

CONTRACT REPORT

**Potato Blight (*Phytophthora infestans*),
Sequential Harvesting and the use of
Caliente Mustard for the control
of wireworms
Field Demonstrations, 2006**

**UNDERTAKEN FOR
Centre for Alternative Land Use
under the
Farming Connect Scheme**

Report To: Farming Connect Development Centre
Centre for Alternative Land use

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Period of Investigation: May - December 2006

Date of issue of report: March 2007

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AUTHENTICATION

I declare that this work was done under my supervision according to the procedures described herein and that this report represents a true and accurate record of the results obtained.

..... David Frost
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ACKNOWLEDGEMENTS

This project was funded by the Farming Connect Centre for Alternative Land Use Programme. Seed potatoes were provided by the Sárvári Research Trust (SRT) and Organic Centre Wales. Caliente Mustard seed was donated by Plant Solutions Ltd and ADAS is grateful for the support of Mr Alec Roberts of Plant Solutions at the Open Days and throughout the trial.

INTRODUCTION

Trials of blight resistant cultivars including Sarpo varieties has shown that potato crops can be grown in high-risk blight areas without the use of fungicides and commercially acceptable yields can be obtained (ADAS, 2003; Shaw & Johnson, 2004; Frost & Clarke, 2005).

ADAS undertook demonstrations and evaluations of blight resistant varieties in 2003 (Axona, Sarpo Mira, King Edward). ADAS undertook further demonstrations with support from the Farming Connect Organic Development Centre in 2004 (19 Sarpo & 9 standard varieties plus compost tea treatments) and in 2005 with support from the Farming Connect Centre for Alternative Land Use (12 Sarpo varieties, 6 standard varieties, compost tea treatments, planting density trials).

The experience of the work to date is that growers are interested in blight resistant cultivars, but they need more knowledge of how to produce a crop that is acceptable to the market. Trials undertaken in 2006 and reported here aimed to demonstrate further the wide range of blight resistant cultivars that are potentially available from the Sárvári Research Trust (SRT) and other suppliers and also to demonstrate how techniques such as sequential harvesting and use of brassica green manures can improve the marketability of crops (Frost, Clarke and McLean, 2003).

SECTION 1

POTATO BLIGHT DEMONSTRATIONS, 2006

1. OBJECTIVES

1.1 Primary Objectives

- To examine the level of resistance to *Phytophthora infestans* in selected Sarpo potato cultivars in a high risk blight area
- To undertake potato variety trials, including assessment of yield, on an established certified organic holding
- To evaluate the yield increase of cultivar Mira by sequential harvesting.

1.2 Secondary Objectives

- To evaluate the use of Caliente mustard for the control of wireworms
- To evaluate the biomass production of a number of green manures.

2. TREATMENTS

2.1 Use of varieties with different levels of resistance

The National Institute for Agricultural Botany (NIAB) has developed a rating system to indicate the susceptibility of potato varieties to blight, where 9 = very resistant and 1 = susceptible. According to the British Potato Council, for organic growers, NIAB ratings of 6 or 7 (along with all other methods of control and avoidance) should prove sufficient in most years to grow a crop with minimal or no copper sprays; NIAB ratings of 5 or 6 for tuber and foliar resistance are suitable for organic production if full attention is given to all other methods of blight control; NIAB ratings lower than 5 should only be grown for specialist markets and lower yields due to earlier defoliation should be expected. Organic growers are advised to avoid the use of varieties with ratings less than 3 (British Potato Council, 2003).

Varieties trialed in 2006 were supplied by the Savari Trust and by Organic Centre Wales (OCW). Trials included 4 EUCA standard varieties. Full details are given in Table 1.

Table 1 Potato cultivars evaluated in the blight trials, 2006

Variety	Description
Desiree	Commercially available
Colleen	Commercially available
Sante	Commercially available
Maris Piper	Commercially available
Romano	Commercially available
Maris Peer	Commercially available
Valor	Commercially available
Charlotte	Commercially available
Orla	Commercially available
Duke of York	Commercially available
Verity	Commercially available
L Balfour	Commercially available
Robinta	Commercially available
Cara	Commercially available
Escort	EUCABLIGHT standard
Robinje	EUCABLIGHT standard
Bintje	EUCABLIGHT standard
Alpha	EUCABLIGHT standard
Una	Sarpo
Kate	Sarpo
Mira	Sarpo - Nationally Listed
Jackie	Sarpo
Carrie	Sarpo
Eric	Sarpo

Note: Sarpo varieties, Una and Eric are to be sent for National Listing trials in 2007

3. SITE DETAILS

In order to evaluate the vigour and growth of Sarpo cultivars under organic husbandry, the trial was undertaken on certified organic land. The site selected has been in continuous organic management for over 20 years and certified by the Soil Association since 1984. The site, in a 1.25 ha field surrounded by hedges, was at 120 m above sea level and 1.5 miles from the coast near Llanrhystud in West Wales. Although the land used for the trial had been down to a grass/clover ley for the previous four years, potatoes have been grown on the farm since 1982. According to farm records, foliar blight is usually present in untreated potato crops by the second or third week of July. In 2006, the trials were planted on June 1st and blight was first seen on site on July 19th as single lesions in plots of Duke of York and Verity.

Full site details are given in Table 2.

Table 2. SITE DETAILS

SITE NAME	Llanrhystud
Soil Texture:	Sand / silt Loam
Previous Cropping:	
2005	Grass/clover
2004	Grass/clover
2003	Grass/clover
2002	Grass/ clover
2001	Grass/clover
Cultivations prior to planting:	Plough, power harrow, rotovate
Planting date:	1 June
Harvesting date:	3 November
Fertiliser (g/sqM):	100g/Sq M organic pelleted chicken manure
Mechanical weeding	4 July
Blight seen on site	19 July
Haulm removal	Cut to ground level 26 September
Trace elements	None

4. METHODS

4.1 Layout of the trials

4.1.1 Layout of variety trials for blight resistance

The cultivars were arranged in a fully randomised complete block design with two replicates. The plots were four rows wide (3.0 m) and measuring 3.3 m in length.

4.1.2 Layout of trial to assess effects of sequential harvesting on the yield potential of listed variety Sarpo Mira when compared to two commercial varieties

The plots were arranged with all plots four rows wide and measuring 3.0 m in length.

4.2 Records of weather conditions

Weather conditions, particularly temperature and humidity, affect the spread of the airborne blight fungus. Smith Periods relate weather conditions to blight development. They are periods which are conducive to sporulation of the blight pathogen on lesions – leaf wetness is also necessary. Smith Periods are calculated by the British Potato Council's Blight Watch programme from hourly temperature and relative humidity values supplied by the meteorological office. They are interpolated to postcode areas for the whole of the UK.

A full Smith Period has occurred when there has been at least two consecutive days where the minimum temperature is 10 degrees C or above and on each day at least 11 hours when the relative humidity is 90% or above.

A 'Near Miss' occurs when one or both of the two consecutive days has only 10 hours when the relative humidity is greater than 90%.

Full Smith Periods and Near Misses were recorded for the site from Blight Watch (<http://www.potatocrop.com/potatobligh.htm>).

4.3 Records of foliage blight

Foliage blight was assessed regularly during the epidemic as a percentage of leaf area destroyed by blight using a modified MAFF key 2.1.1 - Potato Blight on the Haulm (Anon., 1947 & 1976; Large, 1952), see Table 3.

4.4 Assessment of yield

Plot yields were taken using an elevator potato harvester and manually forking each plot, all tuber sizes were included in the yield totals excluding rotted tubers.

4.5 Assessment of canopy vigour

Canopy vigour scores were taken by assessing the canopy cover over the whole plot whilst looking down the centre of each plot individually. With total bare ground scoring 0 and no bare ground seen scoring 10.

4.6 Destruction of haulm

The haulm was mechanically cut to ground level from each plot on 26 September.

4.7 Foliar blight - Statistical Analysis

The progress of the foliar blight epidemic for each of the treatments was represented by a sigmoidal disease progress curve. The intensity of blight infection was measured for each plot by calculation of the **Area Under the Disease Progress Curve** (AUDPC) using numerical integration. AUDPC is expressed as units of 'percentage.days'.

AUDPC and yield data for all treatments were subjected to an Analysis of Variance in order to obtain the standard error of the difference (SED) which was used to assess the significance of differences.

4.8 Assessment of tuber blight

Post harvest assessments of the presence and extent of tuber blight were made for each variety in the trial. The number of tubers > 35 mm affected by blight was recorded as a percentage of the total number of tubers; and the weight of tubers > 35 mm affected was also recorded as a percentage of the total weight of tubers.

TABLE 3. KEY FOR ASSESSING FOLIAR BLIGHT

Blight %	Description
0	Not seen
0.1	1+ Lesion per plot)
0.2	25 Lesions per plot)
0.3	50 Lesions per plot)
0.4	75 Lesions per plot)
0.5	100 Lesions per plot or 1 lesion per plant) Assuming
0.6	2 lesions per plant) 100 plants
0.7	4 lesions per plant) per plot
0.8	6 lesions per plant)
0.9	8 lesions per plant)
1.0	10 lesions per plant)
5.0	1 Lesion per compound leaf or 50 lesions per plant)
10.0	2 Lesions per compound leaf or 100 lesions per plant)
25.0	Nearly every leaflet with blight lesions - plants still retaining their normal form - 75% plot leaf area remaining green
50.0	About half of the leaf area destroyed by blight
75.0	About three-quarters of the leaf area destroyed by blight
95.0	Stems green, only a few leaves remaining
100.0	All leaves dead, stems dead or dying

5. RESULTS

5.1 The blight epidemic 2006

5.1.1 Smith Periods

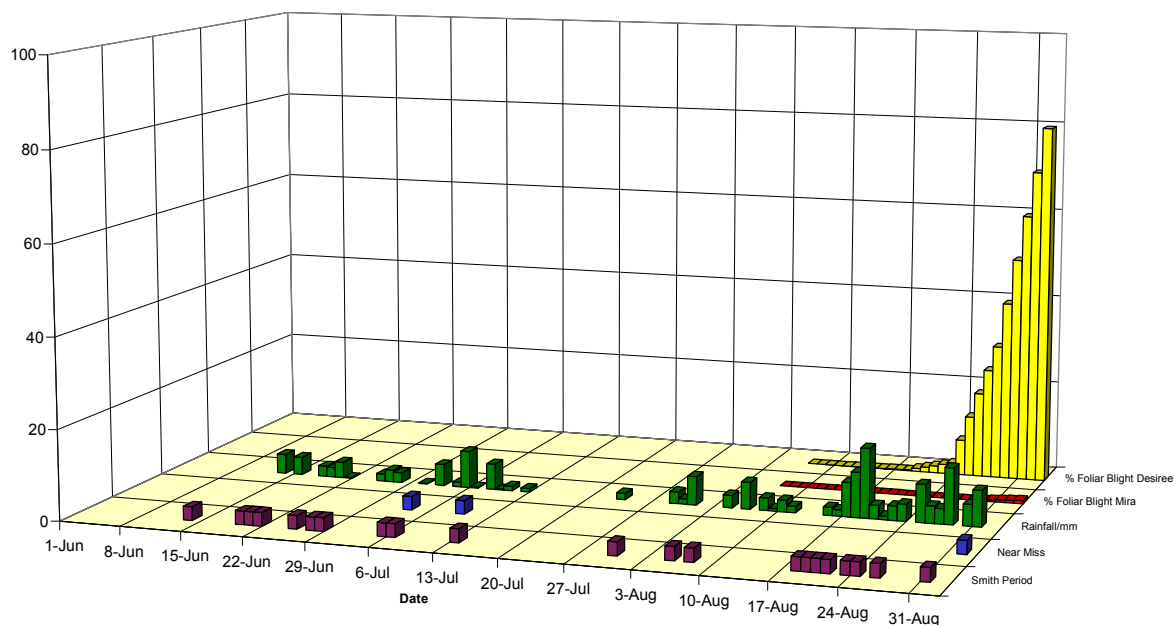
When Smith Periods occur at frequent and regular intervals (7-10 days) in combination with rainfall, there is greater chance of blight development.

Rainfall data recorded at Trawsgoed and Smith Periods recorded at Llanrhystud together with foliar blight progress on Desire plots in the trial are given in Figure 4.

The chart shows the progress of foliar blight in the Desiree and Sarpo Mira crops during the combination of Smith Periods and rainfall in August 2006.

Figure 1 Daily rainfall, Smith periods and blight progress

Daily rainfall as recorded at Trawsgoed, Smith Periods as recorded for Llanrhystud by Blight Watch, and blight progress 2006.



5.1.2 Foliage blight infestation & AUDPC analysis

Foliar blight infection was first recorded on 19th July 2006. The AUDPC analysis is presented in Table 4

5.1.3 Foliage blight on sequential harvest plots

The progress of the blight epidemic through the sequential harvest trial plots is shown in table 5. The table illustrates the blight resistance of Sarpo Mira compared to the standard varieties, Desiree and Robinta. Foliar blight was recorded in the Desiree and Robinta plots on 13 August and had spread to affect almost half of these crops by 28 August and reached 98% in Desiree and 100% in Robinta by 22 September. The infection in Sarpo Mira was 0.1% on 28 August and 3% on 22 September, having not increased from this measure since 15 September.

Table 4. AUDPC (Area Under Disease Progress Curve)

Variety	AUDPC	
Charlotte	1723	a
Romano	1711	a
Orla	1635	ab
Duke of York	1548	abc
Maris Peer	1448	abcd
Colleen	1416	abcde
Binije	1362	abcde
Robinta	1067	abcdef
Sante	974	abcdef
Sarpo Una	925	abcdef
Desiree	921	abcdef
Maris Piper	676	bcdef
Cara	665	bcdef
Escort	632	bcdef
Alpha	548	cdef
Sarpo Jackie	507	def
Valor	484	def
L Balfour	471	def
Verity	397	ef
Sarpo Carrie	297	f
Sarpo Kate	259	f
Robinje	158	f
Sarpo Eric	73	f
Sarpo Mira	8	f
LSD (P=0.05)	573.9	
CV	33.44	
Treatment Prob(F)	0.0001	

Means followed by the same letter do not differ significantly ($P=0.05$)

Table 5. Mean Percentage Foliar Blight on sequential harvest plots

Treatment	02-Aug	13-Aug	28-Aug	08-Sep	15-Sep	22-Sep
Sarpo Mira	0.0	0.0	0.1	0.5	3	3
Desiree	0.0	0.2	50	99	98	98
Robinta	0.0	0.4	40	95	100	100

5.2 Yield of varieties in the blight resistance trials

The total yields for each cultivar in the trial are given in Table 6. The range is from 11.3 tonnes per hectare for Duke of York to 31.9 tonnes per hectare for Sarpo Mira.

TABLE 6. TOTAL YIELDS FOR EACH CULTIVAR IN BLIGHT TRIALS, 2006

Variety	Yield t/ha
Sarpo Mira	31.9 a
Sarpo Una	26.7 ab
Sarpo Eric	26.3 ab
L Balfour	25.7 abc
Cara	25.4 abc
Escort	23.7 abc
Verity	23.6 abc
Sante	23.3 abc
Robinta	22.6 abc
Sarpo Carrie	22.0 abc
Orla	21.5 abc
Valor	20.9 abc
Robinje	20.0 abc
Sarpo Jackie	19.4 abc
Colleen	18.4 abc
Maris Piper	17.4 bc
Desiree	17.4 bc
Sarpo Kate	16.6 bc
Romano	16.2 bc
Maris Peer	15.3 bc
Charlotte	15.1 bc
Alpha	13.7 bc
Bintje	12.5 bc
Duke of York	11.3 c
LSD (P=0.05)	7.7
CV	18.45
Treatment Prob(F)	0.0013

Means followed by the same letter do not differ significantly ($P=0.05$)

5.3 Growth vigour and canopy height

Canopy heights and growth vigour for each variety in the blight trial are given in table 7. It can be noted that Sarpo Mira and cultivar Sarpo Kate had the lowest canopy heights (0.4 metre) when measured on 7th July 2006. Sarpo Mira, Sarpo Kate and Charlotte had the lowest vigour score (2.5) at that date, but by 13th August 2006 the lowest vigour score was recorded for Colleen (4.0). The combination of highest canopy height and vigour score was achieved by Cara (height 0.6 m and vigour score 9).

TABLE 7. vigour scores and height

Variety	Canopy height (m) 7/7/06	Vigour score	
		7/7/06	13/8/06
Alpha	0.5	3.0	6.5
Bintje	0.6	5.0	6.0
Cara	0.6	5.0	9.0
Sarpo Carrie	0.5	3.0	6.5
Charlotte	0.5	2.5	5.0
Colleen	0.6	4.0	4.0
Desiree	0.5	4.0	6.0
Duke of York	0.5	4.5	5.0
Sarpo Eric	0.5	4.5	6.5
Escort	0.6	4.5	7.0
Sarpo Jackie	0.5	3.0	6.0
Sarpo Kate	0.4	2.5	5.5
L Balfour	0.5	3.5	8.0
Maris Peer	0.5	3.5	5.5
Maris Piper	0.6	4.0	6.0
Sarpo Mira	0.4	2.5	6.5
Orla	0.6	4.0	5.0
Robinje	0.6	5.0	6.5
Robinta	0.5	3.0	6.5
Romano	0.5	3.5	5.5
Sante	0.5	4.0	7.0
Sarpo Una	0.5	4.0	7.0
Valour	0.5	3.0	8.0
Verity	0.6	6.0	8.5

5.4 Tuber blight assessments

Post-harvest assessments of tuber blight for all varieties in the trial are shown below. Measured by the percentage number of tubers affected and weight. Tuber blight was most present in cultivars Alpha (16%) followed by Escort (6%) Bintje and Robinje (4%), Carrie and Sante (2%).

Variety	% Tuber Blight	
	Number	Weight
Alpha	16	15.96
Bintje	4	5.76
Cara	0	0.00
Sarpo Carrie	2	1.92
Charlotte	0	0.00
Colleen	0	0.00
Desiree	0	0.00
Duke of York	0	0.00
Sarpo Eric	0	0.00
Escort	6	5.88
Sarpo Jackie	0	0.00
Sarpo Kate	0	0.00
L Balfour	0	0.00
Maris Peer	0	0.00
Maris Piper	0	0.00
Sarpo Mira	0	0.00
Orla	0	0.00
Robinje	4	6.77
Robinta	0	0.00
Romano	0	0.00
Sante	2	2.98
Sarpo Una	0	0.00
Valor	0	0.00
Verity	0	0.00

6. ASSESSMENT OF YIELD POTENTIAL OF SARPO MIRA IN COMPARISON TO DESIREE AND ROBINTA.

Successional harvesting started on 2 August and continued at approximate 14 day intervals until 9 October. Crops harvested were sorted by tuber size and yields assessed by weight. Full details are given in table 8 and the accompanying figures.

Table 8. yield of Sarpo Mira, Desiree and Robinta (t/ha)

Variety	Date	Yield t/ha						Total
		12-20mm	20-25mm	25-30mm	30-40mm	40-60mm	>60mm	
Desiree	2-Aug	0.11	0.22	0.44	5.74	4.42	0.00	10.93
Sarpo Mira	2-Aug	0.22	0.22	0.66	0.88	0.44	0.00	2.43
Robinta	2-Aug	0.11	0.22	0.66	5.30	4.86	0.00	11.15
Desiree	13-Aug	0.11	0.11	0.22	2.87	10.15	0.00	13.47
Sarpo Mira	13-Aug	0.22	0.44	0.88	6.62	3.09	0.00	11.26
Robinta	13-Aug	0.11	0.11	0.22	3.53	11.70	0.00	15.67
Desiree	28-Aug	0.11	0.11	0.22	1.32	13.91	1.77	17.44
Sarpo Mira	28-Aug	0.22	0.44	0.44	4.86	11.92	1.77	19.65
Robinta	28-Aug	0.11	0.11	0.44	2.43	13.69	4.64	21.41
Desiree	8-Sep	0.11	0.11	0.22	2.65	14.35	2.21	19.65
Sarpo Mira	8-Sep	0.11	0.11	0.88	3.09	14.57	3.97	22.74
Robinta	8-Sep	0.11	0.11	0.22	2.65	13.47	10.15	26.71
Desiree	15-Sep	0.11	0.11	0.22	2.21	12.80	3.97	19.43
Sarpo Mira	15-Sep	0.00	0.11	0.44	3.53	14.79	5.52	24.39
Robinta	15-Sep	0.11	0.22	0.66	2.43	16.78	7.95	28.15
Desiree	22-Sep	0.11	0.11	0.22	1.55	14.13	3.75	19.87
Sarpo Mira	22-Sep	0.11	0.11	0.44	3.31	17.00	8.61	29.58
Robinta	22-Sep	0.11	0.22	0.44	2.21	15.67	7.51	26.16
Desiree	9-Oct	0.09	0.13	0.28	2.21	12.15	1.04	15.89
Sarpo Mira	9-Oct	0.06	0.10	0.19	3.54	20.55	17.00	41.43
Robinta	9-Oct	0.02	0.06	0.25	2.92	19.46	9.40	32.12

Figure 2 Total yield (t/ha) Sarpo Mira, Desirée and Robinta

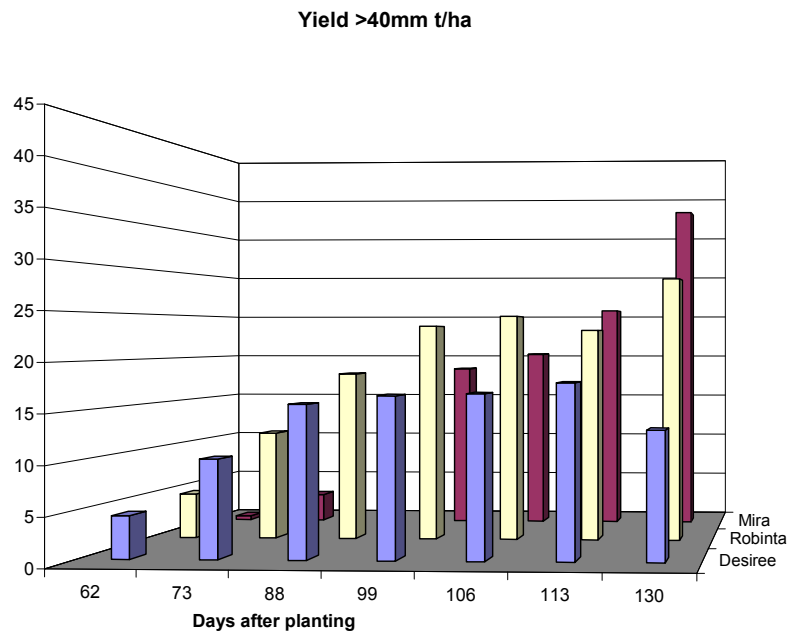
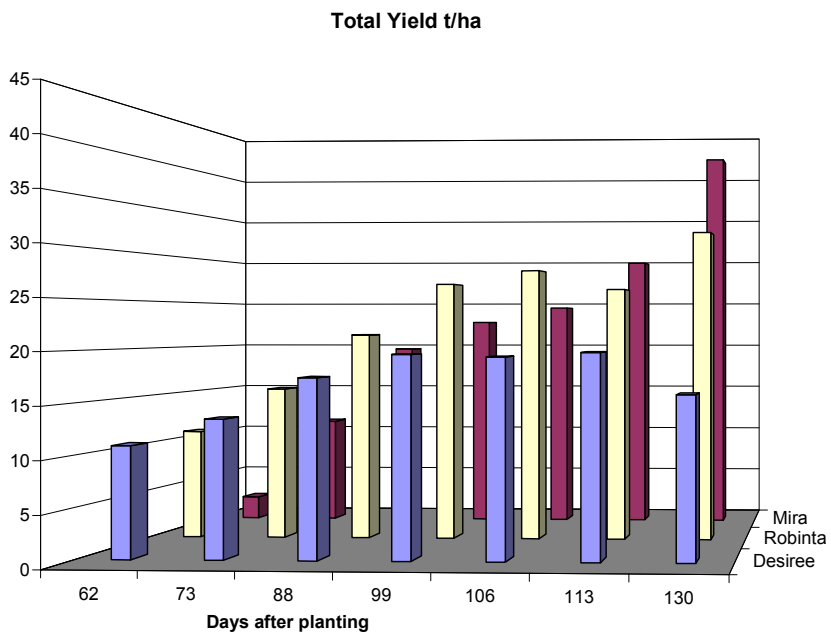


Figure 3 Yield (t/ha) of tubers >40mm Sarpo Mira, Desirée and Robinta



SECTION 2
7 EVALUATION OF GREEN MANURE BIOMASS AND THE EFFICACY OF CALIENTE MUSTARD FOR THE CONTROL OF WIREWORM IN POTATOES.

Trials were undertaken at two sites. A field-scale demonstration trial at the Llanrhystud site and a plot-scale scientific trial at Rhydlewys, Ceredigion.

7.1 Evaluation of biomass production of mustards when used as a green manure and preparation of demonstration site

The 1ha (approx) enclosure at Llanrhystud was divided into 6 equal sized demonstration plots and prepared for sowing with mustards and clovers. Details of the site and cultivations are given below:

SITE NAME	Llanrhystud
Soil Texture:	Sand / silt Loam
Previous Cropping:	
2005	Potatoes/Grass/clover
2004	Grass/clover Potatoes
2003	Grass/clover
2002	Grass/ clover
2001	Grass/clover
Cultivations prior to planting:	Plough, power harrow
Planting:	Hand broadcasting
Cultivations post planting:	Chain Harrow, rolled
Planting date:	12 May
Fertiliser (g/sqM):	90g/Sq M organic pelleted chicken manure

The demonstration plots were each sown with a green manure. Two were sown with clovers – Crimson clover *Trifolium incarnatum* and Sweet clover *Melilotus alba*¹, and four were sown with mustards. Three of the mustard plots were sown with ‘Caliente’ varieties supplied by Plant Solutions Ltd and one with a standard mustard variety. Compared to standard mustards used as green manures, Caliente Brand Mustards contain varieties protected by breeders' rights and are claimed to improve soils and control soil-borne pests by a process of ‘bio fumigation’. Those used in the trials were bred and selected by ISCI, Bolonga, Italy “to produce large amounts of biomass and high levels of...glucosinolates and enzyme (myrosinase) that are needed for the crops biocidal attributes” (Plant Solutions, nd) .

Treatments are detailed in Table 9. Caliente 119 is described by the supplier as “the best all round variety” . It was first developed for the potato industry and has been used in the field for over twelve years. Caliente 99 is a newer introduction with high

¹ Seed obtained from Cotswolds Grass Seeds Ltd. For details of cultivation of Sweet clover and Crimson clover as green manures, see, for example, Cotswolds Seeds (2007) *Seeds for Organic Farmers*. Moreton in Marsh, Gloucestershire, pp 15 - 25

glucosinolate levels (30% more than Caliente 119). Nemat, *Eruca sativa* also has high glucosinolate levels including in the roots.

Table 9: Treatments in the demonstration trial, 2006

Treatment	Seed Rate Kg/ha
Mustard	20
Caliente 119	15
Caliente 99	10
Sweet Clover	20
Crimson Clover	20
Nemat, <i>Eruca sativa</i>	8

7.1.1 Green manures - Crop heights

Table 10 compares the crop heights of each green manure at three dates after sowing. It should be noted that limited data were obtained for clover varieties as germination was delayed compared to mustard. Further, it became necessary for both clover plots to be mechanically topped on 29 June 2006 to control smothering weeds. Caliente 119 was the highest growing crop, closely followed by Caliente 99.

Table 10: Comparison of crop heights for each treatment

Crop	Mean crop height (cm)		
	31-May	9-Jun	7-Jul
<i>Weeks after sowing</i>	2.7	4.0	8.0
Caliente 119	3.4	8.1	80.2
Caliente 99	1.5	5.8	78.3
Crimson Clover		3.7	
Mustard	3.0	6.9	61.8
Nemat	3.0	5.7	58.9
Sweet Clover			

7.1.2 Green manures – biomass production

Table 11 compares the fresh and dry matter yields for each mustard treatment. The highest dry matter yield was from Caliente 119 followed by Caliente 99.

Table 11: Comparison of fresh and dry matter yields for each MUSTARD treatment

Crop	Fresh Yield t/ha	% Dry Matter	Dm Yield t/ha
Caliente 119	15.6	22.8	3.6
Caliente 99	16.8	19.6	3.3
Mustard	9.9	26.3	2.6
Nemat	10.0	19.5	1.9

7.1.3 Demonstrations – Open Days

The demonstration plots were open to visitors on 19th July and 20th September, 2006. Farmers and growers had the opportunity to inspect the trial plots which were

grown in an enclosure adjacent to the potato variety trials, and to discuss the trial with ADAS staff and representatives from Plant Solutions Ltd.

7.2 Evaluation of the efficacy of Caliente Mustard for the control of wireworm

The trial to assess the efficacy of Caliente mustards for the control of wireworm was undertaken at a second site at Rhydlewis, Ceredigion. This site was chosen as it was on a licensed organic holding specialising in vegetable crops and potatoes. The site had known high wireworm larvae populations. Wireworm populations were assessed by taking 20 x 6 inch core samples to plough depth and using Blasedale extractors.

The trial protocol was to prepare the site, sow replicated plots with three mustard varieties – standard white mustard, Caliente 119 and Caliente 99, and then to incorporate the green manures after approximately six weeks and prior to planting potatoes, cultivar Sarpo Mira. The potato tubers to be assessed for wireworm damage at harvest. Full details of the site and cultivations, etc are summarised below:

SITE NAME	Rhydlewis, Ceredigion	
Soil Texture:	Sand / silt Loam	
Previous Cropping:		
2005	Grass/clover	
2004	Grass/clover	
2003	Grass/clover	
2002	Grass/ clover	
2001	Grass/clover	
Plot layout	Latin Square (see appendix)	
Wireworm Population	95/m ²	
Cultivations prior to planting:	Plough	10 April
	Power harrow	14 April
Planting:	Hand broadcasting	14 April
Cultivations post planting:	Chain harrow, rolled	14 April
Fertiliser (g/sqM):	200g/Sq M organic pelleted chicken manure	14 April
Cultivations prior to potato planting	Flail Mower	
	Biofence applied at 1.5t/ha **	9 June
	Rotovate	
	Rotovate	28 June
Cress test	26 June	
Potato planting	28 June	
Variety	Sarpo Mira	
Seed spacing	30cm	
Row width	30inch	
Plot length	10 Metres	

** White mustard (T2 only) germination very poor, Biofence substituted

7.2.1 Progress of the Caliente Mustard trial

Mustard varieties were sown on 14 April. Due to logistical problems, this was later than initially planned. The late sowing date also meant that the potato trial was planted later than planned with the result that yield differences could not be assessed. An end of June planting date is too late to assess any yield differences, but the tubers could be assessed for wireworm holes.

After planting, growing conditions were poor, with cold wet weather as shown in table 12 . The white mustard (which was from an old batch of seed) failed to germinate satisfactorily and the crop was terminated and this treatment was replaced in the trial with 'Biofence' – a dried mustard meal – provided by Plant Solutions Ltd.

The weather after planting potatoes was very hot and dry (see table 12) and the crop suffered from drought stress. For this reason, mechanical weeding was not undertaken - with the result that when precipitation did arrive, weed and crop grew quickly to fill the rows and prevent the possibility of inter-row cultivations.

Table 12 Rhydlewis trial – weather conditions, April – August, 2006

	Rainfall (mm)	Max degrees C	Min degrees C
<i>April</i>	39	10.5	5.8
<i>May</i>	118	13.9	8.1
<i>June</i>	19	18.0	11.3
<i>July</i>	32.8	21.2	13.7
<i>August</i>	68	17.1	12.9

Source: Aberporth Met. Station Data, 2006

7.2.2 Results of the Caliente Mustard trial

The growth of the green manures is shown in table 13 for four dates after sowing. It can be seen that Caliente 119 achieved greater crop heights than Caliente 99

Table 13: Green Manures - Mean crop heights (cm)

Treatment	16-May	25-May	03-Jun	09-Jun
<i>Weeks after sowing</i>	4.6	5.9	7.1	8.0
Caliente 119	8.2	9.6	22.6	53.35
Caliente 99	6.4	7.8	16.9	38.74

Poor early growing conditions may have affected the biomass potential of the Caliente mustards. When mustards and Biofence were incorporated into the soil, ground conditions were dry. Although there was precipitation four days later, ideally the soil should have contained more moisture at incorporation. Dry conditions may

have resulted in lower than expected 'bio-fumigant' effect (see table 14, below) as it needs moisture to drive the reaction.²

Table 14: Assessment of Wireworm damage - Table of means

Treatment	18 Sept			9 Oct		
	% tuber affected	Holes per affected tuber	Holes/ 100 tubers	% tuber affected	Holes per affected tuber	Holes/ 100 tubers
Untreated	18.0	1.47	0.15	41.5	2.18	0.46
Biofence	15.0	1.73	0.14	39.0	2.57	0.50
Caliente 119	16.0	1.43	0.13	47.5	2.51	0.63
Caliente 99	17.5	1.84	0.17	47.5	2.47	0.58

Table 14 shows no significant differences found in any assessment at either harvest date.

8. SUMMARY AND CONCLUSIONS

Trials in 2006 demonstrated a high level of resistance to *Phytophthora infestans* in the Sarpo potato cultivars when grown in a high-risk blight area. At September 8, the date of the final foliar blight assessment in the variety trials, the cultivars with least foliar blight were Sarpo Mira (0.75%) and Sarpo Eric (15.0%). In the sequential harvesting trial, foliar blight progressed through Desiree and Robinta plots and reached 98% and 100% respectively by 22 September, 2006. The assessment of Sarpo Mira at that date was 3% foliar blight.

The highest yields in the variety trials were obtained from Sarpo Mira, Sarpo Una and Sarpo Eric followed by Lady Balfour and Cara. In the sequential harvest trials, Sarpo Mira had much lower total yields (c. 60% lower) at the first harvest on August 2 compared with Desiree and Robinta. After the onset of blight affected Desiree and Robinta plots however, the situation was reversed. At the final harvest, on October 2 the Sarpo Mira yield was c.25% greater than Robinta and c.40% greater than Desiree.

Sarpo varieties tend to be late bulking but, because of their high foliar blight resistance, tubers continue to grow until very late in the season. To obtain optimum crops, growers should remove haulm once the required tuber size has been reached to avoid high numbers of over-size tubers (with associated physiological disorders such as 'hollow-heart') in harvest samples.

In the ADAS blight trials between 2003 and 2006, Sarpo cultivars have been assessed in a high-risk blight area and, since 2004, on an organic holding on Grade 4 Agricultural land. These trials have demonstrated high levels of blight resistance among Sarpo cultivars and an associated potential for high yields.

² For further details, see www.plantsolutionsltd.com

To further assess these cultivars for market and consumer acceptance, it is recommended that trials should be undertaken on good potato land, for example in Pembrokeshire, with irrigation available when required, with the aim of producing the highest quality crops.

Trials of Caliente mustard for biomass production demonstrated the vigour of growth of Caliente 119 and Caliente 99 compared to Nemat and standard mustard varieties when measured by crop height. Both Caliente mustards also produced higher dry matter yields, measured as DM tonnes per hectare compared with standard mustard and Nemat varieties.

Trials to evaluate the use of Caliente mustard for the control of wireworms in potato crops found no significant effect using either Caliente 119; Caliente 99 or Biofence compared to untreated crops. It should be noted however, that weather conditions at the site were unfavourable for the growth and incorporation of the mustards. It was also the case that due to logistical reasons, the trial was late starting and of short duration. It is therefore recommended that further evaluations of Caliente mustards should be undertaken over a longer time period / growing season, and that protocols for their use as a soil bio-fumigant should be followed.

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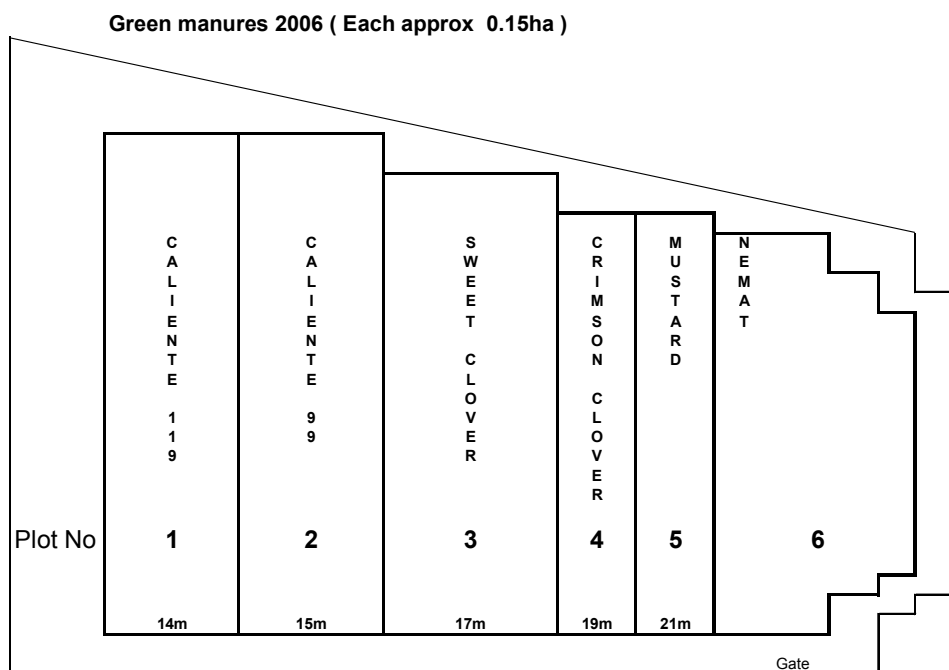
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Appendix I

	Mean % Foliar Blight						
Variety	7-Aug	13-Aug	18-Aug	23-Aug	28-Aug	2-Sep	8-Sep
Alpha	0.00	0.00	0.10	0.20	7.00	50.00	65.00
Bintje	0.00	0.30	6.50	20.00	84.00	99.50	100.00
Cara	0.00	0.10	0.30	1.60	15.00	60.00	67.50
Sarpo Carrie	0.00	0.05	0.50	0.50	4.10	27.50	31.00
Charlotte	0.05	2.55	35.10	57.50	85.00	100.00	100.00
Colleen	0.00	0.05	0.35	30.00	82.50	100.00	100.00
Desiree	0.00	0.05	0.20	2.50	30.00	80.00	94.50
Duke of York	0.00	2.55	40.05	47.65	70.00	90.00	100.00
Sarpo Eric	0.00	0.00	0.15	0.20	2.25	4.50	15.00
Escort	0.00	0.00	0.25	0.45	8.00	55.00	85.00
Sarpo Jackie	0.00	0.10	0.35	1.70	13.50	45.00	50.00
Sarpo Kate	0.00	0.00	0.10	0.15	1.50	22.50	37.50
L Balfour	0.00	0.05	0.25	2.55	10.50	36.00	70.00
Maris Peer	0.10	2.60	15.05	42.50	70.00	90.00	98.50
Maris Piper	0.00	0.05	0.15	1.15	15.25	60.00	75.00
Sarpo Mira	0.00	0.00	0.00	0.00	0.05	0.75	0.75
Orla	0.00	1.05	12.80	55.00	85.00	99.50	100.00
Robinje	0.00	0.00	0.15	0.15	1.05	12.50	27.50
Robinta	0.00	0.10	0.65	10.00	57.50	82.50	97.00
Romano	0.05	5.10	28.00	55.00	92.50	98.00	100.00
Sante	0.00	0.15	0.55	5.00	32.50	82.50	98.50
Sarpo Una	0.00	0.05	0.25	5.50	22.50	80.00	95.00
Valor	0.00	0.00	0.25	2.55	6.50	42.50	55.00
Verity	0.00	0.15	2.50	3.05	13.00	29.00	52.50

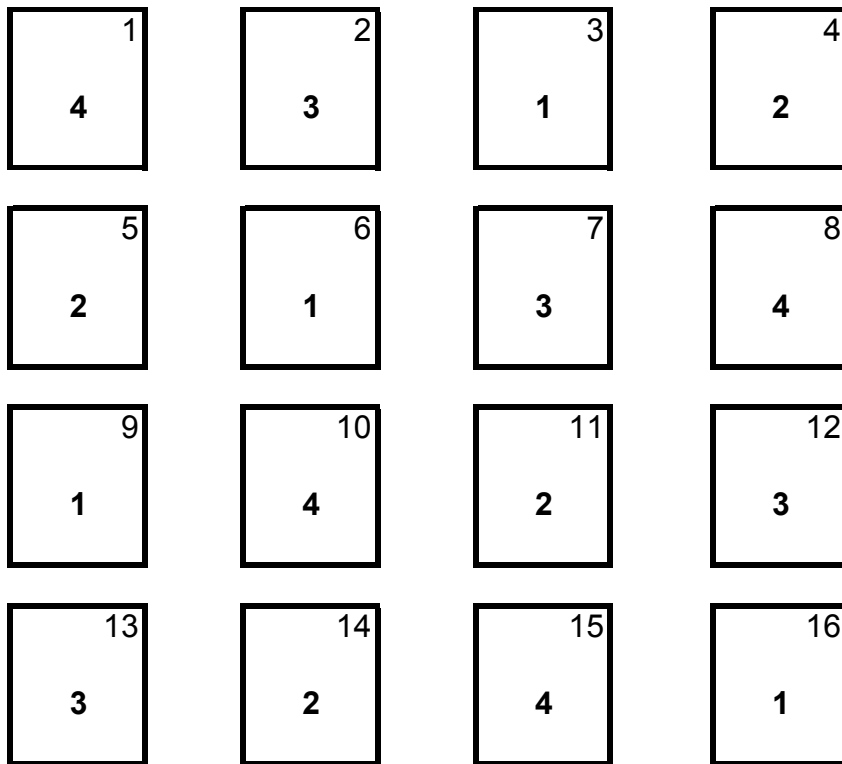
1 Desiree	2 Colleen	3 Una	4 Sante
5 Kate	6 Escort	7 Maris Piper	8 Romano
9 Maris Peer	10 Mira	11 Robinje	12 Valor
13 Jackie	14 Carrie	15 Charlotte	16 Eric
17 Orla	18 Bintje	19 Duke of York	20 Verity
21 Alpha	22 Lady Balfour	23 Robinta	24 Cara
25 Una	26 Jackie	27 Bintje	28 Alpha
29 Escort	30 Eric	31 Robinta	32 Charlotte
33 Orla	34 Desiree	35 Kate	36 Robinje
37 Sante	38 Colleen	39 Cara	40 Maris Piper
41 Mira	42 Carrie	43 Maris Peer	44 Lady Balfour
45 Romano	46 Valor	47 Verity	48 Duke of York

Variety Trial Layout 2006



Green Manure Plot Layout 2006

Plot Layout Rhydlewis 2006



Gate

ROAD

Treatment No	Treatment	Rate Kg/ha
1	Untreated	
2	Biofence	1563
3	Caliente 119	15
4	Caliente 99	10