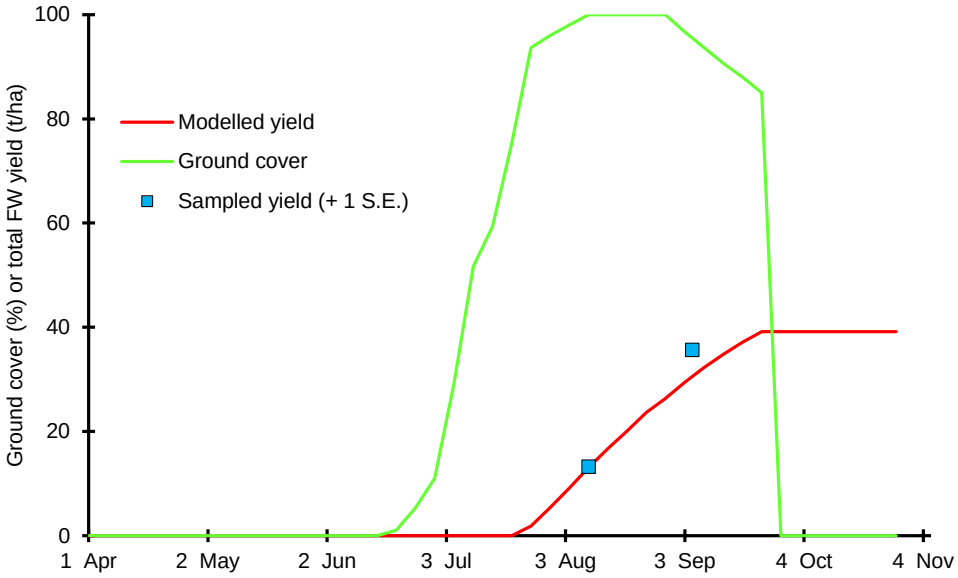
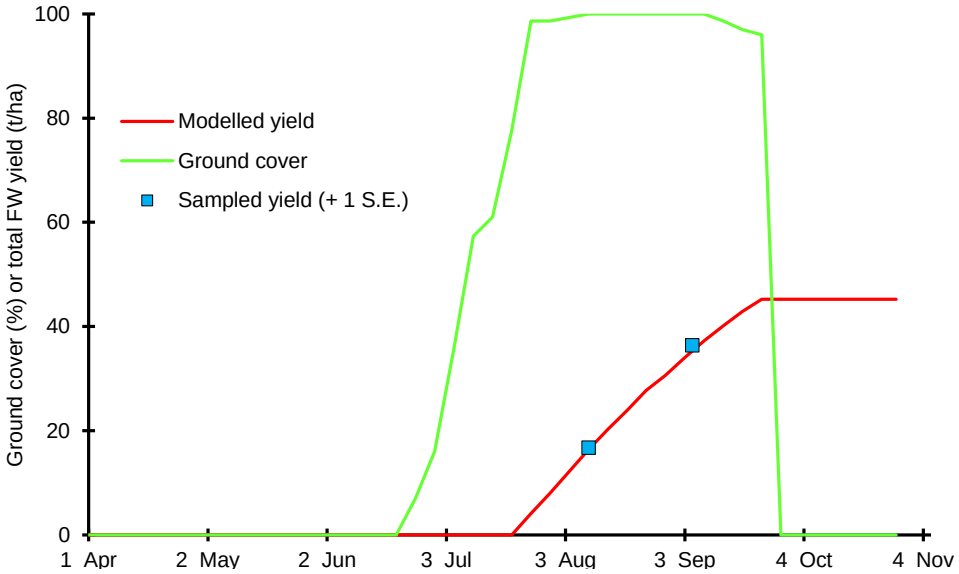
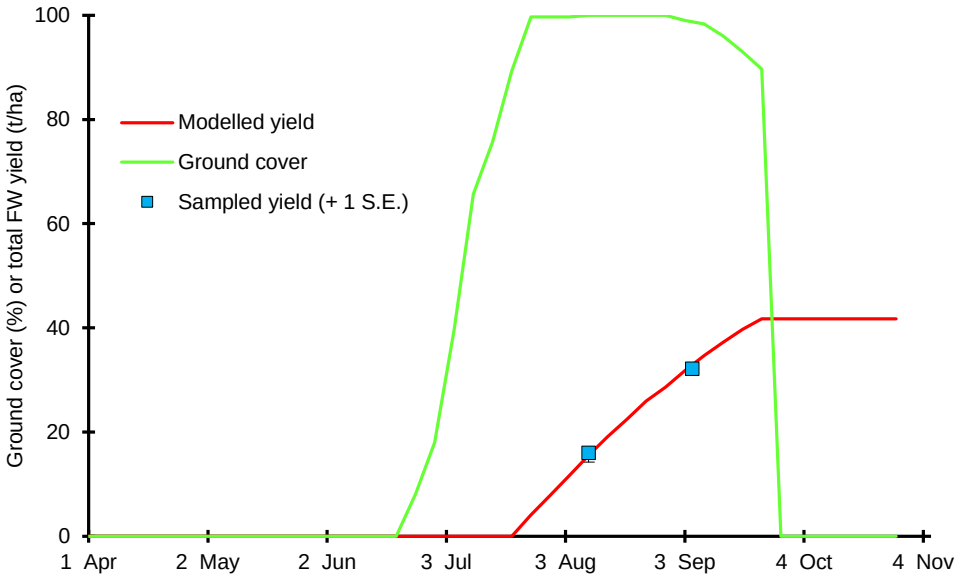


Figure 46. Comparison of modelled yield and sampled yield for (a) Richardson, VR808 standard crop and (b) Richardson, VR808 reduced seed rate crop.

(*a*)



(*b*)



Branston Ltd

Branston potatoes joined the collaboration program in 2010. In 2012, the program concentrated on testing seed rate recommendations for the production of bakers-sized Estima and on testing seed rates for the salad variety, Piccolo Star. This variety is included in the Potato Council funded project (Project R446) to determine seed rate recommendations and for this variety the grower collaboration comparisons were conducted to complement this project rather than to test established recommendations.

Estima seed rate comparisons

The Estima seed rate comparison was planted on 25 May and both comparisons had attained 50% plant emergence by *c*. 13 June. Ground cover development was not recorded in this crop. A final crop sampling was taken on 17 September (84 DAE) a few days before the crop was defoliated. For both the standard and modified spacings, the achieved plant population was less than that planned (Figure 47) and whilst the plant populations differed by *c*. 10 % there was little difference in stem population between the standard and modified crops. The total (> 10 mm) tuber yield in the standard crops was 48.5 t/ha compared with 29.9 t/ha in crop grown with the modified spacing. The observed difference in yield was a consequence of blight infection in the reduced seed rate area rather than due to the effect of seed rate *per se*. Dry matter concentrations were similar in both the standard and modified seed rate areas and averaged 21.3 %. Due to the effect of blight on yield, the mean tuber size was smaller in the Estima crop grown with the reduced seed. Since the results from this comparison were biased due to the effects of blight, they have been excluded from the summary tables.

Figure 47. Branston Estima seed rate comparison

Grower:	Branston	Branston
Field name:	DB3	DB3
Unique ID:	BRA12012032	BRA12012392
Part Field Name:	Standard seed & N	Modified seed & standard N
Variety:	Estima	Estima
Intended yield:	48 t/ha	48 t/ha
Intended use:	Bakers	Bakers
Planting date (start):	25 May	25 May
Date of 50 % emergence:	13 Jun	13 Jun
Total N applied:	200 kg N/ha	200 kg N/ha
Seed size:	45-55 mm	45-55 mm
Seed count:	475 per 50 kg	475 per 50 kg
Planned density:	29.0 000/ha	25.3 000/ha
Planned spacing:	37.7 cm	43.2 cm
Achieved density:	30.1 000/ha	27.3 000/ha
Achieved spacing:	36.4 cm	40.0 cm

Yield Samples (S.E. in italics)

		Standard seed & N		Modified seed & standard N
		17 Sep		17 Sep
Plants (000/ha)		30.1		27.3
		0.91		*1.05*
Stems (000/ha)		123.9		126.7
		3.94		*10.13*
Stems/plant		4.1		4.7
		0.18		*0.42*
Tubers (000/ha)	> 10 mm	615	> 10 mm	575
		14.3		*35.9*
Tubers (000/ha)	> 60 mm	44	> 60 mm	8
		9.3		*3.8*
Tuber yield (t/ha)	> 10 mm	48.5	> 10 mm	29.9
		3.94		*3.12*
Tuber yield (t/ha)	> 60 mm	10.9	> 60 mm	1.9
		2.10		*0.85*
DM (%)		21.1		21.4
		0.25		*0.44*
Mean tuber size (mm)		51.5		43.3
		0.76		*1.43*

Piccolo Star seed rate comparisons

The Piccolo Star seed rate comparisons were done in Field E, near Spridlington, Lincolnshire. Rather than using large machine-planted blocks to establish areas testing different plant population, this study used small, adjacent strips that were hand planted. The seed (E3, 35-45 mm, 858/50 kg) was planted on 16 May and 50 % plant emergence was obtained 25 days later on *c*. 10 June. Ground cover expansion was slow in all treatments and ground covers did not exceed 50 % before the crop was defoliated on 11 August (Figure 48). Plant population had no discernible effect on ground cover. The crop was sampled on

23 August (78 DAE) and population and yield data are shown in Table 14. The achieved plant populations were always smaller than intended and this may have been a consequence of poor seed emergence or loss of plants during the growing season. When compared with the plant population, stem populations were erratic with the largest stem population (242 000/ha) being associated with the second smallest plant population. This variation in stem population may be a consequence of counting stems several days after the crop had been defoliated by flailing. Tuber populations > 10 mm varied systematically with achieved plant population and ranged from 722 to 870 000/ha.

Figure 48. Effect of varying plant population on ground covers of Piccolo Star, Branston 2012

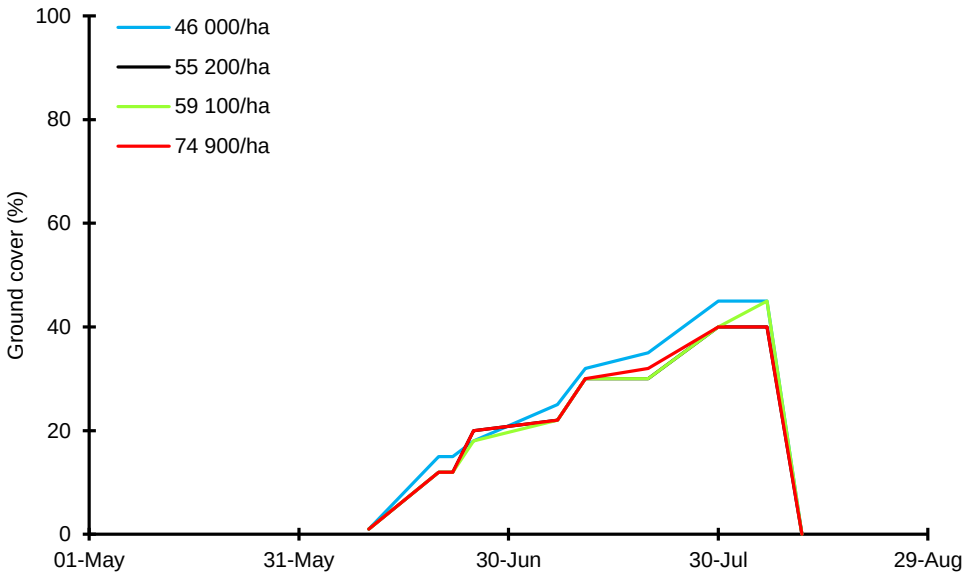


Table 14. Effect of Piccolo Star plant population on stem and tuber population, tuber FW yield and mean tuber size. The crop was sampled on 23 August.

Target plant population (000/ha)	Plant population (000/ha)	Stem population (000/ha)	Tuber population > 10 mm (000/ha)	Tuber FW yield > 10 mm (t/ha)	Tuber FW yield > 40 mm (t/ha)	Mean tuber size (mu, mm)
74.9	66.8 ± 1.22	216 ± 14.3	870 ± 47.8	31.1 ± 1.37	8.4 ± 1.00	36.8 ± 0.42
59.1	57.1 ± 1.22	182 ± 7.6	845 ± 10.8	31.2 ± 0.59	11.6 ± 0.80	37.7 ± 0.28
55.2	51.0 ± 0.00	242 ± 8.51	838 ± 28.9	27.4 ± 0.77	6.1 ± 1.63	35.9 ± 0.42
46.0	38.9 ± 1.22	177 ± 5.3	722 ± 32.4	30.3 ± 0.59	13.5 ± 0.76	38.7 ± 0.25

Co-operative Farms

The Co-operative Farms joined the Grower Collaboration program in 2010. In 2010 and 2011 work was done on crops grown near Goole, Humberside, however, in 2012 work was moved to Coldham, Cambridgeshire. Field and seed details for crops of Melody and Harmony were send to CUF in early 2012 and are shown in Table 15. For the Melody crop, the CUF modified spacing differed by less than 10 % from the standard spacing and no spacing comparisons were planted. A comparison was done, however, between the standard N application rate (190 kg N/ha) and a reduced N application rate (150 kg N/ha). For the Harmony crop grown in Field 38 the difference between grower standard and CUF modified seed rates were sufficiently large to warrant comparison as were the differences between the standard and reduced N application rates.

Table 15. Field, seed and cropping details for crops of Melody and Harmony grown by Co-Operative Farms, Coldham in 2012

	Melody	Harmony
Field name	Field 34	Field 38
Seed size (mm)	45-55	45-55
Seed count (no/50 kg)	483	468
Seed crop emergence date	12 May 2011	7 June 2011
Intended ware planting date	15 April 2012	20 April 2012
Intended ware yield	55	60
Intended market	Pre-pack bakers	Pre-pack bakers
Intended mean tuber size (mm)	63	63
Intended defoliation date	16 August 2012	17 Aug 2012
Estimated season length (days)*	92	89
Soil type	Deep fertile silt soil	Deep fertile silt soil
Soil organic matter content	2-6 %	2-6 %
Previous crop	Cereal	Cereal
Organic manure usage (type, amount)	None	None
N from organic manure (kg N/ha)	0	0
Grower standard plant spacing (cm)	45.2	37.8
CUF modified plant spacing (cm)	41.3	43.1
Grower standard N application rate (kg N/ha)	190	190
CUF modified N application rate (kg N/ha)	150	140

*From ware crop emergence to defoliation

Field 34 Melody nitrogen rate comparisons

The planting date of the Melody crop was close to that given in the original cropping plan. The interval between planting and the date of 50 % plant emergence was 47 days (Figure 49). This interval is larger than normal for the time of year and is probably a consequence of the colder than average spring slowing sprout growth. There was no difference in the interval in the areas receiving the standard and reduced N application rates. Achieved plant

populations in the standard and reduced N areas were similar and averaged 25 100/ha. Reducing the N application rate from 190 to150 kg N/ha had no discernible effects on the rate of ground cover expansion, maximum ground cover or ground cover persistence and crops grown in the standard and reduced N areas would be expected to absorb similar amount of solar radiation. At the first sampling on 25 July (55 DAE) the total tuber yield in the standard and reduced N areas was 26.0 t/ha and the average total tuber population was 502 000/ha. The second sampling was taken on 13 September (105 DAE). Total tuber yield in the standard N area was 62.8 t/ha whereas the total tuber yield in the reduced N area was 71.0 t/ha. The total tuber population averaged 590 000/ha suggesting there may have been a slight increase in the tuber population > 10 mm between the two sampling. Tuber ware yield (> 60 mm) in the standard and reduced N area was 9.7 and 13.7 t/ha, respectively. Decreasing the N application rate had little effect on tuber DM concentration which averaged 15.2 % at the first sampling and 22.0 % at the second.

Field 38 Harmony seed rate comparisons

Due to excessive rain the Harmony crop in Field 38 about planted *c*. four week later than intended on 17 May. Irrespective of planting density, 50 % plant emergence was on 13 June (27 DAE). For both the standard and reduced seed rates, the achieved plant populations were similar to those intended (Figure 50). However, since the plant population in the standard crop was slightly smaller than intended and the plant population in the modified crop was slightly larger than intended the difference in plant population was not as great as originally planned. Initial ground cover expansion was marginally slower in the modified crop but both the standard and modified crops attained complete ground cover and had very similar patterns of canopy persistence. At the first sampling on 25 July (42 DAE), total tuber yield averaged 12.5 t/ha. Numerically, the standard crop had a slightly larger yield and this may have been due to the slightly larger ground cover at the start of the season. The second crop sample was taken on 13 September (92 DAE) and at this sampling total yields in the crops grown at standard and reduced seed rates had increased to 50.3 t/ha and 61.0 t/ha respectively. The apparent increase in total yield as a consequence of reducing plant population is unexpected especially when the similarity in ground cover curves (and thereby radiation absorption) are considered. The average total yield in the modified seed rate area was associated with a larger than usual standard error. Ware yield (> 60 mm) was 10 t/ha for the crop grown at the standard compared with 21.9 t/ha for the crop grown at a reduced seed rate. Reducing the plant population resulted in an increase in mean tuber size from 53.8 to 57.4 mm, however this increase was mainly due to the increase in total yield

since the effect of reducing the plant population on tuber population was much smaller than expected.

Field 38 Harmony nitrogen rate comparisons

Reducing the N application rate from 190 to 140 kg N/ha had no effect on the interval between planting and 50 % crop emergence and averaged 27 days (Figure 51). For both the standard and reduced N crops the achieved plant populations were close to that intended and should not affect interpretation of the results. Ground cover expansion and persistence was similar irrespective of nitrogen application rate, although the crop grown at the reduced N rate may have got to complete ground cover slightly before the standard crop. At the first sampling on 25 July, total tuber yields in standard and reduced N areas were almost identical (13.8 t/ha) as were total tuber populations which averaged 322 000/ha. At the second sampling on 13 September, the total tuber yield in the standard area was 50.3 t/ha compared with 62.7 t/ha in the area that had received only 140 kg N/ha. Similarly, ware yield (> 60 mm) in the standard and reduced N areas was 10.0 and 19.0 t/ha respectively

Collectively the data suggest that both the Melody and Harmony crops crop could be grown with about 40 kg N/ha less than the standard application without having any negative effect on total or ware yield. It is possible that the numeric increase in yield associated with the decrease in N inputs is genuine although analysis using the CUF N model shows that the magnitude of the increase may not be as great the samples suggest (see later). Similarly, the seed rate comparison in Harmony showed that reducing the seed rate by about 0.4 t/ha resulted in an increase in baker yield although the actual increase in yield may not be as large as the data imply.

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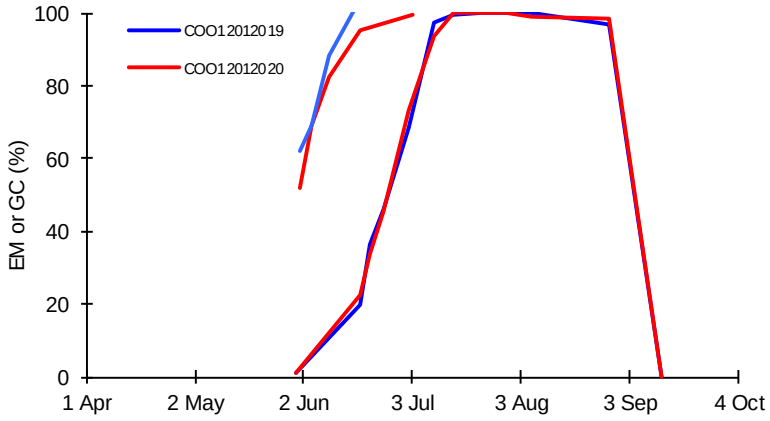
Figure 49. Cooperative Farms, Melody, Field 38, seed rate comparisons

Grower:	Co-operative Farm	Co-operative Farm
Field name:	Field 34	Field 34
Unique ID:	COO12012019	COO12012020
Part Field Name:	Seed & N standard	Seed standard & N modified
Variety:	Melody	Melody
Intended yield:	55 t/ha	55 t/ha
Intended use:	General Ware	General Ware
Planting date (start):	14 Apr	14 Apr
Date of 50 % emergence:	31 May	31 May
Total N applied:	190 kg N/ha	150 kg N/ha
Seed size:	45-55 mm	45-55 mm
Seed count:	483 per 50 kg	483 per 50 kg
Planned density:	24.2 000/ha	24.2 000/ha
Planned spacing:	45.2 cm	45.2 cm
Achieved density:	25.5 000/ha	24.6 000/ha
Achieved spacing:	42.9 cm	44.4 cm



Yield Samples (S.E. in italics)

		Seed & N standard			Seed standard & N modified	
		25 Jul	13 Sep		25 Jul	13 Sep
Plants (000/ha)		24.6	26.4		23.7	25.5
		0.91	*0.91*		*1.05*	*1.49*
Stems (000/ha)		149.5	139.4		137.6	149.5
		9.41	*14.46*		*9.80*	*8.55*
Stems/plant		6.1	5.3		5.8	5.9
		0.38	*0.50*		*0.22*	*0.30*
Tubers (000/ha)	> 10 mm	515	599	> 10 mm	488	581
		81.1	*71.3*		*25.4*	*33.7*
Tubers (000/ha)	> 60 mm	0	40	> 60 mm	0	48
		0.0	*9.6*		*0.0*	*2.3*
Tuber yield (t/ha)	> 10 mm	26.4	62.8	> 10 mm	25.6	71.0
		2.40	*3.38*		*0.70*	*4.22*
Tuber yield (t/ha)	> 60 mm	0.0	9.7	> 60 mm	0.0	13.7
		0.00	*2.50*		*0.00*	*1.02*
DM (%)		14.9	21.9		15.4	22.0
		0.12	*0.79*		*0.26*	*0.62*
Mean tuber size (mm)		39.4	51.7		40.0	53.7
		0.82	*1.27*		*1.35*	*0.61*

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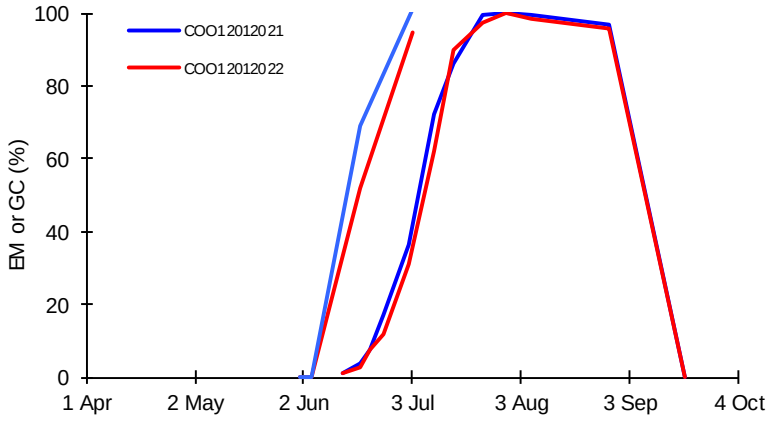
Figure 50. Cooperative Farms, Harmony, Field 38 seed rate comparison

Grower:	Co-operative Farm	Co-operative Farm
Field name:	Field 38/02	Field 38/02
Unique ID:	COO12012021	COO12012022
Part Field Name:	Seed & N Standard	Seed modified & N Standard
Variety:	Harmony	Harmony
Intended yield:	60 t/ha	60 t/ha
Intended use:	General Ware	General Ware
Planting date (start):	17 May	17 May
Date of 50 % emergence:	13 Jun	13 Jun
Total N applied:	190 kg N/ha	190 kg N/ha
Seed size:	45-55 mm	45-55 mm
Seed count:	468 per 50 kg	468 per 50 kg
Planned density:	28.9 000/ha	25.4 000/ha
Planned spacing:	37.8 cm	43.1 cm
Achieved density:	28.3 000/ha	26.0 000/ha
Achieved spacing:	38.7 cm	42.1 cm



Yield Samples (S.E. in italics)

		Seed & N Standard			Seed modified & N Standard	
		25 Jul	13 Sep		25 Jul	13 Sep
Plants (000/ha)		26.4	30.1		27.3	24.6
		1.75	*1.75*		*1.05*	*0.91*
Stems (000/ha)		135.8	166.8		109.4	105.7
		5.24	*8.34*		*4.94*	*7.87*
Stems/plant		5.2	5.6		4.0	4.3
		0.39	*0.39*		*0.14*	*0.25*
Tubers (000/ha)	> 10 mm	309	441	> 10 mm	265	434
		26.3	*13.6*		*43.3*	*29.8*
Tubers (000/ha)	> 60 mm	0	44	> 60 mm	0	80
		0.0	*5.2*		*0.0*	*10.7*
Tuber yield (t/ha)	> 10 mm	13.7	50.3	> 10 mm	11.3	61.0
		0.79	*1.40*		*1.81*	*3.01*
Tuber yield (t/ha)	> 60 mm	0.0	10.0	> 60 mm	0.0	21.9
		0.00	*1.19*		*0.00*	*1.90*
DM (%)		11.5	19.7		11.3	18.9
		0.11	*0.07*		*0.16*	*0.57*
Mean tuber size (mm)		38.3	53.8		38.5	57.4
		0.51	*0.33*		*0.44*	*0.71*

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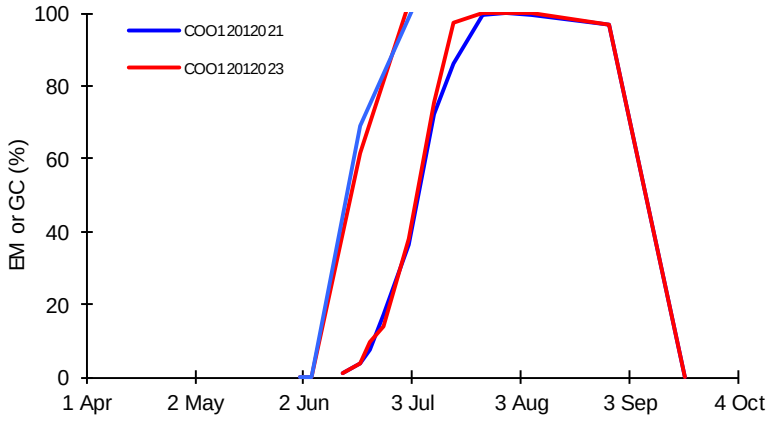
Figure 51. Cooperative Farms, Harmony, Field 38 nitrogen rate comparison

Grower:	Co-operative Farm	Co-operative Farm
Field name:	Field 38/02	Field 38/02
Unique ID:	COO12012021	COO12012023
Part Field Name:	Seed & N Standard	Seed standard & N modified
Variety:	Harmony	Harmony
Intended yield:	60 t/ha	60 t/ha
Intended use:	General Ware	General Ware
Planting date (start):	17 May	17 May
Date of 50 % emergence:	13 Jun	13 Jun
Total N applied:	190 kg N/ha	140 kg N/ha
Seed size:	45-55 mm	45-55 mm
Seed count:	468 per 50 kg	468 per 50 kg
Planned density:	28.9 000/ha	28.9 000/ha
Planned spacing:	37.8 cm	37.8 cm
Achieved density:	28.3 000/ha	31.0 000/ha
Achieved spacing:	38.7 cm	35.3 cm



Yield Samples (S.E. in italics)

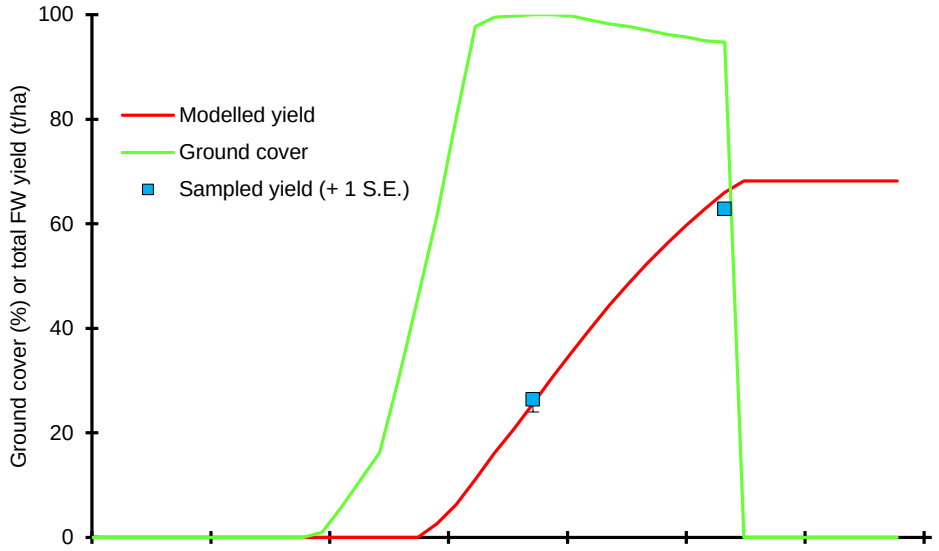
		Seed & N Standard			Seed standard & N modified	
		25 Jul	13 Sep		25 Jul	13 Sep
Plants (000/ha)		26.4	30.1		31.0	31.0
		1.75	*1.75*		*2.35*	*1.05*
Stems (000/ha)		135.8	166.8		153.1	159.5
		5.24	*8.34*		*12.97*	*4.04*
Stems/plant		5.2	5.6		4.9	5.2
		0.39	*0.39*		*0.27*	*0.21*
Tubers (000/ha)	> 10 mm	309	441	> 10 mm	335	494
		26.3	*13.6*		*28.7*	*34.9*
Tubers (000/ha)	> 60 mm	0	44	> 60 mm	0	73
		0.0	*5.2*		*0.0*	*14.0*
Tuber yield (t/ha)	> 10 mm	13.7	50.3	> 10 mm	13.8	62.7
		0.79	*1.40*		*1.20*	*2.51*
Tuber yield (t/ha)	> 60 mm	0.0	10.0	> 60 mm	0.0	19.0
		0.00	*1.19*		*0.00*	*4.15*
DM (%)		11.5	19.7		10.7	20.5
		0.11	*0.07*		*0.21*	*0.55*
Mean tuber size (mm)		38.3	53.8		37.8	55.8
		0.51	*0.33*		*0.66*	*1.29*

Analysis of Cooperative crop performance using the CUF yield model

Figure 52 to Figure 54 compares the observed total yield with modelled total yield. For the Melody crop (Figure 52), the modelled yield on 13 September for the standard crop was slightly larger than that observed. Conversely the model underestimated the sample yield of the reduced N crop. The mean observed total yield for both the standard and reduced N crops was 66.9 t/ha compared with a mean modelled yield of 66.0 t/ha. It is possible that the apparent observed difference in yield between the two areas of Melody were simply a consequence of the sample digs underestimating the yield in one area and overestimating it in another. Similarly, for the Harmony crop, the average observed total yield for all three comparisons was 58.0 t/ha compared with an average modelled yield of 52.9 t/ha. The model analysis suggests that the difference between the treatments may not have actually been as large as the yield data suggested. The yield model was also run early in the season (26 July) the day after the first sample had been taken. To do this the model assumed that the ground cover would persist for an amount of type that was typical for that variety and that the weather conditions for the remainder of the season would be similar to the long-term average. For the standard Melody and Harmony crops the model predicted a yield of 57 and 51 t/ha, respectively. The canopy of the Melody crop persisted for longer than expected and the achieved yield at the end of the season was a little larger than was forecasted in July. However the forecasted yield of the Harmony was quite similar to that observed. This information provided an early warning that the Harmony crop in particular would struggle to attain its target ware yield and a large proportion of the yield would not get into the baker fraction.

Figure 52. Comparison of modelled yield and sampled yield for (a) Field 34, Melody standard crop and (b) Field 34, Melody reduced N crop.

(*a*)



(*b*)

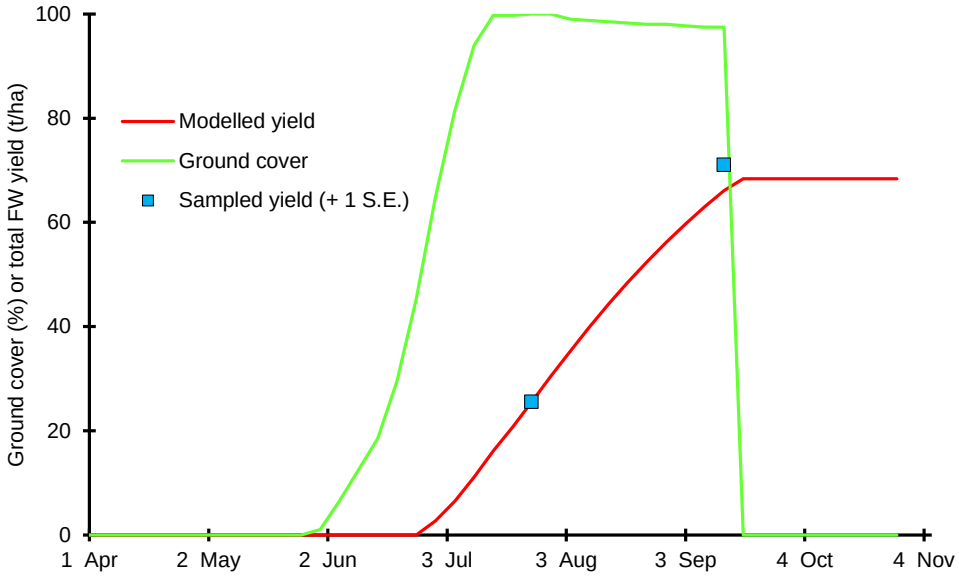
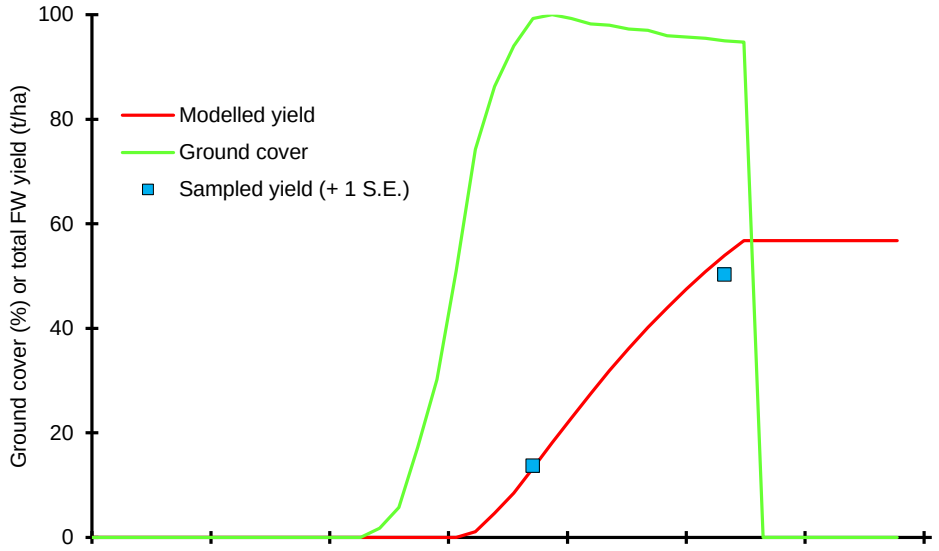


Figure 53. Comparison of modelled yield and sampled yield for (a) Field 38, Harmony standard crop and (b) Field 38, Harmony reduced seed rate crop.

(*a*)



(*b*)

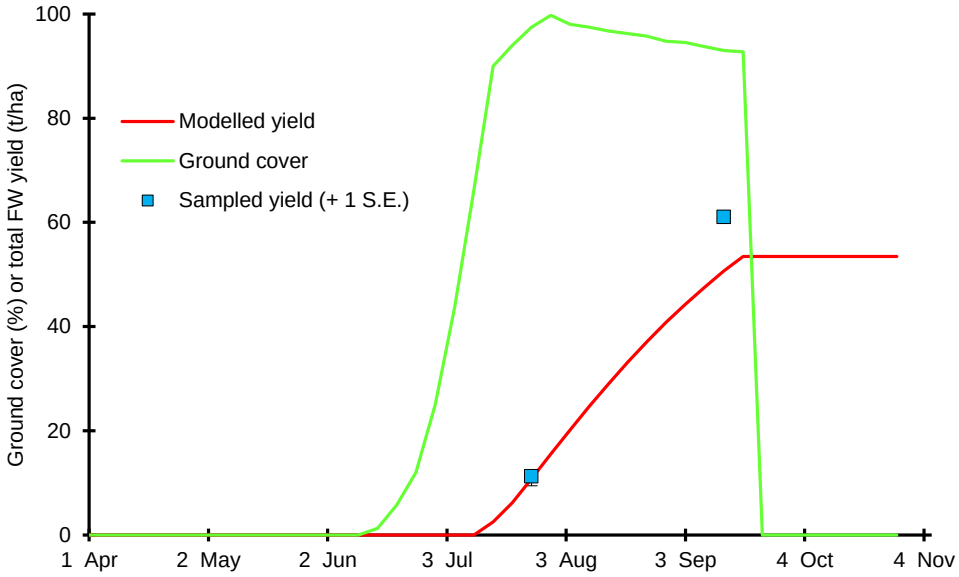
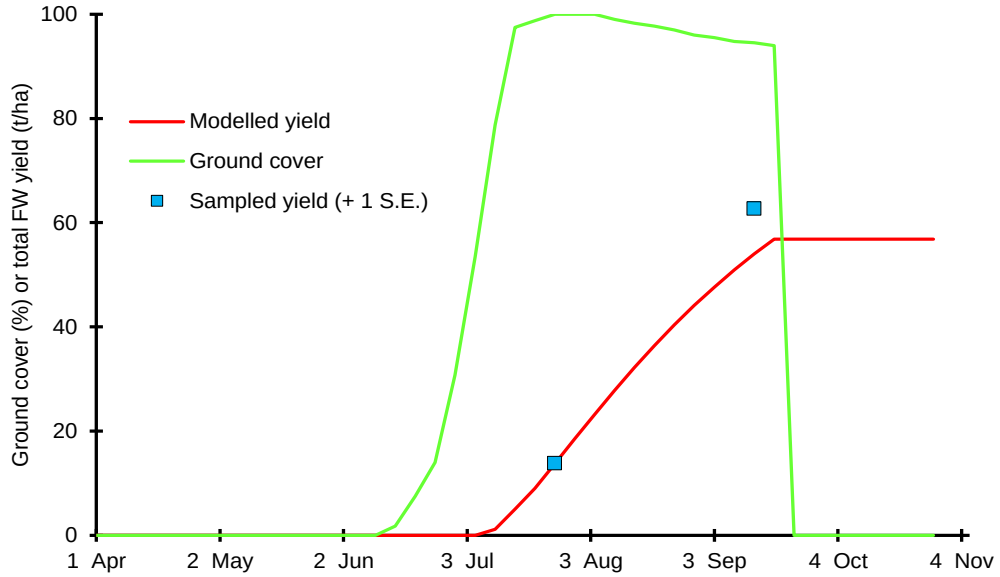


Figure 54. Comparison of modelled yield and sampled yield for Field 38, Harmony reduced N rate crop



Appendix 1

Table 16. Summary of all N rate comparison data (N rate decreased) collected in PCL/CUF Grower Collaboration Project R295 2007-2012. Yield data are hand-dug-samples taken about the time of defoliation

Year	Grower	Field	Variety	Standard N rate (kg N/ha)	Modified N rate (kg N/ha)	Change in N rate (kg N/ha)	Standard yield > 10 mm (t/ha)	Modified yield > 10 mm (t/ha)	Change in yield > 10 mm (t/ha)	Standard yield > 40 mm (t/ha)	Modified yield > 40 mm (t/ha)	Change in yield > 40 mm (t/ha)
Invalid comparisons												
2008	Strawson Farming†	Bower 8	Hermes	193	169	-24	66.2	60.6	-5.6	63.8	58.2	-5.6
2008	Mease Valley Potatoes‡	MFL B	Russet Burbank	200	160	-40	69.1	52.8	-16.3	64.5	46.8	-17.7
2010	RS Cockerill Ltd#	Field 16	Hermes	175	140	-35	55.8	51.6	-4.3	52.5	48.6	-3.9
2011	Co-operative Farms*	Pasture 116	Maris Piper	200	175	-25	61.0	62.8	1.8	59.7	61.3	1.6
Valid comparisons												
2007	Mease Valley Potatoes	Upper Trent	Russet Burbank	220	165	-55	59.5	67.6	8.1	56.4	64.1	7.7
2007	NNPG	Market Style	Saturna	240	175	-65	40.2	51.0	10.8	29.9	36.4	6.5
2008	AH Worth & Co	Field 13	Maris Piper	180	140	-40	56.0	50.9	-5.1	53.3	47.9	-5.3
2008	NNPG	Malthouse	Saturna	240	180	-60	45.2	48.6	3.4	42.1	45.4	3.3
2008	NNPG	Horseshoes	Hermes	224	175	-49	50.4	53.6	3.2	47.4	50.9	3.6
2009	AH Worth & Co	F38	Maris Piper	180	155	-25	71.4	72.6	1.1	69.8	70.7	0.9
2009	Mease Valley Potatoes	Curborough	Markies	150	130	-20	56.4	55.7	-0.7	51.7	50.9	-0.9
2009	Mease Valley Potatoes	Deercote Barn	Maris Piper	220	200	-20	64.5	54.4	-10.1	59.9	48.6	-11.3
2009	Strawson Farming	Wood 10	Hermes	210	185	-25	37.6	44.0	6.4	35.3	41.4	6.1
2009	Strawson Farming	Godfrey 13	Saturna	220	195	-25	63.1	58.9	-4.2	60.5	55.9	-4.6
2009	NNPG	Bakers 27	Saturna	240	180	-60	48.8	52.0	3.2	46.4	49.4	3.1
2009	NNPG	Long Lions	Hermes	191	181	-10	57.0	61.0	4.0	54.7	58.1	3.4
2010	Co-operative Farms	3/5/7/ B	Estima	230	205	-25	35.9	43.1	7.2	33.8	39.7	5.9
2010	Branston Potatoes	Pit Field	Desiree	140	120	-20	74.3	75.8	1.5	70.7	72.2	1.6
2010	AH Worth & Co	Field 26/27	Marfona	180	150	-30	54.8	60.9	6.1	53.4	59.5	6.0
2010	AH Worth & Co	JEP28	Melody	180	155	-25	44.2	46.5	2.3	40.1	41.3	1.2
2010	RS Cockerill Ltd	Field 35	Saturna	230	195	-35	47.2	39.2	-8.0	43.4	36.6	-6.8

Table 4. (continued)

Year	Grower	Field	Variety	Standard N rate (kg N/ha)	Modified N rate (kg N/ha)	Change in N rate (kg N/ha)	Standard yield > 10 mm (t/ha)	Modified yield > 10 mm (t/ha)	Change in yield > 10 mm (t/ha)	Standard yield > 40 mm (t/ha)	Modified yield > 40 mm (t/ha)	Change in yield > 40 mm (t/ha)
2010	RS Cockerill Ltd	Field 18	Hermes	225	185	-40	65.4	65.9	0.5	62.9	63.8	0.8
2011	RS Cockerill Ltd	Field 11	Hermes	220	190	-30	61.9	80.7	18.8	59.9	77.8	17.9
2011	RS Cockerill Ltd	Stanwick Wall	Saturna	175	160	-15	66.7	72.1	5.4	64.6	70.4	5.7
2011	Co-operative Farms	Pasture 116	Maris Piper	200	175	-25	63.9	68.3	4.4	62.2	66.8	4.6
2012	Co-operative Farms	Field 34	Melody	190	150	-40	62.8	71.0	8.2	57.7	67.1	9.4
2012	Co-operative Farms	Field 38	Harmony	190	140	-50	50.3	62.7	12.4	47.5	60.2	12.7
2012	RS Cockerill Ltd	Richardson	VR808	210	180	-30	37.2	36.3	-0.9	30.4	30.0	-0.4
			Average (n=28)	202	168	-34	56.0	57.9	1.9	52.7	54.3	1.6

Not included in summaries because: †, N application rate smaller than intended; ‡, crop severely affected by potato cyst nematode; #, large difference in dates of emergence of standard and modified crops and *, plant populations different to those intended.

Table 17. Summary of all N rate comparison data (N rate increased) collected in PCL/CUF Grower Collaboration Project R295 2007-2012. Yield data are hand-dug-samples taken about the time of defoliation

Year	Grower	Field	Variety	Standard N rate (kg N/ha)	Modified N rate (kg N/ha)	Change in N rate (kg N/ha)	Standard yield > 10 mm (t/ha)	Modified yield > 10 mm (t/ha)	Change in yield > 10 mm (t/ha)	Standard yield > 40 mm (t/ha)	Modified yield > 40 mm (t/ha)	Change in yield > 40 mm (t/ha)
2012	RS Cockerill Ltd	Richardson	VR808	210	240	30	37.2	32.1	-5.1	30.4	27.1	-3.3

Table 18. Summary of all seed rate comparison data (seed rate increased) collected in PCL/CUF Grower Collaboration Project R295 2007-2012. Yield data are hand-dug-samples taken about the time of defoliation

Year	Grower	Field	Variety	Standard seed rate (t/ha)	Modified seed rate (t/ha)	Change in seed rate (t/ha)	Standard yield > 10 mm (t/ha)	Modified yield > 10 mm (t/ha)	Change in yield > 10 mm (t/ha)	Standard yield > 40 mm (t/ha)	Modified yield > 40 mm (t/ha)	Change in yield > 40 mm (t/ha)
2011	SWAG†	Big Mead	Sante	2.30	2.52	0.23	43.9	45.3	1.5	41.2	42.4	1.2
2007	Mease Valley Potatoes	Thorpe 41	Saturna	1.37	1.60	0.23	54.2	50.1	-4.1	51.8	46.1	-5.8
2007	Strawson Farming	Godfrey Blyth	Saturna	2.42	2.72	0.30	69.0	72.4	3.4	67.4	70.7	3.3
2009	NNPG	Bakers 27	Saturna	1.77	2.02	0.25	48.8	54.2	5.4	46.4	50.0	3.7
			Average (n=4)	1.96	2.21	0.25	54.0	55.5	1.5	51.7	52.3	0.6

Not included in summaries because: †achieved seed rates different to those intended.

Table 19. Summary of all seed rate comparison data (seed rate decreased) collected in PCL/CUF Grower Collaboration Project R295 2007-2012. Yield data are hand-dug-samples taken about the time of defoliation

Year	Grower	Field	Variety	Standard seed rate (t/ha)	Modified seed rate (t/ha)	Change in seed rate (t/ha)	Standard yield > 10 mm (t/ha)	Modified yield > 10 mm (t/ha)	Change in yield > 10 mm (t/ha)	Standard yield > 40 mm (t/ha)	Modified yield > 40 mm (t/ha)	Change in yield > 40 mm (t/ha)
Invalid comparisons												
2008	A H Worth & Co†	Field 69	Estima	2.33	1.85	-0.48	59.0	59.6	0.6	56.5	56.1	-0.5
2008	A H Worth & Co†	Field 69	Estima	3.00	2.59	-0.41	59.2	69.8	10.6	56.1	67.1	10.9
2008	Strawson Farming†	Hoggard 6	Saturna	2.54	2.18	-0.36	67.6	60.1	-7.5	62.6	56.5	-6.1
2008	NNPG†	Millfield	Hermes	4.57	1.87	-2.70	53.9	59.4	5.6	49.0	56.6	7.5
2009	A H Worth & Co†	JEP44	Estima	2.43	2.17	-0.26	60.1	55.2	-4.9	58.7	54.0	-4.7
2009	Mease Valley Potatoes†	Marsh Barn	Lady Rosetta	1.71	1.40	-0.30	57.6	51.1	-6.5	52.3	48.5	-3.8
2009	Strawson Farming†	S. Wood 14	Hermes	3.14	2.87	-0.27	42.3	39.1	-3.1	38.7	36.1	-2.5
2009	NNPG†	Long Lions	Hermes	3.04	2.40	-0.64	57.0	62.2	5.2	54.7	59.6	4.9
2010	A H Worth & Co†	Field 26/27	Marfona	2.97	2.67	-0.30	54.8	63.3	8.5	53.4	62.2	8.7
2010	RS Cockerill Ltd†	Field 35	Saturna	2.36	2.28	-0.09	47.2	44.4	-2.8	43.4	40.8	-2.6
2011	SWAG†	Big Mead	Sante	2.30	2.07	-0.23	43.9	53.1	9.2	41.2	51.1	9.9
2011	B&C Farming Ltd†	Grove Farm 89	Russet Burbank	1.49	1.05	-0.44	61.6	65.3	3.7	55.8	59.6	3.8
2012	B&C Farming Ltd†	Fengate	Russet Burbank	1.50	1.33	-0.18	62.1	57.6	-4.5	55.0	53.0	-2.0
2012	B&C Farming Ltd†	Fengate	Russet Burbank	1.50	1.29	-0.22	58.3	59.4	1.1	51.4	52.9	1.5
2012	Branston Ltd††	DB3	Estima	3.05	2.66	-0.39	48.5	29.9	-18.6	41.6	18.9	-22.7
Valid comparisons												
2007	Mease Valley Potatoes	Ellis B	Hermes	2.89	2.44	-0.44	64.4	75.8	11.4	60.5	71.9	11.4
2007	Mease Valley Potatoes	Thorpe 41	Saturna	2.94	2.44	-0.51	58.8	51.4	-7.4	56.0	46.5	-9.5
2007	Strawson Farming	K. Narborough	Saturna	2.30	2.11	-0.20	51.0	49.8	-1.1	48.2	47.8	-0.4
2007	Strawson Farming	S. Creake	Hermes	3.43	2.46	-0.97	47.5	46.8	-0.7	46.9	46.4	-0.5
2007	Strawson Farming	B. Carburton	Hermes	4.39	2.81	-1.58	55.5	58.6	3.1	52.3	56.7	4.3
2007	NNPG	45 acres	Saturna	2.56	2.15	-0.42	68.7	62.8	-5.9	64.7	59.9	-4.8
2007	NNPG	Wrights	Hermes	3.07	2.16	-0.91	49.8	54.0	4.2	45.5	51.0	5.5

Table 6. (continued)

Year	Grower	Field	Variety	Standard seed rate (t/ha)	Modified seed rate (t/ha)	Change in seed rate (t/ha)	Standard yield > 10 mm (t/ha)	Modified yield > 10 mm (t/ha)	Change in yield > 10 mm (t/ha)	Standard yield > 40 mm (t/ha)	Modified yield > 40 mm (t/ha)	Change in yield > 40 mm (t/ha)
2008	A H Worth & Co	Field 13	Maris Piper	1.54	1.13	-0.41	64.4	56.0	-8.4	59.9	53.3	-6.7
2008	Strawson Farming	Bower 8	Hermes	4.47	2.50	-1.96	66.2	57.9	-8.3	63.8	56.2	-7.6
2008	Strawson Farming	Godfrey 8	Saturna	2.45	2.17	-0.29	50.6	52.0	1.5	46.8	48.5	1.6
2008	NNPG	Millfield	Hermes	4.57	2.96	-1.61	53.9	59.3	5.5	49.0	56.8	7.7
2008	NNPG	Horseshoes	Hermes	2.59	2.09	-0.49	50.4	53.6	3.2	47.4	51.7	4.3
2008	NNPG	Malthouse	Saturna	2.02	1.61	-0.41	45.2	43.3	-1.9	42.1	41.3	-0.8
2008	Mease Valley Potatoes	Bowling Alley	Lady Rosetta	3.27	2.98	-0.29	66.9	64.7	-2.1	62.2	60.9	-1.2
2008	Mease Valley Potatoes	P. Quarry	Hermes	3.89	2.53	-1.36	57.8	55.0	-2.8	51.8	49.9	-1.9
2009	A H Worth & Co	JEP44	Estima	3.42	2.89	-0.54	67.8	66.2	-1.6	65.8	65.1	-0.7
2009	Mease Valley Potatoes	Marsh Barn	Lady Rosetta	2.37	1.80	-0.57	54.5	52.2	-2.3	46.2	48.5	2.3
2009	Strawson Farming	S. Wood 14	Hermes	3.14	2.27	-0.86	42.3	39.6	-2.6	38.7	37.5	-1.1
2009	NNPG	Bakers 55	Hermes	3.05	2.40	-0.66	56.6	58.2	1.6	52.1	55.8	3.7
2010	Cooperative Farms	3/5/7/ B	Estima	2.80	2.36	-0.44	35.9	39.5	3.6	33.8	38.0	4.2
2010	Branston Potatoes Ltd	Hall Field	King Edward	2.14	1.88	-0.27	67.2	66.0	-1.1	60.6	61.3	0.7
2010	RS Cockerill Ltd	Field 16	Hermes	3.45	2.56	-0.89	55.8	58.4	2.6	52.5	55.8	3.2
2010	RS Cockerill Ltd	Field 18	Hermes	3.14	2.35	-0.79	57.1	65.4	8.3	55.6	62.9	7.3
2011	Branston Potatoes Ltd	Nocton 2	Maris Piper	1.76	1.51	-0.25	71.2	68.3	-2.9	69.3	67.0	-2.3
2011	RS Cockerill Ltd	Field 11	Hermes	3.70	2.65	-1.05	61.9	73.5	11.6	59.9	72.1	12.1
2011	Co-operative Farms	Pasture 116	Maris Piper	2.40	2.08	-0.32	63.9	61.0	-2.9	62.2	59.7	-2.5
2011	Co-operative Farms	Pasture 116	Maris Piper	2.40	2.08	-0.32	68.3	62.8	-5.5	66.8	61.3	-5.5
2011	Tame Valley Potatoes	29 Acre	Russet Burbank	1.73	1.43	-0.30	71.5	66.4	-5.1	67.7	63.5	-4.2
2011	Tame Valley Potatoes	29 Acre	Russet Burbank	1.83	1.51	-0.32	65.0	60.4	-4.5	57.8	55.0	-2.9
2011	B&C Farming Ltd	Grove Farm 91	Russet Burbank	1.49	1.05	-0.44	75.6	67.1	-8.5	70.0	62.4	-7.6
2011	B&C Farming Ltd	Grove Farm-91	Russet Burbank	1.47	1.01	-0.46	72.4	66.5	-5.9	65.0	59.8	-5.2
2011	B&C Farming Ltd	Medler Melton	Russet Burbank	1.49	1.05	-0.44	59.8	57.3	-2.5	51.0	50.2	-0.8

Table 6. (continued)

Year	Grower	Field	Variety	Standard seed rate (t/ha)	Modified seed rate (t/ha)	Change in seed rate (t/ha)	Standard yield > 10 mm (t/ha)	Modified yield > 10 mm (t/ha)	Change in yield > 10 mm (t/ha)	Standard yield > 40 mm (t/ha)	Modified yield > 40 mm (t/ha)	Change in yield > 40 mm (t/ha)
2011	B&C Farming Ltd	Medler Melton	Russet Burbank	1.47	1.01	-0.46	58.5	61.3	2.8	48.6	54.8	6.2
2012	Co-operative Farn	Field 38/02	Harmony	3.09	2.71	-0.38	50.3	61.0	10.7	47.5	58.4	10.9
2012	Cockerills	Richardson	VR808	1.92	1.49	-0.43	37.2	35.6	-1.6	30.4	31.3	0.8
2012	James Daw	Green Lane	Markies	1.98	1.66	-0.31	43.1	54.4	11.3	40.1	52.4	12.2
2012	James Daw	Green Lane	Russet Burbank	1.71	1.40	-0.31	41.4	46.4	5.0	35.2	40.5	5.3
2012	B&C Farming	Grove Farm 82	Russet Burbank	1.50	1.29	-0.22	72.5	69.9	-2.7	68.0	66.0	-2.0
2012	B&C Farming	Fengate	Russet Burbank	1.53	1.25	-0.27	63.6	65.2	1.6	58.8	59.5	0.8
2012	B&C Farming	Fengate	Russet Burbank	1.74	1.15	-0.59	64.0	59.5	-4.5	55.5	55.2	-0.4
2012	B&C Farming	Medler C. Hall	Russet Burbank	1.50	1.29	-0.22	61.4	57.4	-4.1	54.1	50.5	-3.6
			Average (n=56)	2.55	1.99	-0.56	57.6	57.3	-0.2	53.2	53.9	0.6

Not included in summaries because: †achieved seed rates different to those intended; ††variable crop due to blight.

Appendix 2.

Table 20. Summary statistics comparing standard seed and nitrogen application rates with modified for all comparisons and restricted to valid comparisons in 2007-2012. P is the probability that the difference between standard and modified agronomy is zero

		Total yield > 10 mm (t/ha)		Tuber yield > 40 mm (t/ha)	
Comparison		Standard	Reduced	Standard	Reduced
N application rate	Valid data (n=24)	54.8±2.26	58.0±2.46	51.4±2.43	54.4±2.68
	Difference	+3.3±1.31; P=0.02		+3.0±1.28; P=0.03	
	All data (n=28)†	*56.0±2.04*	*57.9±2.14*	*52.7±2.18*	*54.3±2.33*
Seed rate	Valid data (n=41)	58.3±1.59	58.1±1.42	53.2±1.27	53.9±1.33
	Difference	-0.2±0.86; P=0.79		+0.8±0.86; P=0.36	
	All data (n=56)†	*57.6±1.27*	*57.3±1.27*	53.9±1.59	54.7±1.42

† All data shown for completeness but they included invalid comparisons