Potato Council & NIAB-CUF Grower Collaboration Project (R295) Report for 2014

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Seed rate comparison in Challenger, Field 14JP027, near Holt, Norfolk, 24 June 2014

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Summary

1. In 2014, comparisons of contrasting agronomic practices were done with Frederick Hiam, Ltd., Three Musketeers Ltd., Robin Baines and WB Daw and Son.

2. In total 25 seed rate comparison were done in the varieties Challenger, Golden Nugget, Innovator, Lady Claire, Marabel, Marfona, Markies and VR808 and five N rate comparison were done in the varieties Lady Rosetta and Melody. In some cases the comparisons were done to provide information to help develop improved agronomic practices rather than as a test of grower standard practices against best practice determined from recent research.

3. In common with previous seasons, a proportion of the comparisons between "standard" and "improved" agronomies had to be excluded from summary tables since the achieved plant populations were excessively (> 10 %) different from those intended.

4. For the 21 valid comparisons of reduced N application rate, reducing the N application from an average of 196 kg N/ha to an average of 168 kg N/ha was associated with a statistically significant increase in total yield from 56.4 to 61.0 t/ha an estimated increase in the financial margin over seed and N costs of £614/ha. Similarly, for the 41 valid comparison of reduced seed rates, reducing the average seed rate from 2.34 to 1.91 t/ha was associated with a small decrease in total yield (0.3 t/ha) but an increase in the margin over seed and costs of £176/ha.

5. Whilst these conclusions are not directly applicable to the wider UK crop, they demonstrate that opportunities exist to reduce inputs of N fertilizer and seed whilst maintaining or increasing financial performance.

Introduction

The 'Grower Collaboration' project is funded by Potato Council (Project R295) and started in 2007. It is a mechanism of knowledge transfer that scales up results from small-plot research to larger scale (e.g. split-field) demonstrations of principle. The project involves collaboration between NIAB-CUF, Potato Council, growers and their agronomists and other supply-chain partners. This structure promotes understanding of the constraints within current production systems and then helps identify opportunities for future improvement in production practices. The collaborating growers and agronomists are responsible for providing cropping information (see below) and for planting the strips that compare contrasting agronomies. Staff at NIAB-CUF were responsible for devising 'improved' agronomies based on the information supplied by the grower. A key component of the process is the accurate and systematic documentation of 'standard' and 'improved' practises so that it is possible to objectively compare these contrasting agronomies.

Materials and Methods

In spring 2014, cropping information (Table 1) was collated by growers and agronomists for a selection of candidate crops and sent to NIAB-CUF for processing. Fertilizer and seed rate recommendations were calculated for a sub-set of these crops using the information supplied.

Table 1. Summary of typical information used by NIAB-CUF to calculate seed rates and nitrogen application rates

Information used by NIAB-CUF to calculate optimum seed rate	Information used by NIAB-CUF to calculate optimum nitrogen application rate
Variety	Variety
Planting configuration and average row widths	Field location
Seed size (mm) and seed count (number/50 kg)	Intended planting date of ware crop
Emergence date of seed crop	Intended defoliation/harvest date(s) of ware crop
Intended planting date of ware crop	Intended ware crop yield (total or marketable)
Intended ware crop yield (total or marketable)	Soil texture and organic matter content
Intended ware crop size specification	Previous crop
Grower intended ('standard') seed rate	Organic manure usage history
	Form, timing and method of nitrogen applications
	Historic information: problems with skin-set, tuber dry matter concentration, defoliation of excessive canopies etc.
	Grower intended ('standard') nitrogen application rate

The dates of seed crop emergence and ware crop planting were factors accounted for in determining NIAB-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 NIAB-CUF were identified and opportunities for making comparisons of 'standard' with 'NIAB-CUF modified' recommendations were then discussed with collaborating growers. Some seed rate comparisons were set up with varieties for which only limited data were available including varieties forming part of part of a project to derive seed rates rapidly (Potato Council Project R446). For these comparisons, the seed rates were experimental rather than representing recommended rates. In each case a width of *c.* 24 m within a field received modified agronomy whilst standard agronomy was applied to the rest of the crop. 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. Furthermore, since comparisons were only tested if the modified agronomy differed by more than 10 % from standard agronomy the results from these comparisons should not be used to make inferences about potato agronomy in general. In other cases, even where there were no substantial differences between 'standard' and 'NIAB-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 NIAB-CUF during the season. Staff from NIAB-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.

Acknowledgements

The authors thank the following people for making this program possible: Kerry Andrews (3Ms Ltd.), Robin Baines (Robin Baines & Co), Phil Bradshaw (Potato Council Ltd.), Will Brice (Frederick Hiam Ltd.), Richard Dannat (Lamb Weston Meijer), James Daw (WB Daw & Son, Woodhouse Farm) Graeme Ditty (Tame Valley Potatoes), Peter Dobson (Mercian Potatoes), Charlie Hancock (Frederick Hiam Ltd.), Mark Taplin (Tame Valley Potatoes Ltd.), Jim Wayman

(3Ms Ltd.) and Andrew Webster (AW & MA Webster). Thanks are also due to the Technical Staff at NIAB-CUF who assisted in sampling, grading and assessing the potato crops.

Results and Discussion

Sites and monitored crops

In 2014, a total of 30 "crops" were monitored and some details for these crops are shown in Table 2. For crops of Marabel, Golden Nugget, Challenger and Innovator there was little, reliable data to calculate an improved seed rate. For these crops it was decided to compare the performance of the crop planted at the standard population with crops planted at an arbitrary 15 % larger and 15 % smaller populations. For the comparisons in Lady Rosetta, three N rates were tested: an historic rate used by Andrew Webster (225 kg N/ha), the current rate (206 kg N/ha) and an improved rate (188 kg N/ha).

Table 2. Summary of crops monitored as part of Potato Council and NIAB-CUF grower collaboration program in 2014

Grower Group	Sector	Varieties	Number of seed-rate comparisons	Number of nitrogen rate comparisons
Frederick Hiam Ltd.	Fresh Market	Marfona	2	0
Frederick Hiam Ltd.	Fresh Market	Melody	0	2
Frederick Hiam Ltd	Fresh Market	Marabel	3	0
James Daw	Processing	Markies	2	0
James Daw	Processing	VR808	6	0
Andrew Webster	Processing	Lady Rosetta	0	3
Andrew Webster	Processing	Lady Claire	2	0
Robin Baines	Processing	Challenger	3	0
Robin Baines	Processing	Innovator	3	0
3Ms Ltd.	Fresh Market	Golden Nugget	4	0

Three Musketeers Ltd.

Seed rate comparisons in Golden Nugget

Three Musketeers Ltd (3Ms) are a production and marketing cooperative based near Butley, Suffolk and they joined the Grower Collaboration programme in 2013. Three Musketeers specialise in the supply of early salad-potatoes to several customers. Following discussions with Jim Wayman at 3Ms it was decided to use the Grower Collaboration project to collect information about a new salad potato variety (Golden Nugget) that would help inform future seed rate recommendations. To achieve this, two seed sizes (30-40 and 40-50 mm) were planted at either 80 % or 115 % of the 'standard' rate giving a total of four comparisons (Table 3). All the comparisons were planted on 9 May and 50 % plant emergence was estimated to have occurred on 2 June. However, emergence was reported to have been erratic and plant populations were variable across the field.

Table 3. Details of seed and ware crops for comparison of increased and decreased seed rates for Golden Nugget

Field name	Beacon	Beacon
Variety	Golden Nugget	Golden Nugget
Planting configuration	Four row bed	Four row bed
Average row width (cm)	45.72	45.72
Seed crop†		
Seed size (mm)	30-40	40-50
Count (no./50 kg)	1640	895
Ware crop		
Intended total yield (t/ha)	30	30
Intended date of planting	9 May	9 May
Intended grower and NIAB-CUF plant population and within row spacings		
Increased population (000/ha)†	143.50	54.70
Increased spacing (cm)†	15.2	22.9
Decreased population (000/ha)†	107.60	66.20
Decreased spacing (cm)†	20.3	33.0
Intended grower application rate		
Grower N rate (kg N/ha)	146	146

†The date of seed crop emergence not known and was assumed to be 1 June 2013 by default.

For the small seed (30-40 mm and with a count of 1640/50 kg) the intended plant populations for the decreased and increased seed rates were 107 600 and 143 500/ha, respectively, (Figure 1).

Figure 1. Comparison of reduced and increased seed rates for small seed Golden Nugget, Three Musketeers Ltd. Beacon Field, Butley, Suffolk.

Grower:	Capel St Andrews Farms	Capel St Andrews Farms
Field name:	Beacon	Beacon
Unique ID:	TMS12014281	TMS12014282
Part Field Name:	30-40-80%	30-40-115%
Variety:	Golden Nugget	Golden Nugget
Intended yield:	30 t/ha	30 t/ha
Intended use:	Salad	Salad
Planting date (start):	9 May	9 May
Date of 50 % emergence:	2 Jun	2 Jun
Total N applied:	146 kg N/ha	146 kg N/ha
Seed size:	30-40 mm	30-40 mm
Seed count:	1640 per 50 kg	1640 per 50 kg
Planned density:	107.6 000/ha	143.5 000/ha
Planned spacing:	20.3 cm	15.2 cm
Achieved density:	99.6 000/ha	130.0 000/ha
Achieved spacing:	22.0 cm	16.8 cm

Yield Samples (S.E. in italics)

		30-40-80% 13 Aug		30-40-115% 13 Aug
Plants (000/ha)		99.6		130.0
		15.80		*9.95*
Stems (000/ha)		414.4		503.1
		79.46		*16.44*
Stems/plant		4.1		3.9
		0.31		*0.28*
Tubers (000/ha)	> 10 mm	893	> 10 mm	1091
		22.2		*8.0*
Tubers (000/ha)	> 35 mm	176	> 35 mm	287
		13.5		*23.2*
Tuber yield (t/ha)	> 10 mm	20.8	> 10 mm	28.7
		0.86		*0.34*
Tuber yield (t/ha)	> 35 mm	8.6	> 35 mm	14.1
		0.79		*1.32*
DM (%)		23.1		21.3
		0.18		*0.45*
Mean tuber size (mm)		32.9		34.3
		0.47		*0.49*

For both comparisons, the achieved plant populations were *c*. 10 % smaller than intended but they still differed from each other by *c*. 30 000 plants/ha. The number of stems produced per plant was similar for both comparisons and in consequence the stem population was 414 400/ha in the reduced plant population comparison compared with 503 100/ha in the comparison using the increased plant population. Despite the difference

in stem populations, both comparisons produced similar numbers of tubers per stem (average 2.2) and, in consequence, the total (> 10 mm) tubers population differed by *c*. 200 000/ha between the two comparisons. The total yield (> 10 mm) for the reduced and increased plant populations was 20.8 and 28.7 t/ha, respectively. However, this difference in yield is unlikely to be a consequence of the difference in plant population since even the reduced plant population comparison had sufficient plants to ensure rapid ground cover development and yield formation should not have been compromised. Due to its larger total yield, the increased plant population plots had a larger mean tuber size than the decreased plant population plots despite having a larger tuber population.

For the large seed (50-60 mm and with a count of 895/50 kg) the intended plant populations for the decreased and increased seed rates were 66 200 and 95 700/ha, respectively, (Figure 2). For the reduced seed rate, the achieved plant population was larger than intended, whereas for the increased seed rate the achieved plant population was smaller. In consequence, the difference in achieved plant populations between the two comparisons was small (2 500/ha). On average the large seed produced 6.0 main stems and the main stem populations were 478 800 and 533 400/ha in the reduced and increased seed rate comparisons, respectively. Total tuber populations were 1 135 000/ha when planted at the smaller seed rate and 877 000/ha when planted at the larger. In common with the small-seed comparisons, there was a large difference in total yield between the crops planted with reduced or increased seed rates and this difference is unlikely to be a consequence of the seed rate used. In response to the smaller tuber population and larger tuber yield, the mean tuber size for the reduced seed rate was 36.2 mm compared with 33.8 mm when the increased seed rate had been used. Due to variation in the crop unconnected with the seed rate comparisons, it is difficult to draw too many conclusions from this experiment. However, data on the effects of seed count on main stem population, the number of tuber initiated and retained per stem and other factors such as tuber shape will be useful in devising improved seed rates for this variety.

Figure 2. Comparison of reduced and increased seed rates for large seed Golden Nugget, Three Musketeers Ltd. Beacon Field, Butley, Suffolk.

Grower:	Capel St Andrews Farms	Capel St Andrews Farms
Field name:	Beacon	Beacon
Unique ID:	TMS12014283	TMS12014284
Part Field Name:	40-50-80%	40-50-115%
Variety:	Golden Nugget	Golden Nugget
Intended yield:	30 t/ha	30 t/ha
Intended use:	Salad	Salad
Planting date (start):	9 May	9 May
Date of 50 % emergence:	2 Jun	2 Jun
Total N applied:	146 kg N/ha	146 kg N/ha
Seed size:	40-50 mm	40-50 mm
Seed count:	895 per 50 kg	895 per 50 kg
Planned density:	66.2 000/ha	95.7 000/ha
Planned spacing:	33.0 cm	22.9 cm
Achieved density:	83.8 000/ha	86.3 000/ha
Achieved spacing:	26.1 cm	25.4 cm

Yield Samples (S.E. in italics)

		40-50-80%		40-50-115%
		13 Aug		13 Aug
Plants (000/ha)		83.8		86.3
		2.10		*5.30*
Stems (000/ha)		478.8		533.4
		23.28		*13.69*
Stems/plant		5.7		6.2
		0.35		*0.52*
Tubers (000/ha)	> 10 mm	1135	> 10 mm	877
		63.9		*58.4*
Tubers (000/ha)	> 35 mm	383	> 35 mm	231
		5.6		*3.2*
Tuber yield (t/ha)	> 10 mm	32.9	> 10 mm	25.2
		0.47		*0.79*
Tuber yield (t/ha)	> 35 mm	20.0	> 35 mm	11.5
		0.58		*0.11*
DM (%)		21.7		21.8
		0.09		*0.36*
Mean tuber size (mm)		36.2		33.8
		0.57		*0.11*

AW & MA Webster

AW and MA Webster is a family-run farm based near Ormskirk, Lancashire. A component of their potato business is as a member of Mercian Potatoes and the supply of crisping potatoes to the Walker's factory at Skelmersdale. AW and MA Webster joined the Grower Collaboration program in 2014 partly with the objective of improving the efficiency of production but also to provide knowledge transfer opportunities for the Potato Council's Northwest Potato Day in September 2014. Discussions with Andrew Webster identified two areas of interest: a comparison of seed rates for Lady Claire and a comparison of nitrogen application rates in Lady Rosetta. In total, three nitrogen application rates were tested: an historical rate (225 kg N/ha), the current "standard" rate (206 kg N/ha) and NIAB-CUF reduced application rate (188 kg N/ha). Key details of the field history, seed, ware crop specification and comparisons are shown in Table 4. All the comparisons were planted on 25 April and all were sampled on two occasions: 7 August (75 days after emergence) and 12 September (111 days after emergence).

Table 4. Details of field, seed and ware crops for comparison of seed rates in Lady Claire and nitrogen application rates in Lady Rosetta

Field name	Marks	Marks
Variety	Lady Claire	Lady Rosetta
Planting configuration	Two row bed	Two row bed
Average row width (cm)	91.44	91.44
Seed crop†		
Seed size (mm)	30-40	40-50
Count (no./50 kg)	1140	865
Ware crop		
Intended total yield (t/ha)	45	45
Intended date of planting	25 April	25 April
Intended grower and NIAB-CUF plant population and within row spacings		
Grower (standard) population (000/ha)	43.75	39.91
Grower (standard) spacing (cm)	25.0	27.4
NIAB-CUF (modified) population (000/ha)	36.45	n.a.
NIAB-CUF (modified) spacing (cm)	30.0	n.a.
Field details		
Soil texture	Medium	
Previous (2013) crop	Spring Wheat followed by radish &mustard cover crop	
Organic manure applications	34 m^3/ha (3000 gals/acre) pig slurry	
Intended grower application rate		
Historic N rate (kg N/ha)	n.a.	225
Grower standard N rate (kg N/ha)	225	206
NIAB-CUF N rate (kg N/ha)	n.a.	188

†The date of seed crop emergence not known and was assumed to be 1 June 2013 by default.

Seed rate comparisons in Lady Claire

Both seed rate comparisons attained 50 % plant emergence on 24 May (Figure 3). Initial ground cover development was faster in the Lady Claire planted at the standard seed rate but both comparisons achieved near complete ground cover and persisted for a similar length of time. Thus, both of these crops would have absorbed similar amount of solar radiation. For both the standard and modified crops, the achieved plant populations were slightly larger than intended and when averaged over both samplings were 44 960 (equivalent to a within row spacing of 24.3 cm and a seed rate of 1.97 t/ha) and 37 060/ha (29.5 cm, 1.63 t/ha), respectively. The difference between the achieved plant populations was more than 10 % and these data are therefore included in the summary tables. The standard crop had an average stem population of 249 000/ha compared with 202 000 in the modified crop. For both the standard and modified crops the number of tubers set and

retained per stem was large (mean 5.5) and, in consequence, the total tuber (> 10 mm) population was very large, particularly in the standard crop. At the initial sampling (7 August) total tuber yields were 51.0 and 58.8 t/ha in the standard and modified crops, respectively. This difference in yield was unlikely to be a consequence of the plant population and was probably due to the location of the samples in the field. At the second sampling (12 September) total yields were very similar in both comparisons and averaged 57.1 t/ha. Due to the reductions in tuber population, the mean tuber size was larger in the modified crop (47.8 mm) than in the standard crop (45.2 mm). Numerically, the ware yield (> 40 mm) was larger in the modified crop than in the standard crop and this is consistent with the smaller tuber population. The tuber count (no/10 kg) at the second sampling was 122 and 108 for the standard and modified crops respectively. The current Walker's specification is for tubers > 40 mm with a count of between 72 and 112. There was no discernible effect of plant population on tuber dry matter concentration which averaged 19.4 % at the second sampling. This comparison shows that there is the potential to reduce seed rates in Lady Claire without compromising ware yield, indeed the stem and tuber population data suggest that seed rates could have been reduced further and this would have resulted in an increased proportion of ware-sized tuber that were closer to end-user requirements.

Nitrogen rate comparisons in Lady Rosetta

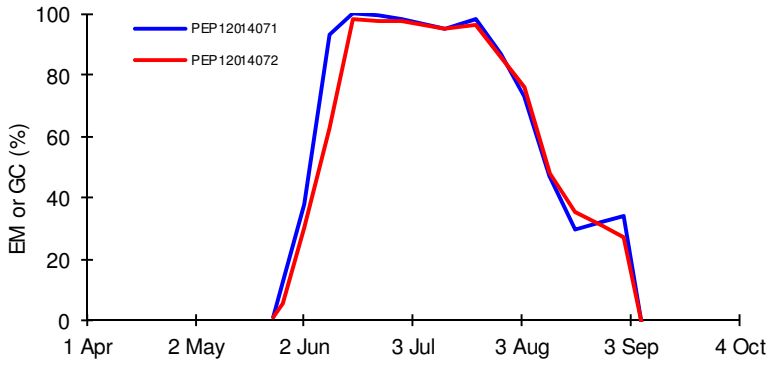
Crops produced using the historic (225 kg N/ha) and standard (206 kg N/ha) N rates achieved 50 % plant emergence on 24 May, about one month after planting (Figure 4). Initial ground cover development was similar for both N comparisons and both achieved complete ground cover which was maintained for several weeks however the standard N treatment senesced earlier than the larger, historic N treatment. The planned planting density for all three N rate comparisons was 39 910/ha (equivalent to a within row spacing of 27.4 cm and a seed rate of 2.31 t/ha). The achieved plant populations for both the standard and historic N rate comparison were similar to that intended. For both comparisons, stem and total tuber populations were larger at the first sampling than at the second but averaged 141 000 and 833 000/ha, respectively for both comparisons. At the first sampling, total yields in standard and historic N rate comparisons were 46.0 and 50.0 t/ha, respectively, and at the second sampling the difference in yield had increased to 12 t/ha. Due to the larger yield at the final sampling, the mean tuber size was larger in the

historic than in the standard comparison and, likewise, the tuber count was smaller in the historic N rate comparison (98 tubers/10 kg) than in the standard N rate comparison (107 tubers/10 kg).

Reducing the N application rate from 206 to 188 had no effect on the date of 50 % plant emergence which averaged 24 May (Figure 5). The achieved plant population for the reduced N comparison was smaller than that intended (41 310/ha at an average, within row spacing of 26.5 cm). In the early part of the season, ground cover development was identical for both the standard and reduced N application rates. Canopy senescence was earlier in the standard N crop than in the reduced N crop and this was unexpected since reduced rates of N application are normally associated with less persistent canopies. When compared with the standard crop, the stem and total tuber populations in the reduced N crop were more consistent between the two sampling and averaged 161 000 and 894 000/ha, respectively. For the reduced N crop, total tuber yield increased from 51.8 to 62.9 t/ha between 7 August and 12 September. At the final sampling and when compared with the standard crop, reducing the N application was associated with an increase in yield from 50.5 to 62.9 t/ha. Of significance, is that the total tuber yield at the historic (225 kg N/ha) and the reduced (188 kg N/ha) were nearly identical and averaged 62.5 t/ha. These data suggest that the standard crop may have been grown in a poor part of the field and its relatively small yield was not directly associated with the amount of N it received. As a consequence of its larger yield, the reduced N crop had a larger mu and a smaller count than the crop that received the standard amount of N.
The similarity in yields of the crops that received 225 and 188kg N/ha suggest that opportunities exist to reduce N applications whilst still maintaining yield and crop quality and these possibilities could be tested in future studies.

Figure 3. Comparison of standard and modified seed rates in Lady Claire, AW & MA Webster, Marks Field.

Grower:	AW & MA Webster	AW & MA Webster
Field name:	Marks	Marks
Unique ID:	PEP12014071	PEP12014072
Part Field Name:	Standard Population (IC-1210)	Reduced Population (IC-1211)
Variety:	Lady Claire	Lady Claire
Intended yield:	45 t/ha	45 t/ha
Intended use:	Crisping-Storage	Crisping-Storage
Planting date (start):	25 Apr	25 Apr
Date of 50 % emergence:	24 May	24 May
Total N applied:	225 kg N/ha	225 kg N/ha
Seed count:	1140 per 50 kg	1140 per 50 kg
Planned density:	43.75 000/ha	36.45 000/ha
Planned spacing:	25.0 cm	30.0 cm
Achieved density:	44.96 000/ha	37.06 000/ha
Achieved spacing:	24.3 cm	29.5 cm

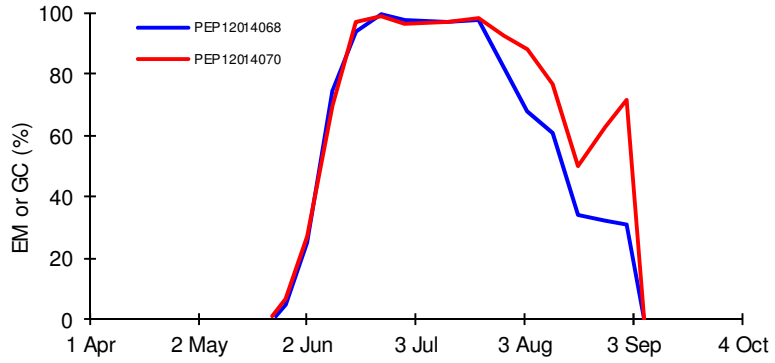


Yield Samples (S.E. in italics)

		Standard Population (IC-1210)			Reduced Population (IC-1211)	
		7 Aug	12 Sep		7 Aug	12 Sep
Plants (000/ha)		45.0	45.0		37.7	36.5
		1.22	*1.22*		*2.43*	*0.00*
Stems (000/ha)		238.2	258.8		215.1	189.6
		4.86	*17.23*		*14.73*	*5.57*
Stems/plant		5.3	5.8		5.7	5.2
		0.22	*0.29*		*0.42*	*0.15*
Tubers (000/ha)	> 10 mm	994	982	> 10 mm	988	855
		94.2	*48.3*		*79.4*	*32.6*
Tubers (000/ha)	> 40 mm	490	558	> 40 mm	560	527
		42.2	*35.4*		*52.6*	*46.2*
Tuber yield (t/ha)	> 10 mm	51.0	57.2	> 10 mm	58.8	57.0
		3.62	*1.24*		*3.40*	*4.73*
Tuber yield (t/ha)	> 40 mm	38.0	45.6	> 40 mm	47.1	48.7
		3.35	*1.30*		*3.36*	*5.13*
DM (%)		20.6	19.3		20.7	19.5
		0.70	*0.65*		*0.46*	*0.13*
Mean tuber size (mm)		44.0	45.2		45.5	47.8
		0.68	*0.33*		*0.78*	*0.54*

Figure 4. Comparison of standard and historic nitrogen application rates in Lady Rosetta, AW & MA Webster, Marks Field.

Grower:	AW & MA Webster	AW & MA Webster
Field name:	Marks	Marks
Unique ID:	PEP12014068	PEP12014070
Part Field Name:	Standard N (IC-1207)	Historic N (IC-1209)
Variety:	Lady Rosetta	Lady Rosetta
Intended yield:	45 t/ha	45 t/ha
Intended use:	Crisping-Storage	Crisping-Storage
Planting date (start):	25 Apr	25 Apr
Date of 50 % emergence:	24 May	23 May
Total N applied:	206 kg N/ha	225 kg N/ha
Seed size:	40-50 mm	40-50 mm
Seed count:	865 per 50 kg	865 per 50 kg
Planned density:	39.91 000/ha	39.91 000/ha
Planned spacing:	27.4 cm	27.4 cm
Achieved density:	38.88 000/ha	39.49 000/ha
Achieved spacing:	28.1 cm	27.7 cm

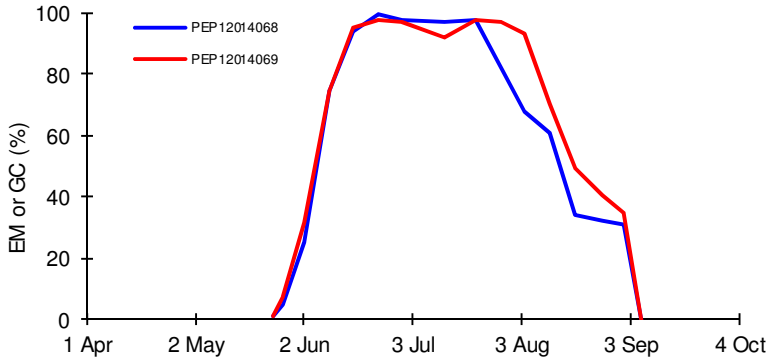


Yield Samples (S.E. in italics)

	Standard N (IC-1207)			Historic N (IC-1209)	
	7 Aug	12 Sep		7 Aug	12 Sep
Plants (000/ha)	38.9	38.9		40.1	38.9
	1.22	*2.43*		*0.00*	*1.22*
Stems (000/ha)	162.8	113.0		153.1	134.9
	4.38	*13.14*		*15.18*	*16.71*
Stems/plant	4.2	2.9		3.8	3.5
	0.15	*0.43*		*0.38*	*0.36*
Tubers (000/ha) > 10 mm	916	704	> 10 mm	913	801
	27.8	*18.0*		*76.2*	*75.8*
Tubers (000/ha) > 40 mm	470	487	> 40 mm	496	555
	31.8	*12.3*		*9.6*	*53.5*
Tuber yield (t/ha) > 10 mm	46.0	50.5	> 10 mm	50.0	62.1
	2.67	*2.29*		*1.04*	*3.02*
Tuber yield (t/ha) > 40 mm	35.8	45.4	> 40 mm	41.1	56.8
	2.92	*2.43*		*2.74*	*2.42*
DM (%)	23.6	22.8		22.4	21.9
	0.63	*0.27*		*0.03*	*0.21*
Mean tuber size (mm)	45.2	50.8		47.4	52.6
	0.46	*0.60*		*1.42*	*1.10*

Figure 5. Comparison of standard and reduced nitrogen application rates in Lady Rosetta, AW & MA Webster, Marks Field.

Grower:	AW & MA Webster	AW & MA Webster
Field name:	Marks	Marks
Unique ID:	PEP12014068	PEP12014069
Part Field Name:	Standard N (IC-1207)	Reduced N (IC-1208)
Variety:	Lady Rosetta	Lady Rosetta
Intended yield:	45 t/ha	45 t/ha
Intended use:	Crisping-Storage	Crisping-Storage
Planting date (start):	25 Apr	25 Apr
Date of 50 % emergence:	24 May	24 May
Total N applied:	206 kg N/ha	188 kg N/ha
Seed size:	40-50 mm	40-50 mm
Seed count:	865 per 50 kg	865 per 50 kg
Planned density:	39.91 000/ha	39.91 000/ha
Planned spacing:	27.4 cm	27.4 cm
Achieved density:	38.88 000/ha	41.31 000/ha
Achieved spacing:	28.1 cm	26.5 cm



Yield Samples (S.E. in italics)

	Standard N (IC-1207)			Reduced N (IC-1208)	
	7 Aug	12 Sep		7 Aug	12 Sep
Plants (000/ha)	38.9	38.9		40.1	42.5
	1.22	*2.43*		*0.00*	*1.22*
Stems (000/ha)	162.8	113.0		162.8	159.2
	4.38	*13.14*		*7.97*	*9.95*
Stems/plant	4.2	2.9		4.1	3.7
	0.15	*0.43*		*0.20*	*0.18*
Tubers (000/ha) > 10 mm	916	704	> 10 mm	932	857
	27.8	*18.0*		*39.8*	*72.0*
Tubers (000/ha) > 40 mm	470	487	> 40 mm	519	606
	31.8	*12.3*		*10.8*	*30.4*
Tuber yield (t/ha) > 10 mm	46.0	50.5	> 10 mm	51.8	62.9
	2.67	*2.29*		*1.13*	*3.88*
Tuber yield (t/ha) > 40 mm	35.8	45.4	> 40 mm	42.8	57.5
	2.92	*2.43*		*2.45*	*3.38*
DM (%)	23.6	22.8		22.7	22.6
	0.63	*0.27*		*0.27*	*0.13*
Mean tuber size (mm)	45.2	50.8		47.4	51.4
	0.46	*0.60*		*1.03*	*1.01*

WB Daw & Son

WB Daw and Sons are based in Staffordshire and, as a consequence of their membership of supplier groups for Walker's Crisp (Mease Valley Potatoes) and for McCain (Tame Valley Potatoes), have been involved with the Grower Collaboration project since its inception in 2007. In 2014, after discussion with Potato Council and James Daw it was decided to test reduced seed rates in a Markies crop destined for French-fry production by McCain and in VR808 an increasingly important variety for Walker's. For the VR808 reduced seed rates were tested on range of seed tuber sizes derived from the same stock whereas for Markies a single comparison was done. Selected details of the seed and ware crops are show in Table 5.

Table 5. Details of field, seed and ware crops for comparison of seed rates in Markies in Ellis Brook field and VR808 in Thorpe 29 field.

Field name	Ellis Brook	Thorpe 29	Thorpe 29	Thorpe 29
Variety	Markies	VR808	VR808	VR808
Planting configuration	2 row bed	2 row bed	2 row bed	2 row bed
Average row width (cm)	91.44	91.44	91.44	91.44
Seed crop				
Date of emergence of seed crop (2013)	24 June	14 June	14 June14	14 June
Seed size (mm)	35-45	30-40	40-50	50-60
Count (no./50 kg)	900	1755	977	574
Ware crop				
Intended total yield (t/ha)	50	65	65	65
Intended date of planting	17 April	27 April	27 April	27 April
Intended grower and NIAB-CUF plant population and within row spacings				
Grower (standard) population (000/ha)	34.18	61.44	41.74	31.16
Grower (standard) spacing (cm)	32.0	17.8	26.2	35.1
NIAB-CUF (modified) population (000/ha)	26.87	43.23	33.14	24.20
NIAB-CUF (modified) spacing (cm)	40.7	25.3	33.0	45.2
Grower standard N rate (kg N/ha)	170	220	220	220

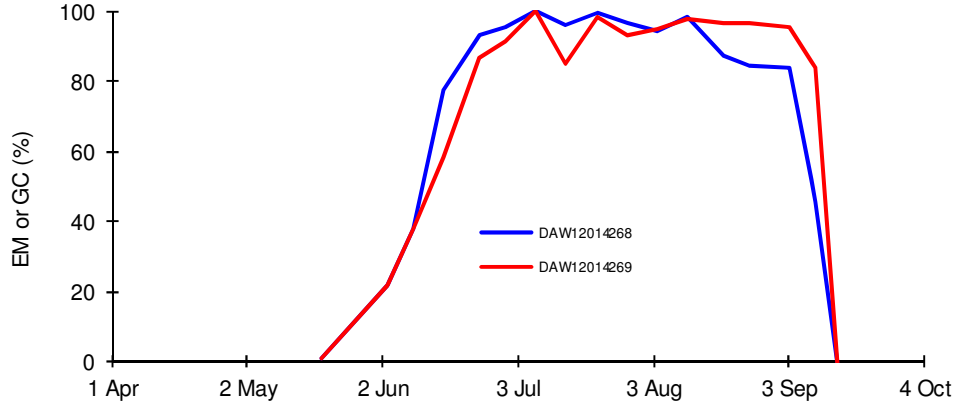
Seed rate comparisons in Markies

The two Markies comparisons were planted on 17 April and both achieved 50 % plant emergence on 19 May (Figure 6). For both comparisons canopy expansion was slower than expected and the crops grown at the wider spacing took longer to achieve complete ground cover. Both crops maintained near-complete ground cover for several weeks. There was some evidence that the crop grown at the standard density started to senesce

before the reduced density. Both crops were defoliated on 9 September. For both the standard and reduced seed rates, the achieved plant populations were similar to those intended and the achieved plant populations differed by more than 10 %. The Markies crop was sampled on two occasions: 22 July (64 days after emergence) and 18 September (122 days after emergence). When averaged over sampling dates, the stem and total tuber populations in the standard crop were 87 500 and 342 000/ha, respectively, compared with 65 600 and 250 000/ha, respectively, in the reduced seed-rate comparison. At both samplings, total yields were similar for the standard and reduced seed rate comparisons and averaged 33.2 t/ha on 22 Jul and 56.2 t/ha on 18 September. Similarly, ware yield (> 45 mm) was also similar for crops grown using the standard and reduced seed rates. Decreasing the achieved plant population from 36 000 to 27 800/ha was associated with an increase in mean tuber at the final sampling from 62.1 to 65.5 mm. There was some evidence that tubers from the reduced density comparison were more likely to have internal rust spot (IRS) (Table 6). However, most of the IRS seen in the reduced seed rate comparison was faint speckling of the tuber and this was unlikely to affect their commercial value.

Figure 6. Comparison of standard and reduced seed rates in Markies, WB Daw & Son, Ellis Brook Field.

Grower:	James Daw	James Daw
Field name:	Ellis Brook	Ellis Brook
Unique ID:	DAW12014268	DAW12014269
Part Field Name:	Standard Population	Reduced Population
Variety:	Markies	Markies
Intended yield:	50 t/ha	50 t/ha
Intended use:	French-fries	French-fries
Planting date (start):	17 Apr	17 Apr
Date of 50 % emergence:	19 May	19 May
Total N applied:	170 kg N/ha	170 kg N/ha
Seed size:	35-45 mm	35-45 mm
Seed count:	900 per 50 kg	900 per 50 kg
Planned density:	34.2 000/ha	26.9 000/ha
Planned spacing:	32.0 cm	40.7 cm
Achieved density:	36.0 000/ha	27.8 000/ha
Achieved spacing:	30.4 cm	39.3 cm



Yield Samples (S.E. in italics)

		Standard Population			Reduced Population	
		22 Jul	18 Sep		22 Jul	18 Sep
Plants (000/ha)		38.3	33.7		30.1	25.5
		1.05	*0.91*		*1.75*	*0.00*
Stems (000/ha)		93.0	82.0		70.2	61.1
		6.74	*5.67*		*8.60*	*5.64*
Stems/plant		2.4	2.4		2.3	2.4
		0.14	*0.10*		*0.30*	*0.22*
Tubers (000/ha)	> 10 mm	353	332	> 10 mm	260	241
		22.0	*17.0*		*42.0*	*23.8*
Tubers (000/ha)	> 45 mm	265	271	> 45 mm	208	201
		22.7	*16.9*		*30.5*	*16.1*
Tuber yield (t/ha)	> 10 mm	33.8	57.4	> 10 mm	32.6	54.9
		2.36	*3.38*		*4.53*	*4.34*
Tuber yield (t/ha)	> 45 mm	28.4	56.3	> 45 mm	29.4	54.1
		2.45	*3.35*		*4.56*	*4.60*
DM (%)		18.1	24.7		17.4	23.3
		1.02	*0.90*		*0.38*	*0.69*
Mean tuber size (mm)		52.1	62.1		55.4	65.5
		0.61	*0.77*		*1.67*	*1.08*

Table 6. Summary of the effect of plant population and mean tuber size on tuber dry matter and internal defects in Markies in 2014

Variety	Achieved plant population (000/ha)	No defects (%)	Slight speckling (%)	Obvious 2-3 mm spots (%)	Large 4-5 mm spots (%)	First signs of hollow heart (%)	Hollow heart 5-10 mm (%)	Hollow heat > 10 mm (%)	Growth crack and spraing (%)
Markies	36.0	92	2	4	0	0	1	1	0
Markies	27.8	76	13	6	4	0	0	2	0

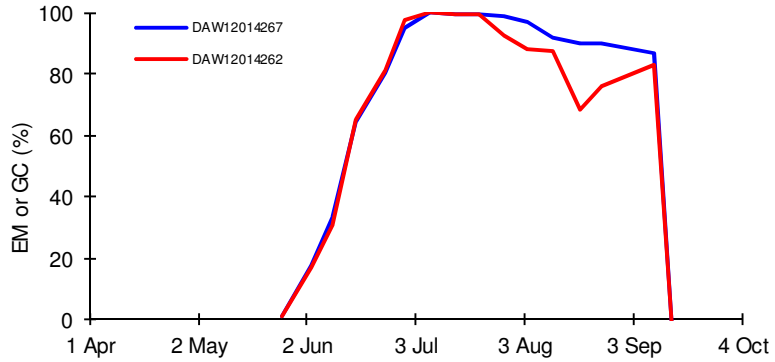
Seed rate comparisons in VR808

Small seed (count 1755/50 kg)

The seed rate comparison with the smallest seed was planted on 27 April and both the standard and reduced seed rates achieved 50 % emergence about one month later (26 May) (Figure 7). Initial ground cover development was identical for both treatments and complete ground cover was achieved irrespective of plant populations. The comparisons planted at the wider started to senesce earlier than the standard crop which is unusual since increased branching usually results in more persistent canopies. Both comparisons were defoliated on 9 September. The crops were sampled on 22 July (57 days after emergence) and 18 September (115 days after emergence). When averaged over both samplings, the achieved plant population was identical to that intended for the comparison planted at the reduced seed rate but for the standard crop the achieved plant population was slightly less than that intended. However, the achieved populations were sufficiently similar to those intended to be used in the summary tables. Average stem populations were 144 400 and 107 000/ha for the standard and modified crops, respectively, and average, total tuber populations were 543 000 and 438 000/ha. At the first sampling, total tuber yield for the standard and reduced seed rate crops were similar (35.0 and 32.4 t/ha), respectively. However, at the second sampling the total tuber yield of the standard crop was about 11 t/ha larger than that in reduced seed rate comparison. In part, this reduction in yield is consistent with the unexpected earlier onset of senescence seen in this treatment but the large difference in yield is more likely due to the location of sampling points. Despite having a smaller total yield, the reduced seed rate comparison had a larger mean tuber size (mu) than the standard crop and this was a consequence of having a total tuber population that was about 80 % of the standard crop. Despite the effect on mu, the ware yield (> 40 mm) was also smaller in the modified crop when compared with the standard crop. Tuber counts at the final sampling for ware tubers > 40 mm were 78 and 67 in 10 kg for the standard and modified crops, respectively.

Figure 7. Comparison of standard and reduced seed rates in VR808 (small seed), WB Daw & Son, Thorpe 29 Field.

Grower:	James Daw	James Daw
Field name:	Thorpe 29	Thorpe 29
Unique ID:	DAW12014267	DAW12014262
Part Field Name:	Small seed standard population	Small seed reduced population
Variety:	VR808	VR808
Intended yield:	65 t/ha	65 t/ha
Intended use:	Crisping-Storage	Crisping-Storage
Planting date (start):	27 Apr	27 Apr
Date of 50 % emergence:	26 May	26 May
Total N applied:	220 kg N/ha	220 kg N/ha
Seed count:	1755 per 50 kg	1755 per 50 kg
Planned density:	61.44 000/ha	43.23 000/ha
Planned spacing:	17.8 cm	25.3 cm
Achieved density:	54.22 000/ha	43.29 000/ha
Achieved spacing:	20.2 cm	25.3 cm



Yield Samples (S.E. in italics)

	Small seed standard population			Small seed reduced population		
	22 Jul	18 Sep		22 Jul	18 Sep	
Plants (000/ha)	53.8	54.7		42.8	43.7	
	2.29	*2.58*		*0.91*	*1.49*	
Stems (000/ha)	136.7	152.2		113.0	101.2	
	9.23	*6.02*		*7.73*	*4.04*	
Stems/plant	2.5	2.8		2.6	2.3	
	0.09	*0.15*		*0.14*	*0.06*	
Tubers (000/ha)	> 10 mm 499	588	> 10 mm	453	424	
	30.3	*10.8*		*26.9*	*17.1*	
Tubers (000/ha)	> 40 mm 352	457	> 40 mm	331	326	
	6.9	*7.9*		*20.3*	*19.9*	
Tuber yield (t/ha)	> 10 mm 35.0	61.3	> 10 mm	32.4	50.8	
	1.00	*1.33*		*1.63*	*1.77*	
Tuber yield (t/ha)	> 40 mm 31.5	58.6	> 40 mm	29.4	48.5	
	0.56	*1.23*		*1.87*	*1.86*	
DM (%)	20.3	23.5		21.2	24.5	
	0.23	*0.52*		*0.28*	*0.13*	
Mean tuber size (mm)	49.0	58.1		49.0	60.3	
	0.33	*0.46*		*0.73*	*1.54*	

Medium seed (count 977/10 kg)

The seed rate comparisons using the medium size seed had 50 % plant emergence on 26 May (Figure 8). Early-season ground cover development was similar for both comparisons. During August, the ground cover of the wider spaced crop was less than that in the standard crop but this difference was negligible at the time of defoliation (9 September). For the standard crop, the intended plant population was 41 740/ha and, using data from both samplings, the achieved plant population was 40 550/ha. For the reduced seed rate crop, the achieved plant population was slightly larger than intended (34 180 compared with 33 140/ha). The difference between the achieved plant population in the standard and modified crop was nonetheless more than 10 %. Stem and tuber populations in the standard crop were 138 100 and 519 000/ha, respectively. In comparison, the stem and tuber population of the reduced seed rate area was 112 100 and 459 000/ha. At the first sampling on 22 July, total tuber yields were 34.5 t/ha in standard crop and 32.6 t/ha in the crop grown using about 0.3 t/ha less seed. At the second sampling in mid-September, total tuber yields had increased to 56.3 and 54.9 t/ha in the standard and modified crops respectively. Because of the reduced tuber population the mean tuber size was slightly larger in the modified crop. Once the standard error of the yield estimates were taken into account, ware (> 40 mm) yields were similar for both comparisons and averaged 53.4 t/ha. Tuber counts at the final sampling were 81/10 kg for standard crop and 74/10 kg for the crop grown with the reduced seed rate.

Large seed (count 574/50 kg)

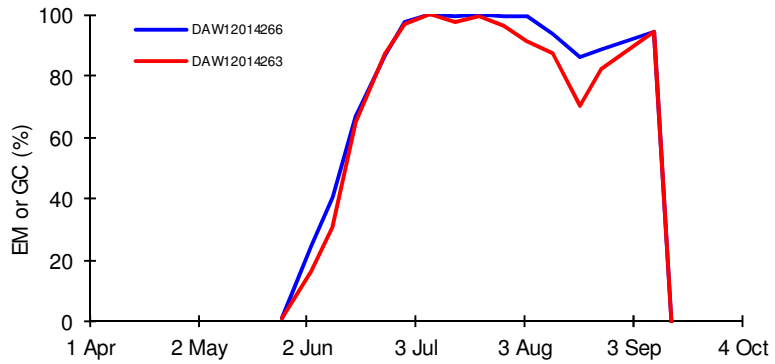
Following planting on 27 April the large seed was 50 % emerged on 26 May (Figure 9). Ground cover development, maximum ground cover and ground cover persistence were similar for both comparisons. The intended plant population for the standard crop was 31 160/ha (equivalent to a within row spacing of 35.1 cm and a seed rate of 2.71 t/ha) and the achieved plant population was similar to this. The intended plant population for the crop grown with the reduced seed rate was 24 190/ha (45.2 cm and 2.11 t/ha) and sample data showed that this was achieved. For both comparisons stem population were reasonably consistent over the two sample dates and averaged 155 800 and 113 500/ha for the standard and modified crop, respectively. For the standard crop, the total tuber population decreased between samplings but averaged 596 000/ha. For the crop grown at the reduced seed rate, the total tuber population increased between the two samplings

and averaged 515 000/ha. Numerically, the total tuber yield was larger in the standard crop than in the modified crops at the first harvest but, numerically, the modified crop had the larger tuber yield at the second harvest. On average, total tuber yields increased from 35.0 t/ha on 22 July to 56.3 t/ha on 18 September. When compared with the standard crop, the modified crop had similar total tuber yield but a smaller tuber population and, in consequence, the mean tuber size of the modified crop was consistently larger than that of the standard crop. Numerically, the ware yield was larger in the modified crop than in the standard crop and this is consistent with the effects of plant population of total tuber yield production and tuber population. For both comparisons the tuber count was in the range specified by Walker's and was 89/10 kg for the standard crop and 81/10kg for the crop grown with a reduced population.

Collectively, these data suggest that seed rates in VR808 could be reduced without compromising total tuber yield and possibly increasing yield > 40mm. There was no evidence in these comparisons, that reducing the seed rate was associated with an increase in over-size tubers (> 90 mm). Thus these data show there may be opportunities for both savings in seed costs and increased saleable yield.

Figure 8. Comparison of standard and reduced seed rates in VR808 (medium seed), WB Daw & Son, Thorpe 29 Field.

Grower:	James Daw	James Daw
Field name:	Thorpe 29	Thorpe 29
Unique ID:	DAW12014266	DAW12014263
Part Field Name:	Medium seed standard population	Medium seed reduced population
Variety:	VR808	VR808
Intended yield:	65 t/ha	65 t/ha
Intended use:	Crisping-Storage	Crisping-Storage
Planting date (start):	27 Apr	27 Apr
Date of 50 % emergence:	26 May	26 May
Total N applied:	220 kg N/ha	220 kg N/ha
Seed count:	977 per 50 kg	977 per 50 kg
Planned density:	41.74 000/ha	33.14 000/ha
Planned spacing:	26.2 cm	33.0 cm
Achieved density:	40.55 000/ha	34.18 000/ha
Achieved spacing:	27.0 cm	32.0 cm

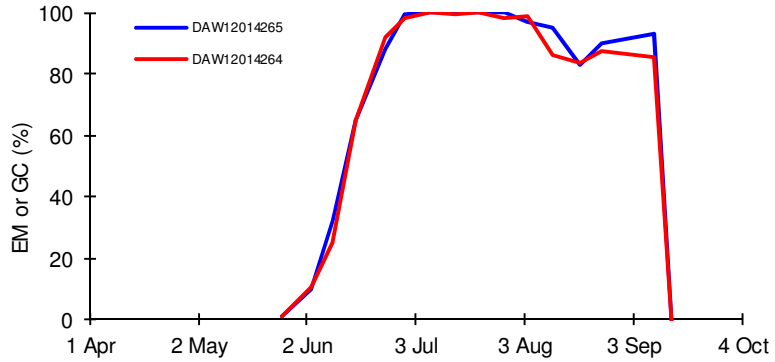


Yield Samples (S.E. in italics)

		Medium seed standard population			Medium seed reduced population	
		22 Jul	18 Sep		22 Jul	18 Sep
Plants (000/ha)		38.3	42.8		35.5	32.8
		1.82	*0.91*		*0.91*	*1.49*
Stems (000/ha)		128.5	147.6		113.0	111.2
		11.17	*8.48*		*6.49*	*7.94*
Stems/plant		3.4	3.5		3.2	3.4
		0.21	*0.26*		*0.24*	*0.36*
Tubers (000/ha)	> 10 mm	483	556	> 10 mm	447	470
		30.8	*57.7*		*33.6*	*26.4*
Tubers (000/ha)	> 40 mm	344	434	> 40 mm	324	394
		14.2	*27.2*		*25.6*	*13.9*
Tuber yield (t/ha)	> 10 mm	34.5	56.3	> 10 mm	32.6	54.9
		1.60	*0.78*		*1.65*	*3.01*
Tuber yield (t/ha)	> 40 mm	30.9	53.9	> 40 mm	29.5	53.0
		1.55	*0.79*		*1.79*	*2.78*
DM (%)		20.2	23.4		21.8	24.9
		0.34	*0.36*		*0.11*	*0.38*
Mean tuber size (mm)		49.0	56.8		48.7	58.1
		0.81	*0.93*		*0.45*	*0.43*

Figure 9. Comparison of standard and reduced seed rates in VR808 (large seed), WB Daw & Son, Thorpe 29 Field.

Grower:	James Daw	James Daw
Field name:	Thorpe 29	Thorpe 29
Unique ID:	DAW12014265	DAW12014264
Part Field Name:	Large seed standard population	Large seed reduced population
Variety:	VR808	VR808
Intended yield:	65 t/ha	65 t/ha
Intended use:	Crisping-Storage	Crisping-Storage
Planting date (start):	27 Apr	27 Apr
Date of 50 % emergence:	26 May	26 May
Total N applied:	220 kg N/ha	220 kg N/ha
Seed count:	574 per 50 kg	574 per 50 kg
Planned density:	31.16 000/ha	24.19 000/ha
Planned spacing:	35.1 cm	45.2 cm
Achieved density:	31.44 000/ha	24.61 000/ha
Achieved spacing:	34.8 cm	44.4 cm



Yield Samples (S.E. in italics)

	Large seed standard population			Large seed reduced population	
	22 Jul	18 Sep		22 Jul	18 Sep
Plants (000/ha)	31.0	31.9		23.7	25.5
	1.05	*1.75*		*1.05*	*0.00*
Stems (000/ha)	165.0	146.7		105.7	121.2
	6.55	*10.77*		*6.49*	*10.77*
Stems/plant	5.3	4.6		4.5	4.8
	0.21	*0.45*		*0.26*	*0.42*
Tubers (000/ha) > 10 mm	620	571	> 10 mm	482	548
	30.6	*33.5*		*25.2*	*30.7*
Tubers (000/ha) > 40 mm	425	471	> 40 mm	349	442
	23.7	*19.1*		*20.4*	*22.4*
Tuber yield (t/ha) > 10 mm	36.8	55.5	> 10 mm	33.3	57.2
	2.37	*2.06*		*1.98*	*3.20*
Tuber yield (t/ha) > 40 mm	31.8	53.2	> 40 mm	29.8	54.8
	2.25	*1.94*		*2.37*	*3.26*
DM (%)	20.3	24.5		20.4	24.2
	0.57	*0.66*		*0.52*	*0.67*
Mean tuber size (mm)	46.0	54.3		48.1	56.4
	0.57	*0.85*		*0.83*	*1.24*

Frederick Hiam Ltd.

Frederick Hiam Ltd are a large farming and vegetable packing company mainly based in East Anglia which joined the Grower Collaboration project in 2013. In 2014, following discussions with Will Brice of Frederick Hiam Ltd. it was decided to set up seed rate comparisons in crops of Marfona and Marabel and a comparison of N rates in a crop of Melody. For Marabel the seed rate comparisons were designed to capture information that would be of use in improving current seed rate recommendations rather than a test of existing recommendations. Further details of the seed and comparisons are given in Table 7. There were no regular observations of the time-course of emergence or of ground cover development.

Table 7. Details of seed and ware crops for comparison of Grower and NIAB-CUF seed rates for Melody, Marabel and Marfona

Field name	Barn Field	Giles	Tuddenham Rd
Variety	Melody	Marabel	Marfona
Planting configuration	Two row bed	Two row bed	Three row bed
Average row width (cm)	91.44	91.44	60.96
Seed crop††			
Seed size (mm)	45-55	55-60	50-60
Count (no./50 kg)	555	374	431
Ware crop			
Intended total yield (t/ha)	60	60	60
Intended date of planting	2 April	1 April	12 March
Intended grower and NIAB-CUF plant population and within row spacings			
Grower population (000/ha)	19.19	28.04	25.63
Grower spacing (cm)	57	39	64
NIAB-CUF population (000/ha)†	n.a.	32.17	23.43
NIAB-CUF spacing (cm)†	n.a.	34	70
NIAB-CUF population (000/ha)†	n.a.	23.77	n.a.
NIAB-CUF spacing (cm)†	n.a.	46.0	n.a.
Intended grower and NIAB-CUF nitrogen application rate			
Grower N rate (kg N/ha)	180	180	180
NIAB-CUF N application rate (kg N/ha)	155	n.a.	n.a.

†For Marabel the two NIAB-CUF population are experimental and were used to collect data to help improve seed rate recommendations rather than as a test of existing recommendations. ††Emergence date of the seed crop was assumed to be 1 June 2013.

Nitrogen rate comparisons in Melody

The grower standard N application rate for the Melody was 180 kg N/ha and this was compared with a NIAB-CUF recommended N application of 155 kg N/ha. The Melody crop was planted on 2 April, achieved 50 % plant emergence on 28 April and was sampled on two occasions: 10 July (73 days after emergence) and 12 August (106 DAE). For both the standard and modified crops, the achieved plant populations were within 10 % of those intended and were also within 10 % of each other (Figure 10). Stem and tuber populations varied between the two samplings but, once standard errors were taken into account there was little effect of the higher and lower rate of N application. At the first sampling, the total (> 10 mm) yield was numerically *c.* 4 t/ha larger in the crop that received 155 kg N/ha than in the crop that received 180 kg N/ha. This apparent difference in total yield was maintained until the second sampling where the total yield in the standard and modified crops was 54.6 and 63.1 t/ha, respectively. The mean tuber size was 1.9 mm larger in the modified crop and this was primarily due to the increase in yield since the reduction in N application had no effect on the tuber population. The large apparent increase in tuber yield (8.5 t/ha) in response to reducing the N application rate from 180 to 155 kg N/ha is unlikely to solely result from difference in N application. However, similar effects have been observed in a Melody crop grown by Co-operative farms in 2012 (see Table 13) and collectively the data suggest that modest reductions in N application rate are associated with statistically significant increases in yield (see Table 11).

Figure 10. Comparison of standard and modified nitrogen application rates for Melody, Frederick Hiam Ltd., Barn Field.

Grower:	Frederick Hiams	Frederick Hiams
Field name:	Barn Field	Barn Field
Unique ID:	FHI12014155	FHI12014156
Part Field Name:	N180	N155
Variety:	Melody	Melody
Intended yield:	60 t/ha	60 t/ha
Intended use:	General Ware	General Ware
Planting date (start):	2 Apr	2 Apr
Date of 50 % emergence:	28 Apr	28 Apr
Total N applied:	180 kg N/ha	155 kg N/ha
Seed size:	45-55 mm	45-55 mm
Seed count:	555 per 50 kg	555 per 50 kg
Planned density:	19.19 000/ha	19.19 000/ha
Planned spacing:	57.0 cm	57.0 cm
Achieved density:	20.96 000/ha	21.42 000/ha
Achieved spacing:	52.2 cm	51.1 cm

Yield Samples (S.E. in italics)

		N180			N155	
		10 Jul	12 Aug		10 Jul	12 Aug
Plants (000/ha)		20.0	21.9		21.0	21.9
		1.82	*0.00*		*0.91*	*0.00*
Stems (000/ha)		49.2	60.1		52.9	53.8
		6.23	*1.82*		*8.22*	*5.64*
Stems/plant		2.4	2.8		2.5	2.5
		0.15	*0.08*		*0.35*	*0.26*
Tubers (000/ha)	> 10 mm	364	387	> 10 mm	406	380
		35.7	*28.3*		*12.9*	*30.5*
Tubers (000/ha)	> 40 mm	231	283	> 40 mm	252	293
		16.1	*23.0*		*4.8*	*18.4*
Tuber yield (t/ha)	> 10 mm	36.1	54.6	> 10 mm	40.3	63.1
		3.06	*3.08*		*2.15*	*4.02*
Tuber yield (t/ha)	> 40 mm	33.2	52.5	> 40 mm	36.6	61.2
		2.98	*2.93*		*2.46*	*4.25*
DM (%)		17.2	19.7		17.5	19.5
		0.27	*0.25*		*0.16*	*0.33*
Mean tuber size (mm)		52.8	60.2		51.8	62.1
		1.03	*0.71*		*1.20*	*1.98*

Seed rate comparison in Marfona

The Marfona crop was planted in Tuddenham Road field in a three-row bed with an average row width of 60.96 cm. The planned seed rate for the standard Marfona crop was 2.97 t/ha (equivalent to 25 630 plant/ha, 64 cm within-row spacing) whereas for the modified crop the planned seed rate had been reduced to 2.64 t/ha (22 72 plants/ha, 72.2 cm within-row spacing). However, since the planter was thought to be incapable of planting seed this wide a compromise treatment was devised which was 2.72 t/ha

(23 430 plants/ha, 70.0 cm average within-row spacing). The experiment was planted on 11 March and 50 % plant emergence was estimated to be 14 April. The crop was sampled on one occasion (15 August, 123 days after emergence). For both the standard and modified crops the achieved plant populations were within 10 % of those intended and the standard and modified crops differed by more than 10 % (Figure 11). As a consequence of reducing the plant population, the stem and total tuber population was smaller in the modified crop than in the standard. Planting at the reduced population had no discernible effect on tuber yield and there was little difference in total yield (> 10 mm) between the standard and modified crops. However, due to the reduction in tuber population, the yield of baking sized potatoes was larger in the crop grown with the reduced plant population. This was also shown in the effect of the change in plant population on mean tuber size which increased from 62.4 to 65.5 mm. Despite the increase in mean tuber size, no tubers were larger than 90 mm.

Seed rate comparisons in Marabel

At present NIAB-CUF has insufficient data to formulate accurate seed rate recommendations for the variety Marabel. It was therefore decided to collect information from Marabel crops grown at a standard seed rate (3.75 t/ha equivalent to 28 040 plants/ha and an average within-row spacing of 39.0 cm); at a higher seed rate (4.30 t/ha, 32 170/ha, 34 cm) and at lower seed rate (3.18 t/ha, 23 770/ha, 46 cm spacing). The comparisons were planted on 1 April and, for all seed rates, 50 % plant emergence was estimated to have occurred on 28 April. The Marabel crop was sampled on two occasions 10 July (73 days after emergence) and 12 August (106 days after emergence). Comparisons of standard and increased seed rates are shown in Figure 12 and comparisons of standard and reduced seed rates are shown in Figure 13. When averaged over both sampling dates, the achieved plant population was 30 530/ha which was a little larger than that intended but still within 10 %. Main stem and tuber populations were reasonably consistent between sampling and averaged 127 000 and 489 000/ha respectively. Between the first and second samplings total (> 10 mm) tuber yields in the standard crop increased from 59.5 t/ha to 82.5 t/ha and the yield of baker-sized (> 60 mm) tubers increased from 16.2 to 45.4 t/ha. The mean tuber size at the final sampling was 60.6 mm. For the Marabel crops planted at an increased seed rate the achieved average plant population was 34 630/ha which was slightly more than planned but still within 10 %. When averaged over the two

samplings the main stem and total tuber averaged 154 000 and 563 000/ha – a substantial increase of over those found in the standard crop. At the first sampling the total and baker-sized yield was 66.5 and 17.5 t/ha respectively and had increased to 84.7 and 46.5 t/ha at the second sampling on 12 August. The mean tuber size at the final sampling was 59.6 mm. When compared to the standard crop, total yields were very similar, but as a consequence of an increased tuber population, the mean tuber size had been reduced.

Figure 11. Comparison of standard and modified seed rates for Marfona, Frederick Hiam Ltd., Tuddenham Road Field.

Grower:	Frederick Hiams	Frederick Hiams
Field name:	Tuddenham Road	Tuddenham Road
Unique ID:	FHI12014279	FHI12014280
Part Field Name:	64 cm	70 cm
Variety:	Marfona	Marfona
Intended yield:	60 t/ha	60 t/ha
Intended use:	General Ware	General Ware
Planting date (start):	11 Mar	11 Mar
Date of 50 % emergence:	14 Apr	14 Apr
Total N applied:	180 kg N/ha	180 kg N/ha
Seed size:	50-60 mm	50-60 mm
Seed count:	431 per 50 kg	431 per 50 kg
Planned density:	25.63 000/ha	23.43 000/ha
Planned spacing:	64.0 cm	70.0 cm
Achieved density:	27.34 000/ha	23.09 000/ha
Achieved spacing:	60.0 cm	71.1 cm

Yield Samples (S.E. in italics)

		64 cm		70 cm
		15 Aug		15 Aug
Plants (000/ha)		27.3		23.1
		0.00		*1.22*
Stems (000/ha)		66.2		53.5
		5.30		*5.80*
Stems/plant		2.4		2.3
		0.19		*0.15*
Tubers (000/ha)	> 10 mm	374	> 10 mm	327
		40.2		*42.7*
Tubers (000/ha)	> 60 mm	145	> 60 mm	168
		9.8		*7.9*
Tuber yield (t/ha)	> 10 mm	61.0	> 10 mm	62.5
		4.36		*4.86*
Tuber yield (t/ha)	> 60 mm	38.3	> 60 mm	47.2
		4.15		*2.50*
DM (%)		14.6		13.6
		0.26		*0.25*
Mean tuber size (mm)		62.4		65.5
		1.69		*1.03*

Figure 12. Comparison of standard and modified (increased) seed rates for Marabel, Frederick Hiam Ltd., Tuddenham Road Field.

Grower:	Frederick Hiams	Frederick Hiams
Field name:	Giles	Giles
Unique ID:	FHI12014158	FHI12014157
Part Field Name:	39 cm	34 cm
Variety:	Marabel	Marabel
Intended yield:	60 t/ha	60 t/ha
Intended use:	General Ware	General Ware
Planting date (start):	1 Apr	1 Apr
Date of 50 % emergence:	28 Apr	28 Apr
Total N applied:	180 kg N/ha	180 kg N/ha
Seed size:	55-60 mm	55-60 mm
Seed count:	374 per 50 kg	374 per 50 kg
Planned density:	28.04 000/ha	32.17 000/ha
Planned spacing:	39.0 cm	34.0 cm
Achieved density:	30.53 000/ha	34.63 000/ha
Achieved spacing:	35.8 cm	31.6 cm

Yield Samples (S.E. in italics)

		39 cm			34 cm	
		10 Jul	12 Aug		10 Jul	12 Aug
Plants (000/ha)		30.1	31.0		31.9	37.4
		0.91	*1.05*		*1.75*	*0.91*
Stems (000/ha)		131.2	123.0		147.6	160.4
		10.52	*5.02*		*13.10*	*6.31*
Stems/plant		4.4	4.0		4.7	4.3
		0.37	*0.06*		*0.56*	*0.14*
Tubers (000/ha)	> 10 mm	480	498	> 10 mm	559	567
		32.8	*17.4*		*27.0*	*33.2*
Tubers (000/ha)	> 60 mm	67	158	> 60 mm	73	181
		9.9	*14.4*		*9.1*	*8.2*
Tuber yield (t/ha)	> 10 mm	59.5	82.5	> 10 mm	66.5	84.7
		2.92	*2.50*		*0.86*	*2.70*
Tuber yield (t/ha)	> 60 mm	16.2	45.4	> 60 mm	17.5	46.5
		3.12	*3.57*		*2.31*	*1.90*
DM (%)		17.0	17.9		16.8	17.9
		0.44	*0.30*		*0.34*	*0.24*
Mean tuber size (mm)		55.4	60.6		55.5	59.6
		0.89	*0.46*		*0.43*	*0.37*

The average, achieved plant population where seed rates had been reduced was 24 610/ha which, in common with the other treatments, was slightly larger than originally planned but within 10 % of that intended. Between the first and second samplings, main stem and tuber populations were variable but averaged 108 000 and 473 000/ha, respectively. Between the first and second sampling, total yields increased from 62.6 to 81.5 t/ha and the baker-sized yield increased from 17.0 to 50.3 t/ha. At the second sampling the mean tuber size in the reduced seed rate crop was 62.3 mm compared with 60.6 mm in the standard crop. When compared with the standard crop, there was no evidence that total

yield was reduced at the lower seed rate however due to the reduced tuber population baker yields were largest. However, irrespective of seed rate, there were no tubers > 90 mm.

The Marabel seed rate comparisons were designed to gather information to help improve seed rates and maximise yields in the most profitable grades thereby minimising crop wastage. These data suggest that opportunities may exist to reduce seed rates (and hence production costs) even in very high-yielding crops.

Figure 13. Comparison of standard and modified (decreased) seed rates for Marabel, Frederick Hiam Ltd., Giles Field.

Grower:	Frederick Hiams	Frederick Hiams
Field name:	Giles	Giles
Unique ID:	FHI12014158	FHI12014159
Part Field Name:	39 cm	46 cm
Variety:	Marabel	Marabel
Intended yield:	60 t/ha	60 t/ha
Intended use:	General Ware	General Ware
Planting date (start):	1 Apr	1 Apr
Date of 50 % emergence:	28 Apr	28 Apr
Total N applied:	180 kg N/ha	180 kg N/ha
Seed size:	55-60 mm	55-60 mm
Seed count:	374 per 50 kg	374 per 50 kg
Planned density:	28.04 000/ha	23.77 000/ha
Planned spacing:	39.0 cm	46.0 cm
Achieved density:	30.53 000/ha	24.61 000/ha
Achieved spacing:	35.8 cm	44.4 cm

Yield Samples (S.E. in italics)

		39 cm			46 cm	
		10 Jul	12 Aug		10 Jul	12 Aug
Plants (000/ha)		30.1	31.0		24.6	24.6
		0.91	*1.05*		*0.91*	*0.91*
Stems (000/ha)		131.2	123.0		119.4	96.6
		10.52	*5.02*		*5.24*	*6.74*
Stems/plant		4.4	4.0		4.9	3.9
		0.37	*0.06*		*0.10*	*0.24*
Tubers (000/ha)	> 10 mm	480	498	> 10 mm	504	441
		32.8	*17.4*		*27.0*	*29.1*
Tubers (000/ha)	> 60 mm	67	158	> 60 mm	68	174
		9.9	*14.4*		*13.7*	*8.7*
Tuber yield (t/ha)	> 10 mm	59.5	82.5	> 10 mm	62.6	81.5
		2.92	*2.50*		*5.21*	*2.83*
Tuber yield (t/ha)	> 60 mm	16.2	45.4	> 60 mm	17.0	50.3
		3.12	*3.57*		*3.47*	*2.71*
DM (%)		17.0	17.9		17.1	18.3
		0.44	*0.30*		*0.69*	*0.47*
Mean tuber size (mm)		55.4	60.6		55.2	62.3
		0.89	*0.46*		*0.66*	*0.47*

Robin Baines & Co

Robin Baines joined the Grower Collaboration program in 2014 as a host for some seed rate comparisons in the varieties Innovator and Challenger. These varieties are grown for Lamb Weston Meijer and are an important component of Robin's production but, currently NIAB-CUF has insufficient information about their characteristics to formulate seed rate recommendation. It was jointly decided therefore that work in 2014 would concentrate on collecting key data that could be used to develop improved seed rate recommendations in the future. The format of the experiments in 2014 was to grow each variety at its standard seed rate and also with reduced and increased seed rate treatments. Details of these comparisons are shown in Table 8.

Table 8. Details of seed and ware crops for comparison of Grower and NIAB-CUF seed rates for Challenger and Innovator

Field name	14JP027	14JP028
Variety	Challenger	Innovator
Planting configuration	Two row bed	Two row bed
Average row width (cm)	91.44	91.44
Seed crop†		
Seed size (mm)	20-35	50-55
Count (no./50 kg)	757	251
Ware crop		
Intended total yield (t/ha)	65	65
Intended date of planting	3 April	3 April
Intended grower and NIAB-CUF plant population and within row spacings		
Grower (standard) population (000/ha)	31.20	27.3
Grower (standard) spacing (cm)	35.0	40.0
Increased population (000/ha)†	43.70	36.50
Increased spacing (cm)†	25.0	30.0
Decreased population (000/ha)†	24.30	21.90
Decreased spacing (cm)†	45.0	50
Intended grower application rate		
Grower N rate (kg N/ha)	270	270

†The date of seed crop emergence not known and was assumed to be 1 June 2013 by default.

Seed rates comparisons in Challenger, Holt Norfolk

The Challenger comparisons were planted on 3 April in field 14JP027 which was on the outskirts of Holt, Norfolk. The crop emerged rapidly and the date of 50 % plant emergence was estimated to be 20 April. The comparisons were sampled on two occasions: 2 July (73

days after emergence) and 10 September (143 days after emergence). The intended plant population for the standard Challenger crop was 31 200/ha (35 cm within-row spacing). When averaged over both samplings, the achieved plant population was 34 600/ha (31.6 cm) (Figure 14). There was some variation in stem and total tuber population between the two samplings but when averaged over both sampling dates, the stem and total tuber populations in the standard crop averaged 74 300 and 433 000/ha, respectively. Between the first and second sampling, total tuber yield increased from 28.5 to 66.8 t/ha and ware yield (> 40 mm) increased from 9.7 to 56.1 t/ha. The mean tuber size for the standard crop at the final sampling was 51.2 mm. Of the ware-sized tubers, *c*. 58 % were in excess of 100 mm long and thus suitable for processing in to French-fries. Combining these value gives an estimate of the yield of tubers suitable for French-fry production (> 40 mm diameter and > 100 long) of 33 t/ha.

The achieved plant population for the Challenger crop grown using an increased seed rate was 41 500/ha (Figure 14). This was a little less than that intended but the achieved difference between the plant populations in the standard and increased areas was still more than 10 %. As a consequence of the increase in plant population, the average stem and total tuber populations were 93 900 and 507 000/ha, respectively. At the first sampling, the total tuber yield of the increased density crop was 28.0 t/ha and this had increased to 68.2 t/ha at the second sampling. The mean tuber size in the high-density crop at the second sampling was 50.6 mm and this reduction in mean tuber size relative to the standard crop meant that the tuber yield > 40 mm was smaller (52.2 t/ha) as was the proportion of the ware yield that was in excess of 100 mm length (51 %). When compared with the other seed rates, the yield of tubers suitable for French-fries was smallest (27 t/ha) in the high density comparison.

The intended plant population for the crop grown at the reduced seed rate was 24 300/ha whereas the average achieved plant population was 27 800/ha (Figure 15). Whilst the achieved population was larger than that intended it was still more than 10 % smaller than that achieved in the standard Challenger crop. Stem and total populations were reasonably similar for the two samplings and averaged 72 500 and 416 000/ha, respectively. Between 2 July and 10 September, total yields increased from 26.5 to 66.6 t/ha. Once the size of the standard errors are taken into account there was little difference in the total tuber yield between the standard crop and the crop grown at the

wider within-row spacing. At the final sampling the mean tuber size of the low-density crop was 52.5 mm and this gave a yield of ware size tubers of 57.6 t/ha. The wider spacing was also associated with the largest (63.6 %) proportion of ware-sized tubers that were in excess of 100 mm long. In consequence, the crop planted with the smallest plant population gave the largest yield of tubers of a suitable specification for French-fry production (37 t/ha).

Figure 14. Comparison of standard and modified (increased) seed rates for Challenger, Robin Baines, Holt-14JP027.

Grower:	Robin Baines	Robin Baines
Field name:	Holt-14JPO27	Holt-14JPO27
Unique ID:	LWM12014150	LWM12014149
Part Field Name:	35 cm	25 cm
Variety:	Challenger	Challenger
Intended yield:	65 t/ha	65 t/ha
Intended use:	French-fries	French-fries
Planting date (start):	3 Apr	3 Apr
Date of 50 % emergence:	20 Apr	20 Apr
Total N applied:	270 kg N/ha	270 kg N/ha
Seed size:	20-35 mm	20-35 mm
Seed count:	757 per 50 kg	757 per 50 kg
Planned density:	31.2 000/ha	43.7 000/ha
Planned spacing:	35.0 cm	25.0 cm
Achieved density:	34.6 000/ha	41.5 000/ha
Achieved spacing:	31.6 cm	26.4 cm

Yield Samples (S.E. in italics)

		35 cm			25 cm	
		2 Jul	10 Sep		2 Jul	10 Sep
Plants (000/ha)		33.7	35.5		40.1	42.8
		0.91	*0.91*		*0.00*	*0.91*
Stems (000/ha)		68.4	80.2		91.1	96.6
		5.24	*0.00*		*7.14*	*10.58*
Stems/plant		2.0	2.3		2.3	2.2
		0.18	*0.06*		*0.18*	*0.21*
Tubers (000/ha)	> 10 mm	391	475	> 10 mm	482	531
		16.8	*14.7*		*23.4*	*42.2*
Tubers (000/ha)	> 40 mm	167	376	> 40 mm	159	383
		39.9	*10.7*		*32.6*	*14.9*
Tuber yield (t/ha)	> 10 mm	28.5	66.8	> 10 mm	28.0	68.2
		4.00	*1.57*		*2.15*	*1.15*
Tuber yield (t/ha)	> 40 mm	9.7	56.1	> 40 mm	7.5	52.2
		4.19	*1.72*		*2.96*	*2.61*
Tuber yield (%)†	> 100 mm		58.4	> 100 mm		51.1
			3.47			*2.87*
DM (%)		16.9	23.1		17.0	22.6
		0.08	*0.62*		*0.11*	*0.45*
Mean tuber size (mm)		41.8	51.2		40.5	50.6
		1.58	*0.31*		*1.75*	*1.45*

† Percentage of tubers > 40 mm diameter and longer than 100 mm

Figure 15. Comparison of standard and modified (decreased) seed rates for Challenger, Robin Baines, Holt-14JP027.

Grower:	Robin Baines	Robin Baines
Field name:	Holt-14JPO27	Holt-14JPO27
Unique ID:	LWM12014150	LWM12014151
Part Field Name:	35 cm	45 cm
Variety:	Challenger	Challenger
Intended yield:	65 t/ha	65 t/ha
Intended use:	French-fries	French-fries
Planting date (start):	3 Apr	3 Apr
Date of 50 % emergence:	20 Apr	20 Apr
Total N applied:	270 kg N/ha	270 kg N/ha
Seed size:	20-35 mm	20-35 mm
Seed count:	757 per 50 kg	757 per 50 kg
Planned density:	31.2 000/ha	24.3 000/ha
Planned spacing:	35.0 cm	45.0 cm
Achieved density:	34.6 000/ha	27.8 000/ha
Achieved spacing:	31.6 cm	39.3 cm

Yield Samples (S.E. in italics)

	35 cm			45 cm	
	2 Jul	10 Sep		2 Jul	10 Sep
Plants (000/ha)	33.7	35.5		27.3	28.3
	0.91	*0.91*		*1.05*	*1.75*
Stems (000/ha)	68.4	80.2		75.6	69.3
	5.24	*0.00*		*8.85*	*1.49*
Stems/plant	2.0	2.3		2.7	2.5
	0.18	*0.06*		*0.23*	*0.13*
Tubers (000/ha) > 10 mm	391	475	> 10 mm	401	431
	16.8	*14.7*		*23.1*	*12.0*
Tubers (000/ha) > 40 mm	167	376	> 40 mm	151	344
	39.9	*10.7*		*30.1*	*9.5*
Tuber yield (t/ha) > 10 mm	28.5	66.8	> 10 mm	26.5	66.6
	4.00	*1.57*		*2.93*	*0.87*
Tuber yield (t/ha) > 40 mm	9.7	56.1	> 40 mm	7.0	57.6
	4.19	*1.72*		*2.78*	*1.32*
Tuber yield (%)† > 100 mm		58.4	> 100 mm		63.6
		3.47			*3.56*
DM (%)	16.9	23.1		16.9	23.2
	0.08	*0.62*		*0.10*	*0.45*
Mean tuber size (mm)	41.8	51.2		40.8	52.5
	1.58	*0.31*		*1.19*	*0.38*

† Percentage of tubers > 40 mm diameter and longer than 100 mm

The main objective of the work with Challenger was to collect some basic data from field crops that would inform the development of improved seed rates. The data collected here suggests that is may be possible to reduce plant populations (and thereby seed cost) whilst maintaining total yield and, importantly, increasing the yield of tubers suitable for French-

fry production. However, low stem populations may compromise the ability to do this without risking yield reductions.

Seed rate comparisons in Innovator, East Winch Norfolk

The Innovator crops were planted in field 14JP028 on 3 April and like the Challenger crops emerged rapidly and achieved 50 % plant emergence on 21 April (Figure 16). The planned plant population for the standard crop was 27 300/ha (equivalent to a seed rate of 5.45 t/ha and a within-row spacing of 40 cm. Crop samples taken on the 2 July (72 DAE) and 10 September (142 DAE) showed that the achieved population was similar to that intended and averaged 26 000/ha. Main stem and total tuber populations decreased between the first and second samplings but averaged 97 500 and 369 000/ha, respectively. The total (> 10 mm) tuber yield at the final sampling was 71.3 t/ha with a mean tuber size of 62.2 mm giving a large ware (> 40 mm) yield of 69.5 t/ha. Nearly two-thirds (64.7 %) of the > 40 mm tuber were longer than 100 mm, giving a yield of *c*. 45 t/ha that was potentially suitable for French-fry production.

The target population for the higher density crop was 36 500/ha (7.26 t seed/ha at 30 cm within row spacing). The achieved plant population was smaller than intended and averaged 33 300/ha (Figure 16) but this was still substantially larger than the achieved plant population in the standard crop. When compared with the standard crop the average main stem and tuber population were also larger with mean values of 116 700 and 427 000/ha, respectively. At the final sampling, the total yield of the high density crop was 70.8 t/ha and this was similar to that measured in the standard crop. However, due to the increase in tuber population, the mean tuber size of the high density crop was 2.4 mm smaller than that in the standard crop. In consequence, the ware yield of the high density crop was 67.2 t/ha of which only 54.7 % were longer than 100 mm. Thus the yield of tubers suitable for French-fry production was *c*. 37 t/ha – a substantial reduction relative to the standard crop.

The reduced density Innovator crop was planted at an intended seed rate of 4.36 t/ha (Figure 17) and when averaged over both samplings, the achieved plant population was identical to that intended (21 900/ha). The mean, main stem and total tuber populations were 82 900 and 383 000/ha, respectively. Based on the plant population, the stem and tuber populations were larger than expected and were, on average, numerically larger than those found in the standard crop. Between the first and second samplings the total yield in

the reduced seed rate crop increased from 32.9 to 81.6 t/ha. This large yield, coupled with the large stem and tuber population suggest that the crop sample may have been taken from unrepresentative areas of the crop. As a consequence of the large total yield, the mean tuber size and the ware yield were also largest in the reduced seed rate crop. Nearly three-quarters of the ware sized tubers were longer than 100 mm and the yield of tuber suitable for French-fry production was estimated to be 58 t/ha.

Figure 16. Comparison of standard and modified (increased) seed rates for Innovator, Robin Baines, East Winch, 14JP028.

Grower:	Robin Baines	Robin Baines
Field name:	East Winch-14JPO28	East Winch-14JPO28
Unique ID:	LWM12014153	LWM12014152
Part Field Name:	40 cm	30 cm
Variety:	Innovator	Innovator
Intended yield:	65 t/ha	65 t/ha
Intended use:	French-fries	French-fries
Planting date (start):	3 Apr	3 Apr
Date of 50 % emergence:	21 Apr	21 Apr
Total N applied:	270 kg N/ha	270 kg N/ha
Seed size:	50-55 mm	50-55 mm
Seed count:	251 per 50 kg	251 per 50 kg
Planned density:	27.3 000/ha	36.5 000/ha
Planned spacing:	40.0 cm	30.0 cm
Achieved density:	26.0 000/ha	34.0 000/ha
Achieved spacing:	42.1 cm	32.1 cm

Yield Samples (S.E. in italics)

		40 cm			30 cm	
		2 Jul	10 Sep		2 Jul	10 Sep
Plants (000/ha)		22.8	29.2		31.0	35.5
		2.73	*0.00*		*4.34*	*1.75*
Stems (000/ha)		110.3	84.8		123.9	109.4
		14.69	*4.79*		*4.46*	*5.16*
Stems/plant		5.2	2.9		4.3	3.1
		1.17	*0.16*		*0.65*	*0.11*
Tubers (000/ha)	> 10 mm	410	328	> 10 mm	446	409
		36.5	*15.2*		*12.6*	*9.3*
Tubers (000/ha)	> 40 mm	256	276	> 40 mm	274	324
		18.8	*9.3*		*10.5*	*13.8*
Tuber yield (t/ha)	> 10 mm	35.6	71.3	> 10 mm	35.6	70.8
		2.60	*2.22*		*0.61*	*3.67*
Tuber yield (t/ha)	> 40 mm	27.5	69.5	> 40 mm	25.6	67.2
		2.26	*2.05*		*1.43*	*4.00*
Tuber yield (%)†	> 100 mm		64.7	> 100 mm		54.7
			2.92			*5.20*
DM (%)		19.9	23.9		20.0	24.1
		0.12	*0.35*		*0.56*	*0.22*
Mean tuber size (mm)		50.1	62.2		49.5	59.8
		0.31	*0.81*		*0.79*	*1.20*

† Percentage of tubers > 40 mm diameter and longer than 100 mm

Figure 17. Comparison of standard and modified (decreased) seed rates for Innovator, Robin Baines, East Winch-14JP028.

Grower:	Robin Baines	Robin Baines
Field name:	East Winch-14JPO28	East Winch-14JPO28
Unique ID:	LWM12014153	LWM12014154
Part Field Name:	40 cm	50 cm
Variety:	Innovator	Innovator
Intended yield:	65 t/ha	65 t/ha
Intended use:	French-fries	French-fries
Planting date (start):	3 Apr	3 Apr
Date of 50 % emergence:	21 Apr	21 Apr
Total N applied:	270 kg N/ha	270 kg N/ha
Seed size:	50-55 mm	50-55 mm
Seed count:	251 per 50 kg	251 per 50 kg
Planned density:	27.3 000/ha	21.9 000/ha
Planned spacing:	40.0 cm	50.0 cm
Achieved density:	26.0 000/ha	21.9 000/ha
Achieved spacing:	42.1 cm	50.0 cm

Yield Samples (S.E. in italics)

		40 cm			50 cm	
		2 Jul	10 Sep		2 Jul	10 Sep
Plants (000/ha)		22.8	29.2		20.0	23.7
		2.73	*0.00*		*1.05*	*1.05*
Stems (000/ha)		110.3	84.8		83.8	82.0
		14.69	*4.79*		*3.94*	*4.34*
Stems/plant		5.2	2.9		4.2	3.5
		1.17	*0.16*		*0.24*	*0.16*
Tubers (000/ha)	> 10 mm	410	328	> 10 mm	412	354
		36.5	*15.2*		*36.4*	*16.1*
Tubers (000/ha)	> 40 mm	256	276	> 40 mm	236	303
		18.8	*9.3*		*9.0*	*15.8*
Tuber yield (t/ha)	> 10 mm	35.6	71.3	> 10 mm	32.9	81.6
		2.60	*2.22*		*1.30*	*3.89*
Tuber yield (t/ha)	> 40 mm	27.5	69.5	> 40 mm	22.9	80.1
		2.26	*2.05*		*1.32*	*4.00*
Tuber yield (%)†	> 100 mm		64.7	> 100 mm		72.3
			2.92			*3.83*
DM (%)		19.9	23.9		19.7	24.0
		0.12	*0.35*		*0.25*	*0.63*
Mean tuber size (mm)		50.1	62.2		49.1	64.2
		0.31	*0.81*		*0.61*	*0.76*

† Percentage of tubers > 40 mm diameterand longer than 100 mm

The interpretation of the Innovator data was compromised by having much larger stem and tuber populations and tuber yield in the reduced seed rate crop. However, there was no evidence that increasing the seed rate of Innovator conferred any benefit in terms of French-fry production and, similar to the Challenger crop, it is possible that there may be some gains from using reduced seed rates.

Effect of seed rate on internal defects in Challenger and Innovator

It is important to determine that any change in seed rate (and thereby mean tuber size) does not compromise quality due to an increase in the incidence or severity of internal defects such as black-spot bruising or hollow-heart. To assess this, tubers (> 40 mm diameter and > 100 mm long) were cut longitudinally and then assessed using the criteria shown in Appendix 2. The samples sizes were small so care needs to be taken when interpreting the results. In general, the overall incidence of internal defects in both varieties was low (Table 9) although Challenger tended to have fewer internal defects than Innovator. There was no obvious correlation between an increase in mean tuber size (or reduction in plant population) and the incidence of internal defects. However as noted above before any change in seed rates were made a more thorough test on the effect on internal tuber quality would need to be done.

Table 9. Summary of the effect of plant population and mean tuber size on tuber dry matter and internal defects in Challenger and Innovator in 2014

Variety	Achieved plant population (000/ha)	Mean tuber size (mm)	Tuber dry matter (%)	No defects (%)	Slight speckling (%)	Obvious 2-3 mm spots (%)	Large 4-5 mm spots (%)	First signs of hollow heart (%)	Hollow heart 5-10 mm (%)	Hollow heat > 10 mm (%)	Growth crack and spraing (%)
Challenger	41.5	50.6	22.6	100	0	0	0	0	0	0	0
Challenger	34.6	51.2	23.1	99	0	0	0	1	0	0	0
Challenger	27.8	52.5	23.2	99	0	0	0	0	1	0	0
Innovator	34.0	59.8	24.1	97	3	0	0	0	0	0	0
Innovator	26.0	62.2	23.9	89	3	0	0	0	0	0	8†
Innovator	21.9	64.2	24.0	98	1	1	0	0	0	0	0

† Severe spraing symptoms found in one replicate only

Economic Analysis of Standard and Modified Agronomies

In previous reports and publications the effects of the contrasting agronomies (standard and improved) were quantified in terms of average, total (> 10 mm) and ware (> 40 mm) yields or by simple economic assessment where ware-size tubers had a uniform value of £120/t and potato seed and nitrogen fertilizer cost £250/t and £0.90/kg, respectively. However, in many commercial contracts potatoes are not valued uniformly and assuming a uniform value for ware sized tuber may obscure the real benefits of devising seed rates to maximise yields in the most valuable grades. To overcome this problem the sample data from 2007 to 2014 were reanalysed to make better estimates of true crop value. This was done by fitting a normal, un-weighted distribution to the graded yields for each plot and using the estimates of mean tuber size (mu) and its standard deviation (sigma) to calculate the proportion of the total yield in the five grades shown in Table 10. The total crop value was then calculated by summing the value in each grade. The cost of the seed (£300/t) and nitrogen fertilizer used (£0.90/kg) to produce this crops was then subtracted to calculate the margin of production over seed and N costs. Whilst this analysis is more sophisticated than shown in earlier reports the pricing structure ignores any bonuses paid for tuber dry matter content, freedom from defects etc. Furthermore, the values of potatoes sold on the free-market are volatile and the absolute benefit of any particular agronomy will be difficult to determine. Some comparisons of N rates were omitted from this analysis due to erratic crop emergence, the effects of PCN or a failure to apply the intended amount of N to either the standard or improved crops. 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). However, 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 improved agronomies resulted in a statistically significant increase in crop value.

Table 10. Potato pricing structure for different sectors of the UK potato industry and used to estimate whole crop value

	Diameter	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
Processing 1	Lower (mm)	0	35	40	65	90
	Upper (mm)	35	40	65	90	200
	Value (£/t)	0	25	110	110	25
Processing 2	Lower (mm)	0	35	40	53	75
	Upper (mm)	35	40	53	75	200
	Value (£/t)	0	25	110	110	25
Baking Potatoes	Lower (mm)	0	35	45	65	85
	Upper (mm)	35	45	65	85	200
	Value (£/t)	0	25	100	150	25
General Ware	Lower (mm)	0	35	45	65	85
	Upper (mm)	35	45	65	85	200
	Value (£/t)	0	25	150	100	25
Salad Potatoes	Lower (mm)	0	20	28	35	41
	Upper (mm)	20	28	35	41	200
	Value (£/t)	0	260	220	100	60

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 (Table 11*a*). 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. Whilst we do not have conclusive proof, 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.

In total there were 41 valid comparisons of standard and reduced seed rates Table 11*b*. 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. The increase (£176/ha) was not statistically significant. The effects of reduced seed rate on the increase in crop value are relatively small and this may be a consequence of our data-set 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. If the data set included a large proportion of salad potato crops then the effects of seed rates on crop value should be more noticeable. Similarly, an agronomy that allowed a grower to produce early-season baker crops before their competitors would also emphasise the importance of optimised seed rates.

Table 11. Summary showing average effects of (*a*) reduced nitrogen application rates and (*b*) reduced seed rates on total tuber population and yield and margin over seed and nitrogen cost. Data from Grower Collaboration project 2007-2014. Seed has been valued at £300/t and N at £0.90/kg. For further details see text

(*a*)	Nitrogen application rate (kg N/ha)	Tuber population > 10 mm at final sampling (000/ha)	Tuber yield > 10 mm at final sampling (t/ha)	Margin over seed and nitrogen costs (£/ha)
Mean of standard crops (n=22)	196 ± 5.3	500 ± 23.8	56.4 ± 2.09	5054 ± 334
Mean of improved crops (n=22)	168 ± 4.9	527 ± 23.8	61.0 ± 2.54	5668 ± 391
Mean difference	-28 ± 2.5	27 ± 11.9	4.6 ± 1.52	614 ± 199
Probability difference is significant	<0.001	0.033	0.007	0.006
(*b*)	Seed rate (t/ha)	Tuber population > 10 mm at final sampling (000/ha)	Tuber yield > 10 mm at final sampling (t/ha)	Margin over seed and nitrogen costs (£/ha)
Mean of standard crops (n=41)	2.34 ± 0.132	549 ± 28.6	57.9 ± 1.44	5055 ± 179
Mean of improved crops (n=41)	1.91 ± 0.104	493 ± 24.5	57.6 ± 1.32	5231 ± 154
Mean difference	-0.43 ± 0.041	56 ± 11.5	-0.3 ± 0.87	176 ± 103
Probability difference is significant	<0.001	0.001	0.741	0.097

Appendix 1

Table 12. Summary of all N rate comparison data (N rate increased) collected in Potato Council/NIAB-CUF Grower Collaboration Project R295 2007-2014. Yield data are hand-dug-samples taken about the time of defoliation. NB These comparison were done for the interest of growers and were not application rates suggested by NIAB-CUF

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 margin (£/ha)	Modified margin (£/ha)	Change in margin (£/ha)
2012	Tim Westgarth	Richardson	VR808	210	240	30	37.2	32.1	-5.1	2588	2173	-416
2013	Frederick Hiam Ltd.	Hill Farm 5	Vivaldi	180	200	20	57.3	65.7	8.5	6077	8072	1995
2014	Andrew Webster	Marks	Lady Rosetta	206	225	19	50.5	62.1	11.6	4224	5518	1294

Table 13. Summary of all N rate comparison data (N rate decreased) collected in Potato Council/NIAB-CUF Grower Collaboration Project R295 2007-2014. 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 margin (£/ha)	Modified margin (£/ha)	Change in margin (£/ha)
Invalid comparisons												
2007	EG Harrison†	Market Style	Saturna	240	175	-65	40.2	51.0	10.8	2596	3343	747
2008	AH Worth & Co†	Field 13	Maris Piper	180	140	-40	64.4	50.9	-13.5	5603	4537	-1066
2008	W B Daw~	MFL B	Russet Burbank	200	160	-40	69.1	52.8	-16.3	6517	4628	-1889
2008	EG Harrison†	Malthouse	Saturna	240	180	-60	45.2	48.6	3.4	3949	4430	481
2008	Strawson Farming††	Bower 8	Hermes	193	169	-24	66.2	60.6	-5.6	5810	5118	-692
2009	EG Harrison†	Bakers 27	Saturna	240	180	-60	48.8	52.0	3.2	4446	4713	267
2009	Strawson Farming†	Wood 10	Hermes	210	185	-25	37.6	44.0	6.4	2927	3559	631
2010	Tim Westgarth**	Field 16	Hermes	175	140	-35	55.8	51.6	-4.3	4801	4375	-426
2010	Fridlington Farms†	Field 18	Hermes	225	185	-40	65.4	65.9	0.5	5855	6038	184

Table 13 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 margin (£/ha)	Modified margin (£/ha)	Change in margin (£/ha)
Valid comparisons												
2007	W.B.Daw	Upper Trent	Russet Burbank	220	165	-55	58.5	66.5	7.9	5157	6190	1033
2008	Toby Mermagen	Horseshoes	Hermes	224	175	-49	50.4	53.6	3.2	4466	4863	397
2009	AH Worth & Co	Field 38	Maris Piper	180	155	-25	71.4	72.6	1.1	7047	7014	-33
2009	W B Daw	Curborough	Markies	150	130	-20	56.4	55.7	-0.7	4650	4579	-71
2009	JF & BM Gray	Deercote Barn	Maris Piper	220	200	-20	64.5	54.4	-10.1	5519	4639	-880
2009	Toby Mermagen	Long Lions	Hermes	191	181	-10	57.0	61.0	4.0	4829	5175	346
2009	Strawson Farming	Godfrey 13	Saturna	220	195	-25	63.1	58.9	-4.2	5674	5235	-439
2010	Co-operative Farms	3/5/7/B	Estima	230	205	-25	35.9	43.0	7.2	2181	2916	735
2010	GM Ward & Co	Pit Field	Desiree	140	120	-20	74.3	75.8	1.5	9458	9716	258
2010	AH Worth & Co	Field 26/27	Marfona	180	150	-30	54.8	60.9	6.1	5420	6101	681
2010	AH Worth & Co	JEP28	Melody	180	155	-25	44.2	46.5	2.3	3039	3323	284
2010	Tim Westgarth	Field 35	Saturna	230	195	-35	47.2	39.2	-8.0	3985	3287	-698
2011	Co-operative Farms	Pasture 116	Maris Piper	200	175	-25	63.9	68.3	4.4	6071	6598	527
2011	Co-operative Farms	Pasture 116	Maris Piper	200	175	-25	61.0	62.8	1.8	5965	5988	22
2011	Tim Westgarth	Stanwick Wall	Saturna	175	160	-15	64.4	72.1	7.7	6095	6941	846
2011	Fridlington Farms	Field 11	Hermes	220	190	-30	61.9	80.7	18.8	5497	7510	2013
2012	Co-operative Farms	Field 34	Melody	190	150	-40	62.8	71.0	8.2	4450	5631	1180
2012	Co-operative Farms	Field 38/02	Harmony	190	140	-50	50.3	62.7	12.4	3580	5110	1530
2012	Tim Westgarth	Richardson	VR808	210	180	-30	37.2	36.3	-0.9	2588	2591	3
2013	Frederick Hiam	Hill Farm 5	Vivaldi	180	160	-20	57.3	73.7	16.5	6077	9359	3281
2014	Frederick Hiam	Barn Field	Melody	180	155	-25	54.6	63.1	8.5	5221	6446	1225
2014	Andrew Webster	Marks	Lady Rosetta	206	188	-18	50.5	62.9	12.5	4224	5480	1256

Not valid because: †achieved seed rates different to those intended; ††incorrect N applications; **large difference in emergence dates; ~PCN in experiment

Table 14. Summary of all seed rate comparison data (seed rate increased) collected in Potato Council/NIAB-CUF Grower Collaboration Project R295 2007-2014. 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 margin (£/ha)	Modified margin (£/ha)	Change in margin (£/ha)
Invalid comparisons												
2009	EG Harrison†	Bakers 27	Saturna	1.49	1.88	0.38	48.8	54.2	5.4	4446	4725	278
2011	Matt Bere†	Big Mead	Sante	1.90	1.87	-0.04	45.3	43.9	-1.5	4033	4021	-12
2013	B&C Farming*	Booton	Russet Burbank	1.34	1.37	0.03	63.6	62.5	-1.1	6058	6025	-33
2013	B&C Farming*	Medler R'rvoir	Russet Burbank	1.41	1.51	0.10	54.6	52.5	-2.0	4969	4483	-486
2014	Frederick Hiam*	Giles	Marabel	4.14	5.00	0.85	82.5	84.7	2.2	7826	7627	-199
2014	Robin Baines*	14JPO27	Challenger	2.35	2.83	0.48	66.8	68.2	1.4	6246	5974	-273
2014	Robin Baines*	14JPO28	Innovator	5.81	7.08	1.27	71.3	70.8	-0.6	5422	5067	-355
Valid comparisons												
2007	Strawson Farming	Godfrey Blyth	Saturna	2.54	2.99	0.46	69.4	72.8	3.4	6421	6613	192
2007	W.B.Daw	Thorpe 41	Saturna	1.37	1.59	0.23	53.3	49.3	-4.0	5036	4293	-743
2013	Frederick Hiam	Hill Farm 5	Vivaldi	2.44	2.76	0.32	57.3	65.0	7.7	6077	7551	1474

Not valid because: †achieved seed rates different to those intended; * experimental seed rates

Table 15. Summary of all seed rate comparison data (seed rate decreased) collected in Potato Council/NIAB-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 margin (£/ha)	Modified margin (£/ha)	Change in margin (£/ha)
Invalid comparisons												
2007	Strawson Farming†	Knights N'bugh	Saturna	2.41	2.25	-0.16	51.0	49.8	-1.1	4311	4264	-47
2007	Strawson Farming†	Shammar Cr'ke	Hermes	2.86	2.42	-0.43	47.5	46.8	-0.7	4023	4114	91
2007	Strawson Farming†	Bower C'bton	Hermes	3.73	3.07	-0.66	55.5	58.6	3.1	4405	4974	569
2008	AH Worth & Co†	Field 69	Estima	2.75	2.75	0.00	59.2	69.8	10.6	5126	6372	1246
2008	EG Harrison†	Millfield	Hermes	4.49	1.81	-2.68	53.9	59.4	5.6	3958	5562	1604
2008	EG Harrison†	Millfield	Hermes	4.49	3.07	-1.42	53.9	59.3	5.5	3958	5194	1237
2008	Toby Mermagen†	Horseshoes	Hermes	2.18	1.92	-0.25	50.4	53.6	3.2	4466	4986	520
2008	Strawson Farming††	Bower 8	Hermes	3.04	2.41	-0.62	66.2	57.9	-8.3	5810	5134	-676
2008	Strawson Farming†	Hoggard 6	Saturna	2.25	2.10	-0.14	67.6	60.1	-7.5	6031	5369	-662
2009	Strawson Farming†	Sansom Wood	Hermes	2.64	2.14	-0.50	42.3	39.6	-2.6	3140	3219	79
2010	GM Ward & Co†	Hall Field	King Edward	1.95	1.89	-0.07	67.2	66.0	-1.1	5978	6011	33
2010	AH Worth & Co†	Field 26/27	Marfona	2.51	2.34	-0.17	54.8	63.3	8.5	5420	6592	1172
2010	Tim Westgarth†	Field 35	Saturna	2.28	2.33	0.05	47.2	44.4	-2.8	3985	3674	-311
2010	Tim Westgarth**	Field 16	Hermes	3.38	2.58	-0.80	55.8	58.4	2.6	4801	5285	484
2011	B&C Farming†	Grove Farm 89	Russet Burbank	1.29	1.32	0.02	61.6	65.3	3.7	5731	6333	603
2011	B&C Farming†	Grove Farm 89	Russet Burbank	1.29	1.17	-0.12	61.6	61.1	-0.6	5731	5980	249
2011	B&C Farming†	Grove Farm 91	Russet Burbank	1.37	1.27	-0.10	75.6	68.1	-7.5	7232	6391	-841
2011	B&C Farming†	Medler Melton	Russet Burbank	1.38	1.20	-0.17	58.5	61.3	2.8	5483	5854	371
2011	Co-operative Farms†	Pasture 116	Maris Piper	2.51	2.28	-0.23	63.9	61.0	-2.9	6071	5965	-105
2011	Co-operative Farms†	Pasture 116	Maris Piper	2.51	2.28	-0.23	68.3	62.8	-5.5	6598	5988	-610
2011	Matt Bere†	Big Mead	Sante	1.87	1.49	-0.37	43.9	53.1	9.2	4021	5427	1406
2011	David Austin†	Nocton 2	Maris Piper	1.64	1.53	-0.11	70.1	67.3	-2.8	6963	7331	368

Table 15. (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 margin (£/ha)	Modified margin (£/ha)	Change in margin (£/ha)
Invalid comparisons												
2012	B&C Farming†	Grove Farm 82	Russet Burbank	1.42	1.32	-0.10	72.5	69.9	-2.7	6763	6770	7
2012	B&C Farming†	Fengate	Russet Burbank	1.29	1.21	-0.08	62.1	57.6	-4.5	5561	5080	-481
2012	B&C Farming†	Fengate	Russet Burbank	1.13	1.01	-0.12	63.6	65.2	1.6	5996	6115	119
2012	B&C Farming†	Fengate	Russet Burbank	1.41	1.37	-0.05	58.3	59.4	1.1	5126	5282	156
2012	Branston~	DB3	Estima	3.17	2.88	-0.29	48.5	29.9	-18.6	2917	574	-2343
2012	B&C Farming†	Medler C' Hall	Russet Burbank	1.50	1.37	-0.12	61.4	57.4	-4.1	5324	4986	-338
2013	W B Daw†	Mercers W.P.	Markies	2.30	1.44	-0.85	68.2	68.1	-0.1	6135	6622	487
2013	B&C Farming†	Booton	Russet Burbank	1.34	1.28	-0.07	63.6	68.8	5.2	6058	6647	589
2014	Capel St Andrew Farm*	Beacon	Golden Nugget	3.96	3.04	-0.93	28.8	20.9	-7.9	3407	2637	-770
2014	Capel St Andrew Farm*	Beacon	Golden Nugget	4.68	4.82	0.14	25.2	32.9	7.7	2740	3193	453
2014	Frederick Hiam*	Giles	Marabel	4.14	3.29	-0.85	82.5	81.5	-1.0	7826	8325	499
2014	Robin Baines*	14JPO27	Challenger	2.35	2.17	-0.18	66.8	66.6	-0.2	6246	6300	54
2014	Robin Baines*	14JPO28	Innovator	5.81	4.72	-1.09	71.3	81.6	10.3	5422	6495	1074
Valid comparisons												
2007	W.B.Daw	Ellis B	Hermes	2.77	2.34	-0.43	63.4	74.6	11.2	5146	6828	1682
2007	EG Harrison	45 acres	Saturna	2.47	2.21	-0.26	68.7	62.8	-5.9	6204	5716	-488
2007	EG Harrison	Wrights	Hermes	3.14	2.03	-1.10	49.8	54.0	4.2	3893	4803	911
2007	W.B.Daw	Thorpe 41	Saturna	3.11	2.47	-0.64	57.9	50.5	-7.3	4962	4182	-779
2008	AH Worth & Co	Field 69	Estima	2.04	1.68	-0.37	59.0	59.6	0.6	5565	5501	-64
2008	AH Worth & Co	Field 13	Maris Piper	1.54	1.18	-0.36	64.4	56.0	-8.4	5603	5144	-459
2008	W B Daw	Bowling Alley	Lady Rosetta	3.31	2.85	-0.46	66.9	64.7	-2.1	5802	5687	-115
2008	W B Daw	Pack'on Quarry	Hermes	4.14	2.67	-1.47	57.8	55.0	-2.8	4509	4692	183
2008	EG Harrison	Malthouse	Saturna	1.94	1.70	-0.24	45.2	43.3	-1.9	3949	3888	-61

Table 15. (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 margin (£/ha)	Modified margin (£/ha)	Change in margin (£/ha)
Valid comparisons												
2008	Strawson Farming	Godfrey 8	Saturna	2.32	2.05	-0.27	50.6	52.0	1.5	4222	4532	310
2009	AH Worth & Co	JEP44	Estima	2.40	2.05	-0.35	60.1	55.2	-4.9	5583	5284	-299
2009	AH Worth & Co	JEP44	Estima	3.34	2.91	-0.43	67.9	66.2	-1.7	6123	6073	-50
2009	EG Harrison	Bakers 55	Hermes	2.99	2.66	-0.32	56.6	58.2	1.6	4493	4884	391
2009	Toby Mermagen	Long Lions	Hermes	2.79	2.40	-0.39	57.0	62.2	5.2	4829	5519	690
2009	W B Daw	Marsh Barn	Lady Rosetta	1.61	1.22	-0.39	57.6	51.1	-6.5	4904	4599	-305
2009	W B Daw	Marsh Barn	Lady Rosetta	2.36	1.90	-0.46	54.5	52.2	-2.3	4107	4440	333
2010	Co-operative Farms	3/5/7/B	Estima	3.01	2.49	-0.52	35.9	39.5	3.6	2181	3030	849
2010	Fridlington Farms	Field 18	Hermes	2.82	2.36	-0.46	57.1	65.4	8.3	4898	5855	956
2011	B&C Farming	Grove Farm 91	Russet Burbank	1.37	1.19	-0.17	75.6	67.1	-8.5	7232	6487	-745
2011	B&C Farming	Grove Farm 91	Russet Burbank	1.35	1.20	-0.15	72.4	69.2	-3.2	7016	6767	-250
2011	B&C Farming	Grove Farm 91	Russet Burbank	1.35	1.11	-0.25	72.4	66.5	-5.9	7016	6465	-551
2011	B&C Farming	Medler Melton	Russet Burbank	1.37	1.19	-0.17	59.8	59.1	-0.7	5623	5538	-85
2011	B&C Farming	Medler Melton	Russet Burbank	1.37	1.19	-0.17	59.8	57.3	-2.5	5623	5450	-173
2011	B&C Farming	Medler Melton	Russet Burbank	1.38	1.18	-0.20	58.5	60.4	1.9	5483	5711	228
2011	W B Daw	29 Acre	Russet Burbank	1.65	1.45	-0.20	71.5	66.4	-5.1	6637	6253	-384
2011	W B Daw	29 Acre	Russet Burbank	1.90	1.65	-0.25	65.0	60.4	-4.5	6134	5732	-401
2011	Fridlington Farms	Field 11	Hermes	3.28	2.79	-0.49	61.9	73.5	11.6	5497	6936	1439
2012	W B Daw	Green Lane	Markies	1.95	1.71	-0.24	43.1	54.4	11.3	3700	5012	1312
2012	W B Daw	Green Lane	Russet Burbank	1.84	1.45	-0.39	41.4	46.4	5.0	3189	3899	710
2012	B&C Farming	Fengate	Russet Burbank	1.67	1.24	-0.43	64.0	59.5	-4.5	5580	5556	-24
2012	Co-operative Farms	Field 38/02	Harmony	3.21	2.63	-0.58	50.3	61.0	10.7	3580	5308	1727
2012	Tim Westgarth	Richardson	VR808	1.97	1.57	-0.41	37.2	35.6	-1.6	2588	2802	214

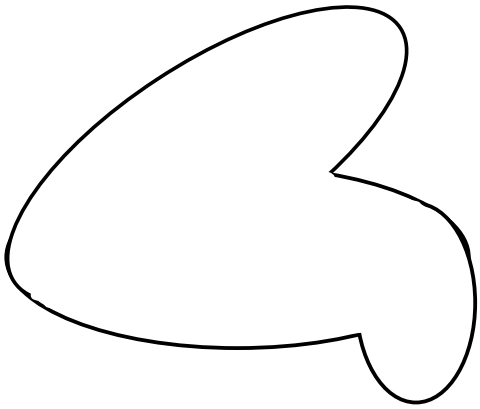
Table 15. (continued)

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 margin (£/ha)	Modified margin (£/ha)	Change in margin (£/ha)
Valid comparisons												
2013	3Ms	Angel Hill	Maris Peer	5.06	3.99	-1.07	44.5	44.2	-0.3	3600	3334	-266
2013	W B Daw	Mercers W.P.	Russet Burbank	2.21	1.71	-0.50	61.9	66.1	4.1	5456	6110	655
2013	B&C Farming	Medler R'rvoir	Russet Burbank	1.41	1.15	-0.26	54.6	54.2	-0.3	4969	5165	196
2014	W B Daw	Thorpe 29	VR808	2.78	2.22	-0.56	55.5	57.2	1.7	4890	5216	326
2014	W B Daw	Thorpe 29	VR808	2.19	1.68	-0.51	56.3	54.9	-1.4	5129	5126	-4
2014	W B Daw	Thorpe 29	VR808	1.56	1.25	-0.31	61.3	50.8	-10.5	5846	4823	-1022
2014	W B Daw	Ellis Brook	Markies	1.87	1.42	-0.46	57.4	54.9	-2.5	5276	4758	-519
2014	Frederick Hiam	Tuddenham Rd	Marfona	3.17	2.68	-0.49	61.0	62.5	1.5	5908	6662	754
2014	Andrew Webster	Marks	Lady Claire	1.97	1.60	-0.37	57.2	57.0	-0.1	4311	4692	382

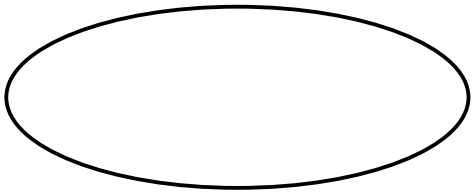
Not valid because: †achieved seed rates different to those intended; ††incorrect N applications; * experimental seed rates; **large difference in emergence dates; ~blight in experiment

Appendix 2.

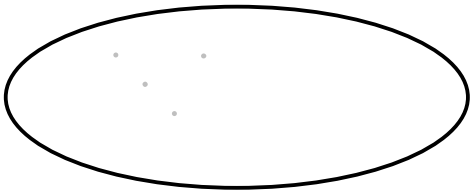
Table 16. Scheme used to assess internal defects in Challenger, Innovator, Markies and Russet Burbank. Assessments are made on all tubers > 90 mm (Markies and Russet Burbank) and > 100 mm (Challenger and Innovator) in length. The number of mis-shapes and dolls are first recorded then all tubers are then cut in half length-ways and assessed for defects.



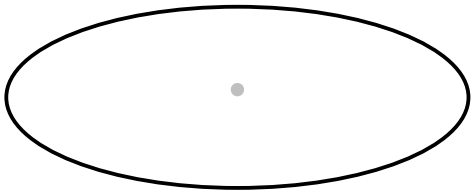
Number of dolls & miss-shapes in sample



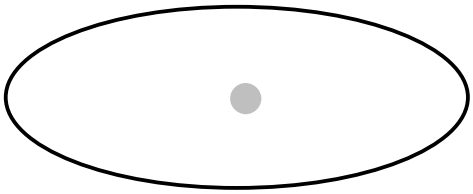
0. No internal discolouration on cut surface



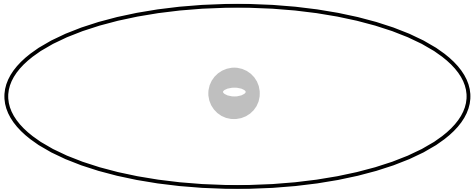
1. Slight speckling



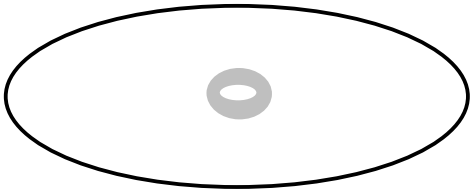
2. Obvious staining . Spots are c. 2-3 mm



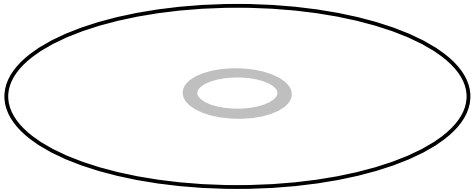
3. Large, 4-5 mm or multiple spots



4. First sign of hollowness at centre of tuber



5. Hollowness at centre of tuber *c.* 5 mm



6. Hollowness at centre of tuber *c.* 10 mm