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CONTRACT REPORT

POTATO BLIGHT (*Phytophthora infestans*) field demonstrations, 2004

UNDERTAKEN FOR
Organic Centre Wales
under the
Farming Connect Scheme

Report To:	Farming Connect Development Centre Organic Centre Wales Institute of Rural Sciences UWA Aberystwyth SY23 2AX
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PRINCIPAL WORKERS

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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
Study Director

Date .....

TABLE OF CONTENTS

TABLES AND FIGURES

ACKNOWLEDGEMENTS

This project was funded by the Farming Connect Organic Development Centre Programme. Seed potatoes were provided by the Savari Research Trust and Compost Tea preparations and information on Controlled Microbial Composting were supplied by Blaencamel, Cilcennin, Ceredigion.

INTRODUCTION

There are approximately 600 diseases that affect potatoes; the most serious of these are bacterial wilt, potato cyst nematode (PCN) and Late Blight.

Late Blight *Phytophera infestans* is a major limiting factor on potato production in the UK. As the pathogen is able to evolve and diversify, the British Potato Council acknowledges that the problems of controlling it are increasing year on year. Traditional control methods relied on copper based fungicides such as Bordeaux mixture (copper sulphate and calcium oxide). Copper (Cu) is a broad-spectrum fungicide which acts as a protectant – it needs to be applied to prevent disease – and is potentially phytotoxic. As the use of copper as a fungicide is being withdrawn, alternative strategies for organic growers, particularly the use of blight resistant varieties, require evaluation.

The EU Framework 5 Pan European Management of Late Blight in Organic Potatoes (MOP) study noted that Cu is banned as a fungicide in Switzerland and that there is greater restriction on its use in German speaking countries than in the EU generally (Speiser *et al*, 2005). The project found that countries with the highest level of restriction on Cu had the lowest returns to organic farmers. It concluded that a Cu ban is likely to reduce, but not eliminate organic potato production). For organic potato production to succeed without Cu or other permitted forms of fungicides (none of which have proved fully successful in trials) a high level of resistance to late blight is needed.

In Hungary, the Sárvári Institute has been selecting for blight resistance continually since the 1940s and has introduced new genetic material from wild Andean species. This process of selection has resulted in cultivars with a high level of horizontal resistance to foliar blight (Shaw and Johnson, 2004). The Sarpo (NB.*Sarpo* = *Sar*vari + *po*tato) seed used in the trial was supplied by the Sárvári Research Trust at the University of Wales, Bangor.

In 2003 ADAS Wales undertook limited blight trials comparing resistance in 3 Sarpo varieties[1] with the commercially available cultivar, King Edward. The trial found that the Sarpo varieties out performed the untreated King Edward variety in foliar blight resistance (ADAS, 2003). In 2004, further trials were undertaken with 28 varieties of potatoes, including 19 Sarpo cultivars, to test their resistance to potato blight in a high-risk area. These trials are reported here.

Although ranking of blight resistant varieties and evaluation of compost extracts were included in the MOP project; the use of compost teas from Controlled Microbial Composting systems as a prophylactic against blight was not assessed. The microbial activity of these preparations provides a potential alternative to chemical pesticides and fungicides such as sulphur and copper (Hutchinson, 2003; Hutchinson, 2004), but to date few trials have been undertaken. A limited trial of compost tea preparations was also undertaken by ADAS Wales in 2004.

[1] The varieties trialed in 2003 were, 87/4/18; 93/4/15; 84/01/104

1. OBJECTIVES

1.1 Primary Objectives

- To examine the level of resistance to *Phytophthora infestans* in Sarpo potato cultivars
- To compare the level of resistance to *Phytophthora infestans* with commercially available cultivars in a high risk blight area
- To undertake potato variety trials, including assessment of yield, on an established certified organic holding
- To examine the vigour and growth of Sarpo cultivars under organic husbandry

1.2 Secondary Objective

- To evaluate the use of compost tea in the control of potato blight in Wales.

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).

In 2004, the Sarvari Trust supplied 19 varieties of Sarpo for trials, including the nationally listed cultivars, Mira and Axona. A further 9 commercially available varieties were also trialed. These included cultivars which NIAB score highly for blight resistance, namely Stirling (8), Lady Balfour (7) and Cara (6); and cultivars that NIAB score low for blight resistance - King Edward (3), Wilja (3) and Pentland Crown (3).

The full list of the potato cultivars used in the 2004 trial is given in Table 1.

TABLE 1: POTATO CULTIVARS

Number	Cultivar	Number	Cultivar
1	96.1.21	15	97.18.38
2	98.2.4	16	97.18.89
3	98.25.12	17	97.18.122
4	98.36.5	18	Sarpo Mira
5	98.9.1	19	Sarpo Axona
6	98.79.1	20	Stirling
7	99.27.405	21	Lady Balfour
8	99.68.2072	22	Cara
9	2000.30.220	23	Maris Piper
10	95.11.2	24	King Edward
11	96.3.16A	25	Desiree
12	96.4.35	26	Wilja
13	97.18.6	27	Majestic
14	97.18.24	28	Pentland Crown

2.2 Compost tea treatments

Compost tea was made in a microbrewer using material from a Controlled Microbial Composting system (see appendix) and applied to 6 plots – three treatments with two replicates. The three treatments were on 2 rows of King Edward in the guard rows; i.e. these rows were not included in the variety trials.

Treatment No	Treatment	Period of Application
1	Untreated	
2	Compost tea @ 4 days	21/06/04 to 08/08/04
3	Compost tea @8 days	21/06/04 to 04/08/04

All sprays were applied using an Oxford Precision Sprayer

Boom width	2 metres
Nozzles	Lumark F110-03
Pressure	1.5 bar
Application Rate	1 litre per plot (370 l/ha)

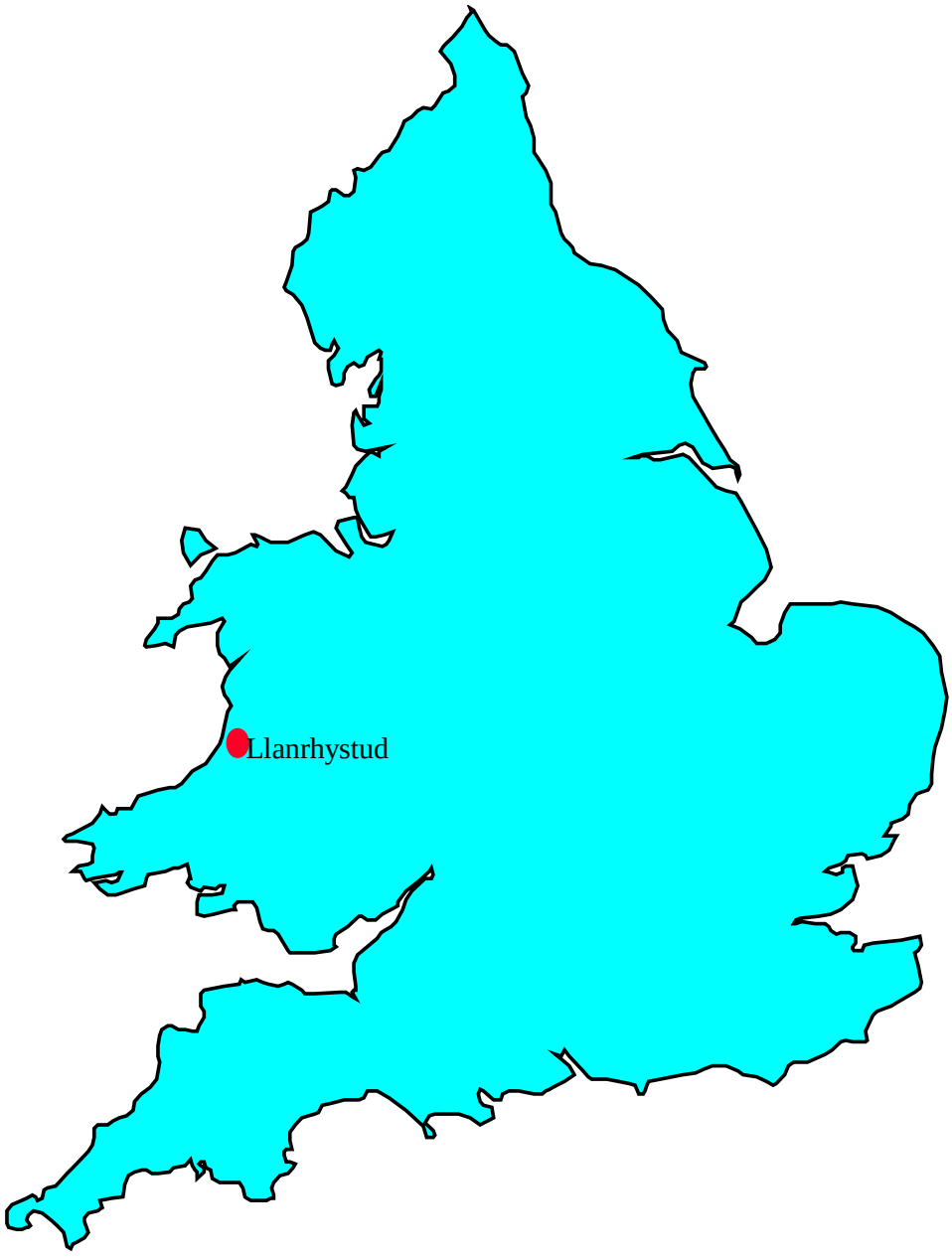
3. SITE DETAILS

In order to evaluate the vigour and growth of Sarpo cultivars under organic husbandry, it was necessary to undertake the trial 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 1.5 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 enclosure used for the trial had been down to a grass/clover ley for the previous three years and to brassicae in the year before this, 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 2004, the trial was planted on May 18th and blight was first seen on site on July 14th. Full site details are given in Table 2.

TABLE 2: SITE DETAILS

SITE NAME	**Llanrhystud**
Soil Texture:	Sand / silt Loam
Previous Cropping:	
2003	Grass/clover
2002	Grass/ clover
2001	Grass/clover
2000	Brassicae
Cultivations prior to planting:	Plough, power harrow, rotovate
Planting date:	18 May
Harvesting date:	2 December
Fertiliser (g/sqM):	230g/Sq M organic pelleted chicken manure
Hand Weeding	18 June
Blight introduced	6 July
Blight seen on site	14 July
Haulm removal	Cut to ground level 16 September
Irrigation	None
Trace elements	None

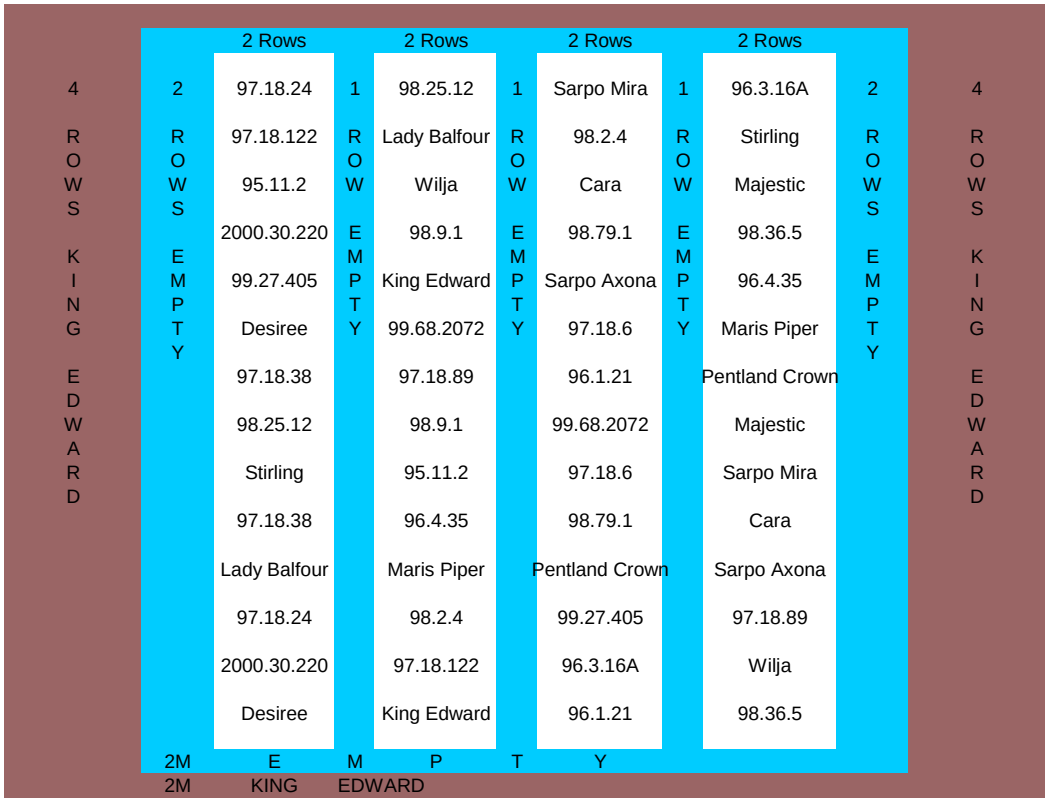
FIGURE 1 LOCATION OF SITE



4. METHODS

4.1 Layout

The cultivars were arranged in a fully randomised complete block design with two replicates. The plots were two rows wide (1.5 m) and measuring 3.3 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 relatively 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 %.

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/potatoblight.htm).

4.3 Photographic records and written descriptions

Photographs were taken of each variety in the trial to show (a) characteristics of growth and haulm habit, and (b) shape and characteristics of tubers. Details of tuber skin colour, skin finish (texture), and tuber shape were noted for each cultivar when samples were lifted for a Growers' Farming Connect Organic Development Centre Open Day on August 11, 2004.

4.4 Records of foliage blight

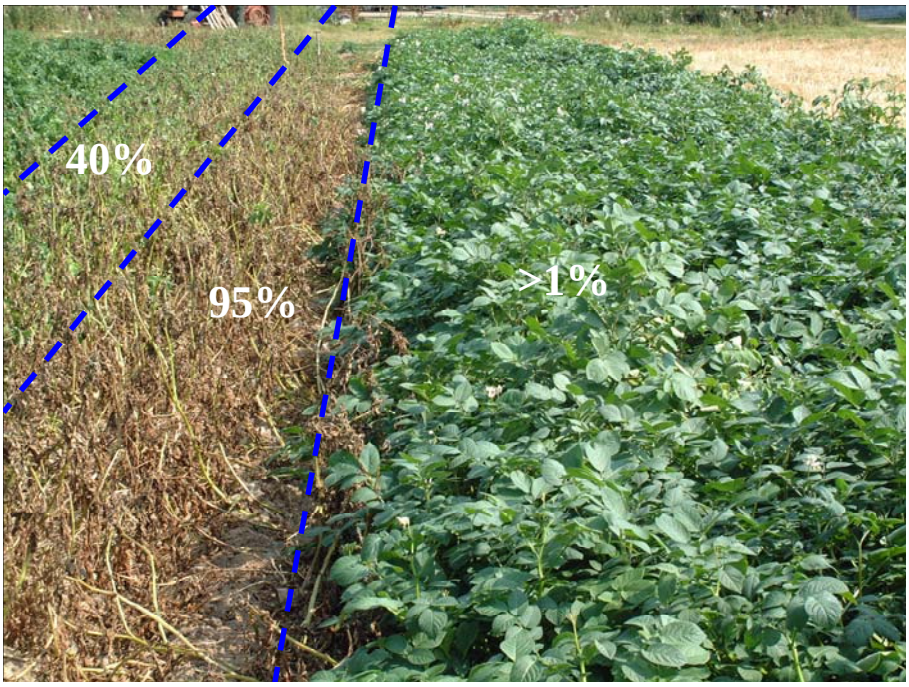
Foliage blight was assessed regularly during the epidemic as a percentage of leaf area destroyed by blight using a modified MAFF key 2.1.1 - Potato Blight on the Haulm (Anon., 1947 & 1976 ; Large, 1952), see Table 3.

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			

4.4.1 Foliar blight measurements on compost tea treatment plots

Foliar blight assessment on the compost tea treatment blocks was undertaken using the same method as for the main trial between 25 July and 9 August, 2004.



Foliar Blight Assessment

4.5 Assessment of yield

Plot yields were taken using an elevator potato harvester and manually forking each plot, All tubers >35 mm were included in the yield totals excluding rotted tubers.

4.6 Destruction of haulm

The haulm was manually cut to ground level and removed from each plot on 16 September.

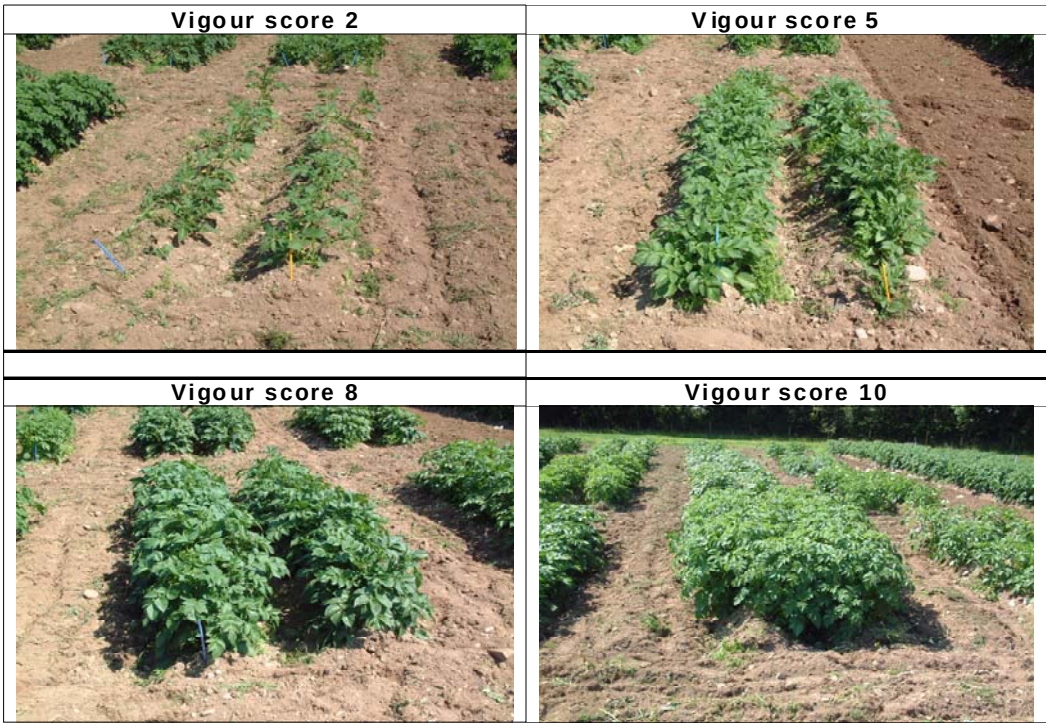
4.7 Assessment of canopy height

Canopy heights were taken from the centre of each plot using a graduated measuring stick.

4.8 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.

FIGURE 2 VIGOUR SCORES



4.9 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 **A**rea **U**nder the **D**isease **P**rogress **C**urve (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.

4.10 Assessment of tuber blight

As the harvest was delayed due to wet weather conditions, it had to be assumed that the majority of blighted tubers had completed rotted prior to lifting. This rendered assessments of tuber blight invalid and so none were undertaken.

5. RESULTS

5.1 The blight epidemic 2004

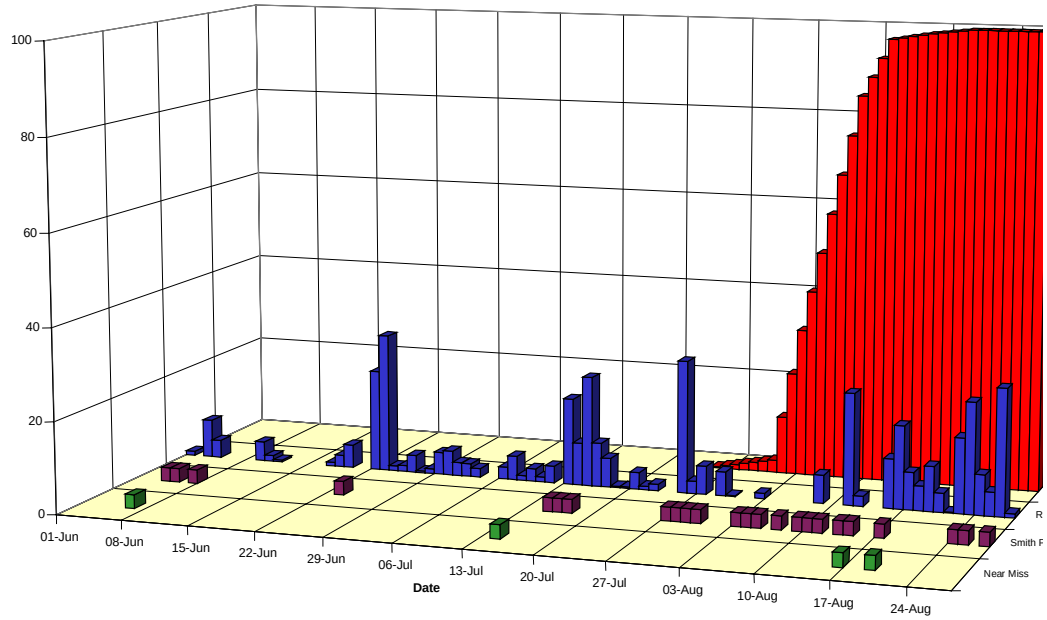
5.1.1 Smith Periods

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

Full Smith Periods at Llanrhystud were recorded on 01/08 June, 22 June, 13 July, 27 July, 03/10 August, 17 August and 24 August. Near Miss conditions were recorded on 01 June, 22 June, 13 July, 16/17 August. Rainfall data recorded at Pwllpeiran and Smith Periods recorded at Llanrhystud together with foliar blight progress on King Edward plots in the trial are given in Fig 3.

FIGURE 3 DAILY RAINFALL, SMITH PERIODS AND BLIGHT PROGRESS IN KING EDWARD PLOTS

Fig 1. Daily rainfall as recorded at Pwllpeiran, Smith Periods as recorded for Llanrhystud by Blight Watch, and blight pr in King Edward plots 2004.



The chart shows the rapid progress of foliar blight in the King Edward crop during the combination of Smith Periods and rainfall in August.

5.1.2 Inoculation

As natural foliar blight infection had not been recorded at the site by the end of June, plants in the spreader areas (cultivar, King Edward) surrounding the trial were inoculated on 6th July.

5.1.3 Foliage blight

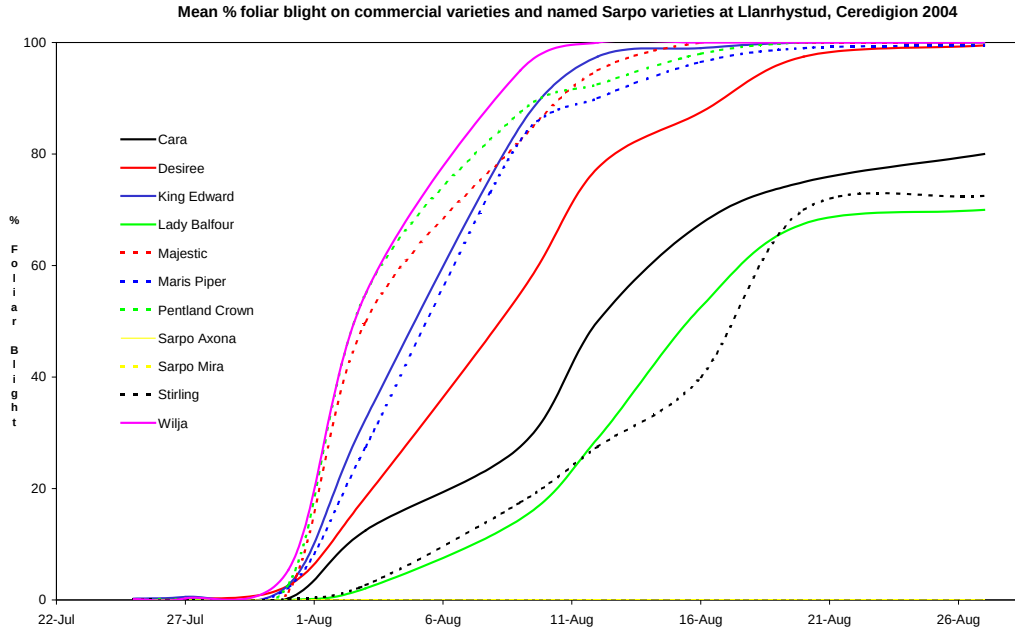
Foliar blight infection was first recorded in the experiment 14th July 2004. The disease developed rapidly in the spreader rows during the last two weeks of August. Foliar blight reached virtually complete haulm destruction in the King Edward plots by 24th August indicating a significant disease challenge at this site. Despite this, foliar blight remained virtually absent in the Sarpo plots. The AUDPC analysis is presented in Table 4

TABLE 4 AUDPC (AREA UNDER DISEASE PROGRESS CURVE)

Cultivar	**AUDPC (percentage.days)**
96.1.21	34 a
98.2.4	10 a
98.25.12	0 a
98.36.5	0 a
98.9.1	0 a
98.79.1	0 a
99.27.405	6 a
99.68.2072	0 a
2000.30.220	0 a
95.11.2	3 a
96.3.16A	12 a
96.4.35	0 a
97.18.6	1 a
97.18.24	0 a
97.18.38	0 a
97.18.89	0 a
97.18.122	0 a
Sarpo Mira	0 a
Sarpo Axona	0 a
Stirling	1080 bc
Lady Balfour	1005 b
Cara	1314 c
Maris Piper	2106 de
King Edward	2200 ef
Desiree	1878 d
Wilja	2374 f
Majestic	2253 ef
Pentland Crown	2291 ef
SED	114.4
LSD (5%)	234.29
P Value (df 28)	<0.001

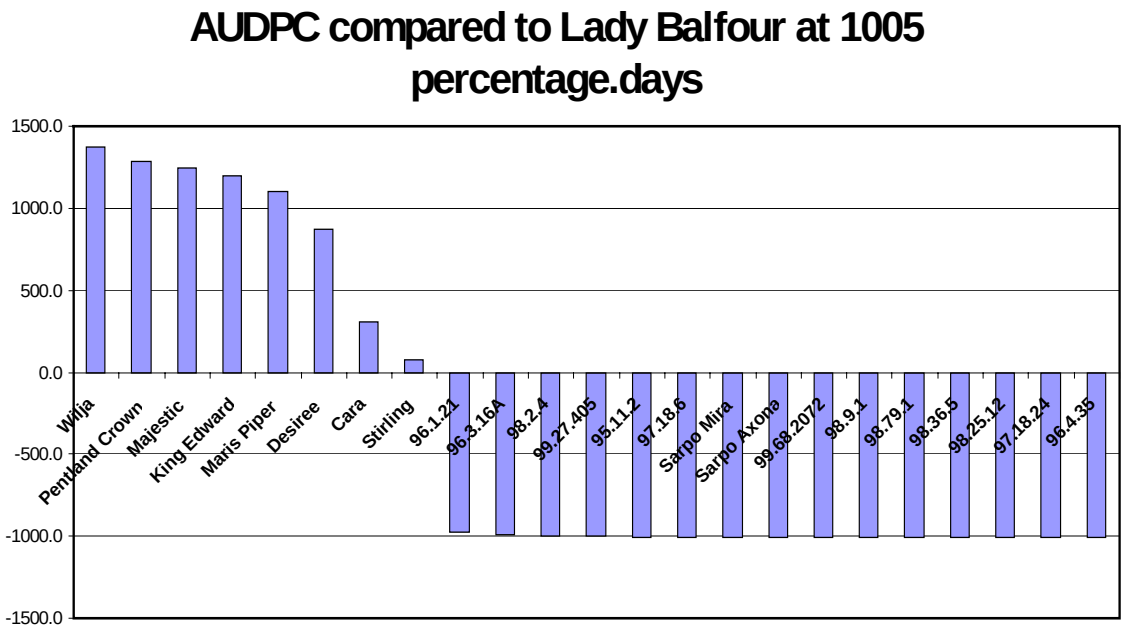
Details of the foliar blight progress expressed as the mean percentage leaf area destroyed by blight for each of the commercial varieties and named Sarpo cultuiivars in the experiment are also shown in Figure 4**.**

FIGURE 4 MEAN % FOLIAR BLIGHT ON COMMERCIAL VARIETIES AND NAMED SARPO VARIETIES AT LLANRHYSTUD, 2004



In Figure 5, foliar blight progress for all cultivars is compared with Lady Balfour. The AUDPC analysis demonstrates that all commercial varieties were less resistant to foliar blight infection than Sarpo varieties.

FIGURE 5 AUDPC COMPARED TO LADY BALFOUR



5*.1.4 Foliage blight on compost tea treatment plots*

As can be seen from Table 5, blight progressed more quickly through the untreated plots than through the plots treated with compost tea. Blight progression was slower through plots with treatment 3 (compost tea applied every 8 days) than plots with Treatment 2 (compost tea applied every 4 days). Applications of compost tea for both of these treatment was discontinued after mean foliar blight exceeded 70%.

TABLE 5 MEAN PERCENTAGE FOLIAR BLIGHT ON COMPOST TEA TREATMENT PLOTS

Treatment	25/06/04	27/07/04	31/07/04	03/08/04	09/08/04
1. Untreated	0.13	0.13	1.55	31.25	75.00
2. Tea @ 4 days	0.05	0.08	0.45	31.25	75.00
3. Tea @ 8 days	0.03	0.08	0.43	17.50	73.75

When subject to Analysis of Variance these findings were found not to be statistically significant.

5.2 Yield of ware

Highest yields in the trial, where yield differences were shown by Analysis of Variance to be statistically significant, were for 6 Sarpo cultivars.
These cultivars were:

1. 97.18.6 (75.2 t/ha);
2. 97.18.24 (74.7 t/ha);
4. 97.18.890 (66.5 t/ha);
5. 99.68.2072 (63.4 t/ha);
6. 96.4.350 (56.9 t/ha).

The listed Sarpo variety Mira (54.1 t/ha), ranked seventh in terms of yield in the trial and Sarpo Axona (48.2 t/ha) ranked 12th. The highest yielding non-Sarpo variety in the trial was Stirling (33.2 t/ha) ranked 19th, closely followed by Lady Balfour (32.1 t/ha) at 20th.

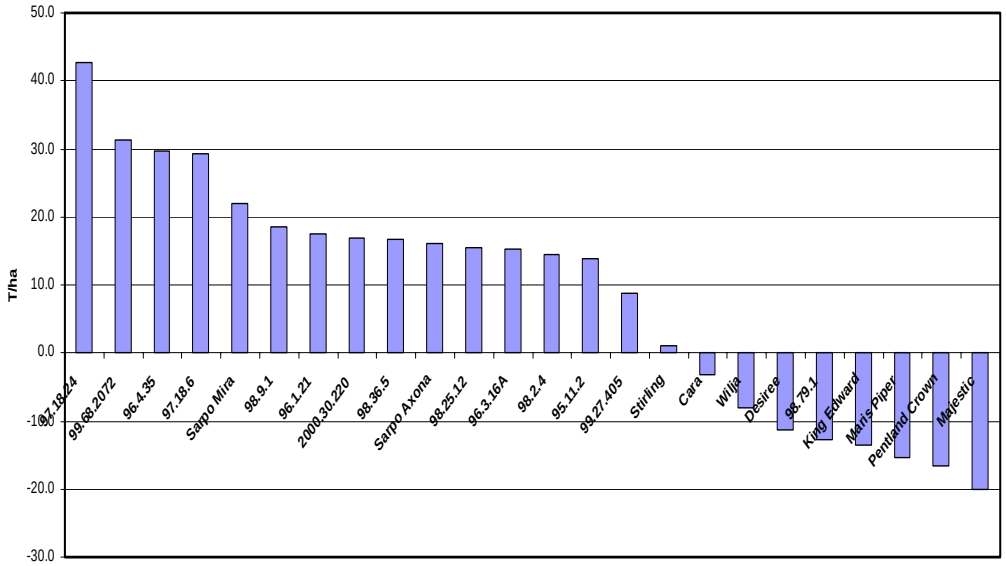
The only Sarpo variety yielding less than Lady Balfour was Sarpo 98.79.1 (19.4 t/ha). This variety exhibited blight resistance (AUDPC %/days = 0), but was notable for its lack of vigour (score 2) and low canopy height. The lowest yield came from Majestic (12 t/ha).

The total yields for each cultivar in the trial are given in Table 6, and for ease of comparison the yields for each cultivar are compared with Lady Balfour in Figure 6.

TABLE 6 TOTAL WARE YIELD (T/HA)

Cultivar	**Yield (t/ha)**	
96.1.21	49.7	defghi
98.2.4	46.6	cdefg
98.25.12	47.6	defg
98.36.5	48.7	defgh
98.9.1	50.7	defghi
98.79.1	19.4	abc
99.27.405	40.9	bcdefg
99.68.2072	63.4	ghi
2000.30.220	49.1	defghi
95.11.2	41.6	bcdefg
96.3.16A	47.4	defg
96.4.35	56.9	fghi
97.18.6	75.2	i
97.18.24	74.7	hi
97.18.38	50.4	defghi
97.18.89	66.5	ghi
97.18.122	47.4	defg
Sarpo Mira	54.1	efghi
Sarpo Axona	48.2	defgh
Stirling	33.2	abcdef
Lady Balfour	32.1	abcdef
Cara	29.0	abcde
Maris Piper	16.7	abc
King Edward	18.6	abc
Desiree	20.8	abc
Wilja	24.1	abcd
Majestic	12.0	abc
Pentland Crown	15.6	ab
SED	11.15	
LSD (5%)	22.84	
P Value (df 28)	<0.001	

FIGURE 6 YIELDS COMPARED TO LADY BALFOUR, 32.1 T/HA



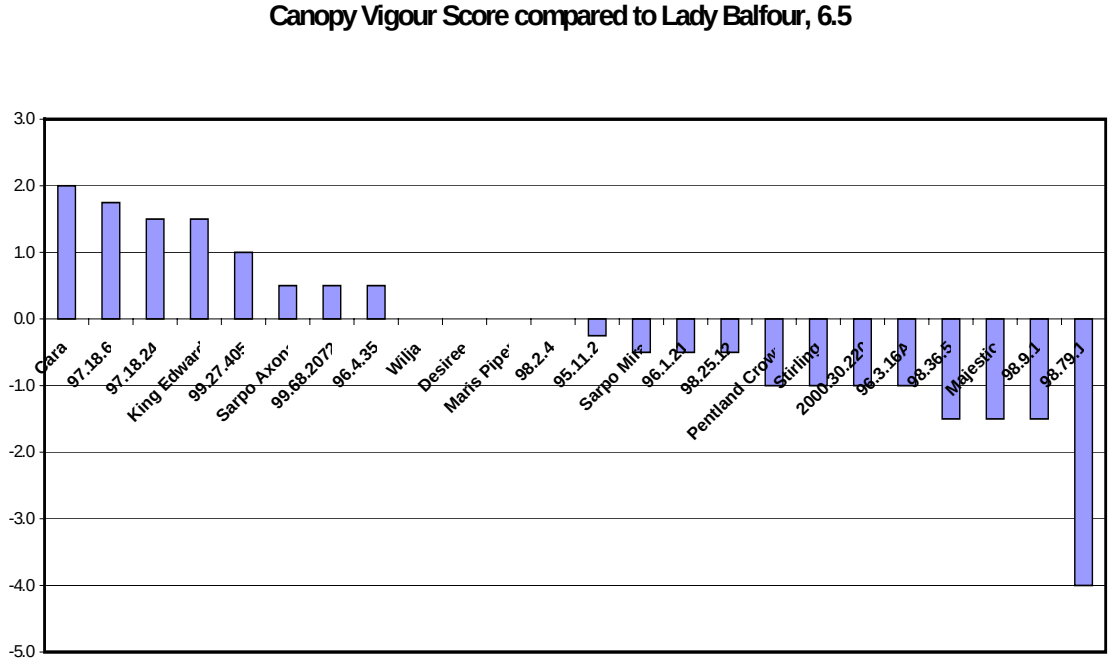
5. 3 Growth vigour and canopy height

Weather conditions following planting were dry and cold. Emergence of all varieties was slow. King Edward and other commercially available varieties tended to emerge first and to show early growth vigour. Sarpo varieties were slower to emerge, with less initial vigour. Once started however, they tended to keep growing and the vigour of growth was not interrupted by the onset of blight.

When growth vigour was assessed on 13 July 2004, the average for all varieties was 6.4. The highest score, 9 was assigned to Sarpo 97.18.6. Cara scored 8.5 and King Edward 8. The listed variety Sarpo Axona scored 7 and Sarpo Mira scored 6.0. Lady Balfour was near the mean at 6.5. The lowest scoring commercially available variety was Majestic (5.0) and the lowest overall was Sarpo 98.79.1 (2.5).

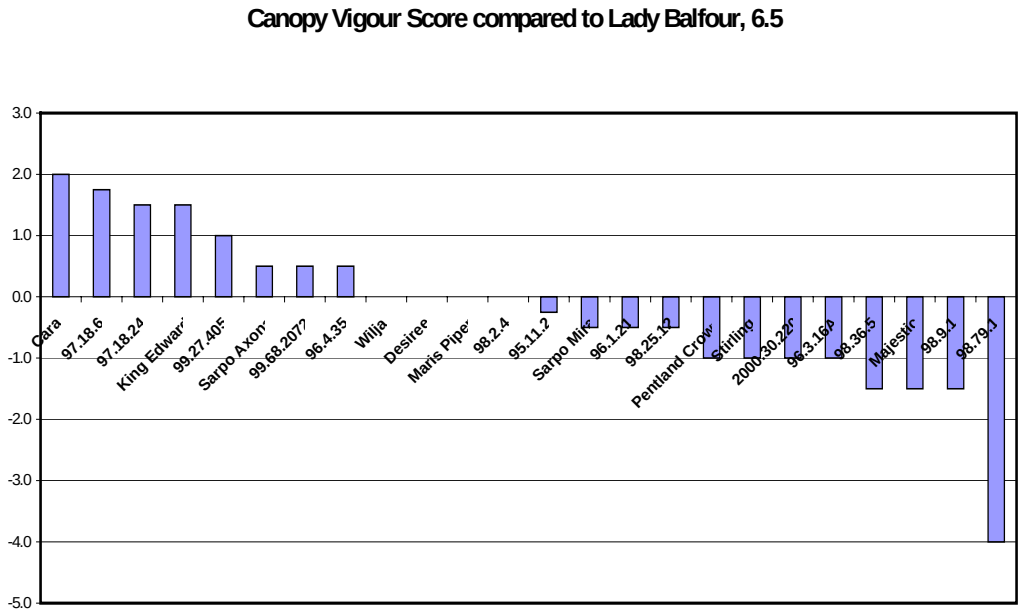
For ease of comparison, vigour scores for each cultivar are compared in the accompanying figure to Lady Balfour.

FIGURE 7 VIGOUR SCORES



Canopy heights also showed considerable variation. For ease of comparison, canopy heights for all varieties are compared in the chart to Lady Balfour when that cultivar reached 75 cm. The Sarpo variety 95.11.2 (+25 cm) had the highest canopy, followed by Sarpo 99.27.405 (+20 cm) and King Edward (+20 cm). The varieties with the lowest canopies were Wilja (-20 cm), Stirling (-15 cm), Pentland Crown (-15 cm) and Sarpo 98.79.1 (- 15 cm).

FIGURE 7 CANOPY HEIGHTS



CONCLUSIONS

The trials undertaken in 2004 found that each of the Sarpo cultivars showed high blight resistance. Furthermore, blight resistance in Sarpo cultivars was greater than in commercially available varieties in the trial. Using the NIAB system of rating, where 9 = very resistant and 1 = susceptible, each of the Sarpo varieties trialed scored 9.

In the trial, there was a considerable range in yield between cultivars, with a range from 12 t/ha to 74 t/ha. With one exception (Sarpo 98.79.1), all the Sarpo varieties had higher yields than the commercially available varieties.

The main factor affecting yields of the commercially available varieties was their susceptibility to foliar blight. Yield difference in Sarpo cultivars, on the other hand, was associated with vigour/weed competition rather than susceptibility to foliar blight.

Compost tea treatments appeared to delay the onset of foliar blight, but the results were not statistically significant. This experiment was a major blight challenge to the treatments since the variety to which the compost tea was applied had low resistance (NIAB rating 3) and as the epidemic progressed the site became heavily infected.

RECOMMENDATIONS

This trial has produced information which will be of value to organic potato growers and to seed breeders. It also leads to the following recommendations:

1. Where sufficient seed is available, there should be a continuation of these potato blight trials with enlarged plot sizes compared to 2004. Such trials will provide further robust findings to add to those already obtained.

2. Evaluations should be undertaken of Sarpo varieties selected from the 2004 trial for vigour of growth and ability to suppress weed competition as well as resistance to potato blight. These characteristics are particularly valuable for organic growers.

3. Evaluations of the eating quality of blight resistant varieties selected from current trial should be undertaken. To be commercially successful, potato varieties need to be edible and produce an economically viable yield of marketable produce.

4. Further evaluation of compost tea treatments as a prophylactic treatment for potato blight on commercial available partially resistant varieties as identified in the current trial (e.g. Lady Balfour, Stirling) should be undertaken.

REFERENCES

ADAS (2003) *ADAS Evaluation of Sarpo potato varieties 2003*. Factsheet available from ADAS Pwllpeiran, Cwmystwyth, Ceredigion SY23 4AB

Anon (1947) 'The Measurement of Potato Blight' *Trans Brit. mycol. Soc* , **31**, 140-1

Anon (1976) *Manual of Plant Growth Stages and Disease Assessment Keys*. MAFF Publications, Pinner, Middlesex

British Potato Council (2003) *Fight against Blight – Advice for growers of organic Crops* Growers Advice Factsheet BPC Oxford

Hutchinson, D. (2003) 'Brewing up' *Grower*, May 1, 23 – 24

Hutchinson, D. (2004) 'Using compost tea in horticulture' *Grower*, Nov. 18, 14 - 15

Large, E. C. (1952) 'The interpretation of Progress Curves for Potato Blight and other Plant Diseases' *Plant Pathology*, **1**, 109-117

Shaw, D. and Johnson, L. (2004) 'Progress in the selection of cultivars with resistance to late-blight disease' *PPO-Special Report no 10* (2004), 203-209

Speiser, B., Tamm, J., Lambion, C., Bertrand, A ., Hermansen, M. A., Ruissen, J., Zarb, J., Santos, P., Shotton, Wilcockson, S and Leifert , C . (2005) 'Potential of novel, blight resistant cultivars for replacing copper fungicides in organic potato production' *Final Conference of the EU FP5 RTD project Blight MOP* Newcastle Upon Tyne University, 6 January 2005

APPENDIX

CONTROLLED MICROBIAL COMPOSTING AND COMPOST TEAS

BENEFITS OF CMC

- improved soil friability & crumb structure
- reduced erosion, nutrient leaching, compaction
- improved C, N & nutrient cycling
- increased benefical soil bacteria & fungi
- reduced soil pathogens & infections
- healthier crops with greater resistence to pests and diseases

COMPOSTING MATERIALS

6 x 50m windrows made up in horizontal layers with:

- 1/3 FYM
- 1/3 brown material (woodchip / spoiled hay etc)
- 1/3 green material (vegetable waste / weeding / cut grass-clover
- small portion loam or clay

ESSENTIAL EQUIPMENT

- compost turner
- tractor with creep gear
- crop covers
- monitoring equipment
- starter mix

COMPOST TURNER

- windrows, mixes and aerates the pile
- operates like an Archimedes screw
- promotes biological activity

COVERS

- Top Tex
- geotextile fabric
- gas permeable
- repel water
- cost £200 sheet
- cheaper than erecting a building
- applied using fleece roller on the compost turner

MONITORING EQUIPMENT

- thermometer with lance

- instrument for measuring and reading CO_2 levels

COMPOST TEAS

- microbrewer makes a tea multiplying organisms from the original compost
- used as a drench on transplants to protect against infection (eg *rhizoctonia*, mildew in lettuce) and on crops as foliar spray
- soil drench
- promising method of controlling fungal diseases but more work needed