



to evaluate the impact of historical loss, fragmentation and degradation of habitats on species richness of plants and animals, and assess extinction debts for species groups with different life history traits across Europe land use changes for biodiversity

to evaluate patterns of land use and biodiversity in Natura 2000 sites, and estimate the extent of impact of large scale historic land use changes on biodiversity in areas of particular conservation value

to develop future land use change scenarios for predicting future species loss and provide tools to project necessary land use changes for biodiversity conservation and restorationland use changes for biodiversity

to identify key drivers and develop decision tools for biodiversity loss. This information will in be used to develop policy options relevant for biodiversity conservation and restoration in key policy are

The 1950s and 1960s were **important decades for the burgeoning of interest in nematodes and the opportunities for their management.** Many nematologists were recruited to University and research station positions, a number of important meetings were held in the US, Caribbean and Central America and we saw the formation of SON in 1961 and ONTA in 1967. In 1968, a Caribbean Symposium on Nematodes of Tropical Crops was held at the University of the West Indies (UWI), Trinidad. This was jointly organised by UWI, the Commonwealth Development Corporation (which had interests in sugar cane, coconuts and bananas), the Commonwealth Institute of Helminthology (now part of CABI Bioscience), and FAO. The meeting brought together nearly 50 scientists including many of the leading nematologists from the USA, and several from the UK and other parts of Europe. The objectives of this meeting were to stimulate greater research effort in the management of nematodes of tropical crops and to promote teaching and training **programmes in plant nematology.** One of us (SRG) was to be a direct beneficiary; "I first met Nigel Hague at this meeting and it was he who encouraged me to do a higher degree in plant nematology (Fig.1). Also present were Fred Jones and David Hooper, and it was through them that I received some specialist training

at Rothamsted Experimental Station in England prior to undertaking a series of contracts in Jamaica, St Lucia and Ecuador for the UK Government's Overseas Development Administration."

The other of us (PAR) also benefited from specialist training at Rothamsted with Fred Jones, David Hooper, Alan Stone and colleagues, from where a career in nematology research and extension ensued in California. Using two contrasting examples, burrowing nematode on banana and stem and bulb nematode on garlic, we recount some of our experiences and insights on work to develop nematode management strategies and tactics for horticultural crops. Although the examples are as different as bananas and garlic, the underlying themes, experiences, and outcomes are remarkably similar, and we suspect they are much like other nematode-plant problems and their solutions in horticulture.

The centenary of the description of the burrowing nematode, *Radopholus similis* [Tylenchus *similis*], by Cobb in 1893 was overlooked by nematological societies, a sad omission! Cobb's material was collected from some banana plants growing in gardens adjacent to Government House in Suva, Fiji. The same population was there when Al Taylor visited in 1967.

*Radopholus similis* is thought to be indigenous to the western Pacific, and its pan-tropical distribution is probably a result of the movement of nematode-infested banana suckers from that region during this past millennium. Nematode infestations of bananas in the New World were recorded as early as 1910, by which time this fruit had become established as an export commodity. A Jamaica Department of Agriculture report mentions that a dreaded banana disease, thought to be caused by bacteria, was suspected to be due to "eel worm at the root". The problem had also been reported in French West Africa before World War II. Not until the 1950s, did the disease known as "blackhead toppling" begin to be recognised as the major banana production constraint (Fig 2). Two unrelated issues had contributed to this.

When the banana trade began in the latter part of the 19<sup>th</sup> century the industry was based upon one variety 'Gros Michel' (*Musa AAA*).

Unfortunately, this variety, although popular with consumers was highly susceptible to Panama wilt caused by the fungus, *Fusarium oxysporum* f. sp. *cubense*. This was devastating for plantation owners and smallholders. With no effective treatments to combat the disease the "industry" changed to the 'Cavendish' varieties which were immune to the pathogen. What was not known at the time was that the Cavendish varieties (also *Musa AAA*) had less tolerance to *R. similis* than did Gros Michel. This change of variety was done over a relatively short period of time and neither propagation nurseries nor quarantine officials were aware that field-produced suckers were likely to be infested with nematodes. Thus the nematode problem became more widespread upon the adoption of Cavendish as the export variety. The connection between the arrival of the nematode problem and the increase in the cultivation of Cavendish varieties has rarely been recognized..

The period after World War II saw bananas return to the international export trade, and the drive towards their more intensive production. As the losses from blackhead toppling became more serious greater attention was given to the cause, creating many careers in practical field nematology. Contemporaneous with this was the ascendancy of the agricultural chemical industry. The Shell Chemical Company and the Dow Chemical Company had developed soil fumigants that had been shown to be very efficient in controlling nematodes. One product, DBCP, first described by C. W. McBeth and G. B. Bergeson in 1955, was non-phytotoxic and could be applied to established banana plants. DBCP became the standard field treatment wherever bananas were grown for export. The liquid formulation was applied at six points around each plant with special hand-operated injectors, not an easy or particularly pleasant task. At last a partial solution to this hitherto undiagnosed and poorly understood problem was available (Fig 3).

In the Caribbean and Central America, the United Fruit Company and Standard Fruit Company and the Jamaica Banana Board (in association with the major chemical companies) led the research on banana nematodes. The research activities moved from the descriptive and taxonomic to the investigative and practical. For

a long time these organisations had employed plant pathologists and the textbooks *Banana Diseases Including Plantain and Abaca* by C. W. Wardlaw and *Banana Plantain and Abaca Diseases* by R. H. Stover were standard references for all banana researchers and provided useful descriptions of the nematode problems.

Several nematologists, including A. Vilardebo, M. Luc and R. Guérout from France, J. Edmunds in the Windward Islands, D. I. Edwards in Central America, and P. Maas in Surinam were assisted by a handful of chemical company representatives in the development of fumigants and the newly discovered non-fumigants for the banana industry.

It was recognized that treating established bananas in the field was not the only solution and that much of the problem was to do with the infection on the planting material. The blackhead-toppling disease was described by R. Leach (also a plant pathologist) in *Nature* 181: 204-205 (1958). At this time C. A. Loos and S. B. Loos were working for the banana companies, and in a series of papers highlighted the problem of blackhead disease and how it might be managed (1960, *Phytopathology* 50: 383-386; 1961, *Plant Disease Reporter* 45: 457-461). In Australia, C. D. Blake and R. C. Colbran were also developing and promoting different "seed" treatments for the banana farmers in New South Wales and Queensland. All of these scientists had concluded that longer lasting control could only be achieved with treatments based on the concept of "clean seed". The options were as follows:

Cut away the dark brown necrosis with a knife or machete and discard suckers with the severest necrosis (Fig. 4).

Heat-treat banana suckers in hot water baths (a method first recommended by A. Malle mire in West Africa in 1939).

Dip suckers in a nematicide (DBCP) suspension.

Establish disease-free nurseries.

These recommendations were sensible but tedious and quite difficult to manage and implement. Hot water treatment was practiced on some banana estates but never became universally adopted. The logistics of the treatment were daunting. Each sucker weighs 1-2 kg and about 2,000 suckers are required





