Project title	**Narcissus: overcoming the problem of 'soil sickness' with particular reference to the Isles of Scilly**
Project number:	BOF 50 and BOF 50a
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AUTHENTICATION

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

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GROWER SUMMARY

Headline

The work began in 2001 when 20 narcissus crops in the Isles of Scilly were surveyed and laboratory tested to determine the causes of un-thrifty growth (often known as 'soil sickness').

- Of these sub-standard crops 10 were found to be carrying the Root lesion nematode *Pratylenchus* and the root-rotting fungus *Nectria (Cylindrocarpon)*
- Two of these sites were selected for long-term trials and received treatments in 2003/4
- Treatments involved growing Tagetes, injection with Telone II soil fumigant and a combination of the two. These were compared with untreated control plots and replicated
- Following re-planting with narcissus, the plots continued to be monitored for soil nematodes and crop growth until 2009 (5 years)
- One of the two sites has shown a large and consistent crop improvement over the full 5-year period. The second site has shown little difference between treated and untreated areas

Background and expected deliverables

In the Isles of Scilly, limited amounts of land reduce the options for crop rotation making it necessary to crop the best land intensively with narcissus. As a consequence, a build up of pathogenic organisms produces a problem of poor growth known as 'soil sickness'.
The project sought to establish, by survey, the extent and causes of 'soil sickness' in narcissus crops in the Isles of Scilly. In the expectation that unthrifty crops are often due to pathogenic free-living soil nematodes and secondary fungi, the work then included trials to test control measures on two selected sites. Following good reports from The Netherlands of nematode control by growing *Tagetes patula,* 'Ground Control' this technique was compared with the standard method of injecting Telone II (dichloropropene) into the soil. The growing of a bio-fumigant crop such as tagetes requires land to be set aside for one year whereas Telone II requires a minimum period of 3 weeks between treatment and planting.

The intended deliverable finding was either that tagetes could provide an alternative to the use of Telone II, a highly toxic substance. Alternatively, growing of tagetes might reduce the need for frequent Telone II application or augment its use to enhance efficiency and the period of nematode control and allow a long-term bulb crop to be grown.

Reliably vigorous long-term crops are more profitable, and reduce the need to move the bulbs to another site so soon. For the production of Tazetta narcissi flowers the optimum crop duration is 4 or 5 years. If soil sickness intervenes to reduce the viable cropping period to 2 or 3 years this presents a serious loss, extra work and management problems for the grower. (See 'Financial benefits' below)

A further important factor relates to the some of the cultural techniques used in producing Tazetta narcissi. 'In situ' treatments are used to advance and retard flowering and these techniques are most effective on established bulbs, ideally 2, 3, 4 years old. A short crop duration is less productive of flowers.

Summary and main conclusions

Treatments applied to one of the two sites, (site 7) produced consistently better growth over 5 years than the untreated areas, delayed senescence and considerably increased bulb yield by the end of the trial. The best treatment was the combination of growing *tagetes* followed by Telone, but both *Tagetes* alone and Telone alone also gave measurable increases.

The other crop (site 10) failed to show consistent differences in response to the treatments. This was despite the fact that the initial survey had shown a population of *Pratylenchus* and root- rotting fungi. The reasons for this are not understood.
(Full details of the crop records are shown in the Science Section under Results.)

Nematode populations fluctuated considerably during the 5-year trials but with the best treatments they remained low for several years.

Financial benefits

The financial benefits of achieving a full economic life span for a narcissus crop are considerable. Suitable soil treatments can achieve a full 5-year flower production. Crops becoming adversely affected by soil sickness, in, say, a 3-year cycle, increase costs and reduce income as shown in the following table.

Assessment	**A 3 - year cycle**	**A 5 - year cycle**
First-year flower crop, often not marketed due to inferior quality	1 year	1 year
Final year with possibility of reduced yield due to soil sickness	1 year	1 year
Full crop yield	1 year in 3	3 years in 5
Frequency of lifting the bulbs, hot-water treating them and replanting on a new site	Every 3 years	Every 5 years
Number of bulb handling and replanting operations in 15 years	5	3
Extra handling and replanting costs over a 15 year period	66%	-

Action points for growers

- Sites showing areas of weak growth and root death should be tested to establish the likelihood of soil sickness complex
- When other possible causes have been eliminated soil treatment is indicated
- Soil treatment should be as thorough as possible in order to achieve as long a period of high productivity as possible.
- Maximum crop improvement is achieved by growing a crop of *Tagetes patula* followed by Telone II treatment which is polythene sheeted over to achieve maximum effect
- The expenditure is justified in order to produce a productive crop of 5 years duration because costs are reduced by 66% compared with a 3-year duration brought about by root disease. A full crop of quality flowers may be worth £15000 per ha in its most productive years, 3, 4 and 5. This could not be achieved if soil sickness intervened.

SCIENCE SECTION

Introduction

The following are diary extracts from the initial survey in 2001-2, the commencement of the trials in 2003 and the final bulb harvest in 2009

2001-2	Twenty poorly performing crops surveyed
2002	Trial sites selected
2003	Tagetes grown on designated plots
2004	Telone applied to designated plots and trial sites planted with narcissus
2005 – 2008	Soil nematode tests carried out each year
2005 – 2009	Crop growth recorded each year
2009	Plots lifted and bulb yields recorded

Results of the 2001-2 survey

Soil samples were taken from growing narcissus crops for the presence of nematodes and accompanying root disease.
Some sites showed poor growth overall and some were patchy. Where poor growth was in patches a sample was taken from both good and bad areas.

Site	Crop	Areas of good growth		Areas of bad growth	
		Pratylenchus	Other spp.	*Pratylenchus*	Other spp.
1	Good overall	0	56	-	-
2	Bad overall	-	-	2	20
3	Patchy	28	0	11	9
4	Patchy	0	25	0	55
5	Bad overall	-	-	0	16
6	Bad overall	-	-	0	88
7	Bad overall	-	-	42	10
8	Patchy	0	39	0	36
9	Patchy	1	206	13	90
10	Patchy	12	34	39	68
11	Good overall	0	26	-	-
12	Patchy	0	203	0	154
13	Patchy	0	750+	171	49
14	Patchy	0	500	0	507+
15	Patchy	0	94	82	153
16	Patchy	0	15	14	119
17	Patchy	67	257+	4	35
18	Patchy	43	400+	28	300+
19	Patchy	1	5	11	161
20	Patchy	1	0	0	24

Pratylenchus spp. Are recognised as the most potentially damaging of the free-living soil nematodes. A range of other species were found. Despite some high populations, nematologists do not rate them as highly damaging to crops although when present in high numbers some other species may contribute to the overall level of root damage.

Of the 20 sites, *Pratylenchus* was present in 12 (60%) although populations varied.
Additionally, fungal tests showed that 11 of the 20 sites bore *Nectria (Cylindrocarpon)*, a disease commonly associated with nematode damage.
Clearly, poor growth on some sites appears to have been due to factors other than nematode attack, for example sites 4, 5, 6, 8 and 20.

Sites 7 and 10 were chosen for the proposed trials. Although not showing the highest populations of *Pratylenchus,* these sites were uniformly affected by soil sickness. Both were available being in their final year of the preceeding crop. Sites with a patchy distribution were avoided for the trials because a uniform distribution of plots would have been impossible.

A full statement of the survey results may be accessed in the final report for BOF 50 for 2002. (NB please observe a correction is required in that site 13, not 6, had particularly bad areas.

Trial layout
Each site had 3 strips (4.5 m wide) of tagetes and 3 strips of Telone (also 4.5m wide) intersecting them producing a criss-cross pattern with untreated control strips within the layout. This provided 6 replicates of each of the 4 treatments.
Samples and records were taken from the centres of the 4.5 x 4.5 m plots.

Results from the two trials located on site 7 and site 10 in the survey.

Table 1 Numbers of *Pratylenchus* and other nematode species on two trial sites

Year	Stage	Treat-ment	Nematode numbers per 200 g. of soil			
			Site 7		Site 10	
			Pratylenchus	Other spp.	*Pratylenchus*	Other spp.
2002	Survey	N/A	42	10	30	56
2003	Pre-treatments	N/A	24	28	13	166
2004	After treatment	Control	16	8	0	65
		Tagetes	0	0	0	65
		Telone	0	0	0	3
		T + T	0	0	0	0
2005	Year 1	Control	29	3	2	47
		Tagetes	1	5	0	30
		Telone	0	21	0	0
		T + T	0	11	0	1
	Soil from roots	Control	15	10	No record	No record
2006	Year 2	Control	8	3	0	26
		Tagetes	9	4	0	37
		Telone	10	1	7	6
		T + T	0	1	0	5
	Soil from roots	Control	11	6	0	40
		Telone	0	0	0	2

Year	Stage	Treat-ment	Nematode numbers per 200 g. of soil			
			Site 7		Site 10	
			Pratylenchus	Other spp.	*Pratylenchus*	Other spp.
2007	Year 3	Control	14	3	0	300+

		Tagetes	37	7	1	217
		Telone	8	1	1	136
		T + T	19	16	0	275
2008	Year 4	Control	6	25	0	65
		Tagetes	11	7	0	44
		Telone	6	16	20	3
		T + T	2	10	22	21
	Soil from roots	Control	30	18	5	250+
		Telone	0	0	0	500+

NB. T + T = Combined treatment, Tagetes followed by Telone

Table 2 Mean leaf length (cm) recorded in May each year

Year	**Site 7**				**Site 10**			
	Control	Tagetes	Telone	T + T	Control	Tagetes	Telone	T + T
2005	54	74	87	86	67	75	75	75
2006	53	64	75	81	83	83	87	90
2007	56	59	70	75	84	86	86	88
2008	62	66	78	80	82	87	77	85
2009	71	75	81	87	92	92	89	94
5 year mean	59	68	78	80	82	85	83	86
% increase over control	-	15	32	35	-	4	1	5

Table 3 % Leaf senescence in June 2007

	Site 7				Site 10			
June 2007	Control	Tagetes	Telone	T + T	Control	Tagetes	Telone	T + T
	53	43	35	25	20	18	17	14

Table 4 Number of bulbs harvested per metre of ridge

	Site 7				Site 10			
	Control	Tagetes	Telone	T + T	Control	Tagetes	Telone	T + T
Bulb Nos.	56	77	91	100	134	161	140	129
% increase over control	-	37	61	77	-	20	4	- 4

Table 5 Mean weight (g) of the 10 largest bulbs per plot

	Site 7				Site10			
	Control	Tagetes	Telone	T + T	Control	Tagetes	Telone	T + T
Bulb weight	108	103	113	138	85	83	80	87
% Increase over control	-	- 5	5	27	-	-2	-6	2

Table 6 Total weight (Kg) of bulbs harvested per metre of ridge

	Site 7				Site 10			
	Control	Tagetes	Telone	T + T	Control	Tagetes	Telone	T + T
Bulb weight	2.7	3.6	4.2	5.2	6.1	7.3	5.7	5.9
% increase over control	-	40	57	94	-	19	-7	-3

Costs and financial benefits

Soil sickness, though frequently patchy in its distribution, can cause severe crop damage. However, its unpredictability is a major management problem since a narcissus flower crop which is normally expected to be productive for 5 years may show areas of depressed growth much sooner.

Lifting the bulbs, re-treating and re-locating them involves considerable cost in addition to the loss of the most productive years of the plantation. The increased costs of an enforced short-term crop compared with a 5-year crop are explained under Financial benefits (P2 above)

Telone II injection at 225 litres /ha. (costing £568 /ha.) plus plastic coverage costs £600 /ha.

Tagetes patula 'Ground Control' (PVP EU5577) sown at 5kg / ha. costs £415 / ha.
This is a Dutch product, available from Ball Colgrave, West Adderbury, Banbury, Oxon, OX17 3EY.
It is sown from 3 weeks before until 3 weeks after the longest day and must achieve an active growing period of at least 100 days before chopping it up and incorporating it into the soil by rotavation.

To achieve the necessary high level of weed control required, herbicides Goltix (metamitron) 1kg/ha. plus Betanal (phenmedipham) 1 litre/ha. are required. These may need to be repeated with further dosage applied according the weed seedling population that develops at about the 2-4 true leaf stage of the tagetes .
It is vitally important to achieve good weed control and a good stand of tagetes so that there are no alternative host plants available for nematodes to feed on.
The tagetes crop, on incorporation, adds to soil organic matter. Up to 85 tonnes fresh weight (20 tonnes dry matter) / ha is claimed by the suppliers of the seed, but in these trials it averaged 40 tonnes fresh weight (9.4 tonnes dry matter) / ha.)

The costs of soil preparation, injecting Telone or drilling the tagetes are common to either method. Both require suitable equipment. The cost of the dual treatment is £1583 / ha. Despite this, if combined treatment maintains a full crop for 5-year period, it is still a viable option because the value of a full crop of flowers is high.
For example 750 boxes of narcissi / ha. @ £25 gives a gross return of £15,000 / ha. in the most productive 3rd to 5th years of a plantation.)

DISCUSSION

Relating to nematodes

Pratylenchus species which are the most pathogenic soil-living nematode was present on untreated plots on site 7 throughout the trial and began to re-invade treated plots in years 3 and 4. Surprisingly, following the initial survey which confirmed its presence, *Pratylenchus* remained virtually absent from all plots on site 10.

The high numbers of other nematodes on site 10 were chiefly of *Rotylenchus* and *Heliocotylenchus* species which are regarded as of little significance in crop production.

Relating to narcissus growth

On site 7, growth improvements were clearly visible throughout the trial and are confirmed by the data for leaf length, senescence and bulb yield. A major effect was the over 30% mean yearly increase in leaf length by the use of Telone and a large increase in bulb yield with all the treatments. Flower yield and quality were not recorded but it is reasonable to assume that these would have been improved in line with the growth differences.

On site 10 crop vigour was good overall throughout the trial and there were no major or consistent differences between the treatments or between treated and untreated plots.

The results from Site 10 which were totally different from those obtained on Site7 cannot readily be explained.

Future options for the control of soil sickness

Since this project began in 2002 there has been a marked change in attitudes to the use of toxic, non-selective soil fumigant materials such as Telone II and its future use will increasingly be reviewed especially where it is being applied regularly to support intensive systems or mono-cultures. A more acceptable alternative will be in adopting wider crop rotations which include bio-fumigant crops such as tagetes. There is every expectation that there will be considerable progress made in this area in the future.

TECHNOLOGY TRANSFER

The information has been presented on various occasions on the Isles of Scilly and is available to all UK growers via HDC.
Reports have been presented in HDC News
Further reports will be available as required by the editor.