Dr Stephen Baker & Daniel Binns of the STRI examine the effectiveness of chemical control for the suppression of earthworm casting on the golf course

Has the worm turned?

Around this time every year it never ceases to amaze us how the earthworm, given the right conditions, can create such chaos on the golf course. Casting activity reaches a peak in damp, yet relatively mild, conditions and we have all seen, if not experienced, the problems earthworms can cause.

With financial support from the R&A, STRI have undertaken an extensive programme of research on earthworm control. Over recent years this research has adopted a more cultural and ecological approach as a response to tighter legislation on pesticide use. Work has focused on the biology of earthworm populations and changes in casting activity in response to soil characteristics and management operations. So at STRI we aim to be one step ahead of legislative change but at the same time we must also appreciate the immediate options available to greenkeepers.

In our last article (June 1998) we gave an insight into the severity of the earthworm problem first hand. This was based on the results of a questionnaire completed by greenkeepers last year. This month we provide an update on the few remaining chemical control methods available, examining the effectiveness of different materials as an alternative to chlordane.

Since turfgrass research started in Bingley in 1929 a lot of time has been devoted to problems of earthworm control. Over the years many materials have been tried and tested to help reduce casting on the golf course. From the 1920s onwards, methods have included the application of copper sulphate, perchloride of mercury, Derris dust and lead arsenate. In the 1960s chlordane was introduced which gave effective control for three or four years if not longer.

Unfortunately some of the most effective worm killers were toxic to many other soil organisms and concerns grew about the environmental effects due to long term persistence in the soil. The final chapter came for these materials on 31 December 1992 when it became illegal to use chlordane for earthworm control.

Other options have included the use of expellants such as mowrah meal, potassium permanganate or formaldehyde. These materials can be effective by driving earthworms to the surface for collection but have relatively little persistence in the soil and problem areas are soon re-populated.

The three materials currently listed for earthworm control on turfgrass in the UK are carbaryl, carbendazim and gamma-HCH + thiophanate methyl (gamma-HCH + tm). Between 1993 and 1998 six trials examined the relative effectiveness and duration of control of these worm killers. The manufacturers' recommended rates applicable at the time of the trials are given in Table 1. All were tested at sites suffering from high rates of casting which were assessed on a monthly basis by counting the number of casts accumulating within a given area.

In all cases results are expressed as a percentage of casting on untreated areas. For example, an area that is 80% relative to untreated turf indicates that the area has 20% less casts than the untreated turf.

Three initial trials were established to compare the relative effectiveness of all three approved materials. The worm killers were applied in October 1994 and by November earthworm casting was significantly reduced for all three pesticides. However, the results showed that carbaryl was the least effective and after 12 months casting rates relative to untreated turf from all three trials averaged 88% for carbaryl compared to for example, 48% for gamma-HCH + tm. The rate of approval for carbaryl was subsequently lowered from 3.96 kg ha -1 to 3.78 kg ha-1, and its use is now only permitted by tractor sprayer with the operator in a completely enclosed cabin.

In 1996 a further two trials were established at separate sites to compare the effectiveness of carbendazim and gamma-HCH + tm against untreated turf. Results from both trials are shown in Figure 1. Significant differences between chemical treatments and the untreated plots were recorded for 12 months at Site one (Nov 96-Oct 97) and 15 months at Site two (Nov 96-Jan 98). During this time casting rates relative to untreated plots given one single application of pesticide averaged 33% and 34% respectively for carbendazim and gamma-HCH + tm at Site one and at Site two, 40% for carbendazim and 42% for gamma-HCH + tm.

After all four trials were complete it was concluded that both carbendazim and gamma-HCH + tm significantly reduced casting for 12 to 15 months. Whereas carbaryl produced some reduction in earthworm casts five to 12 months after treatment but over this period not all reductions were significant.

It is also worth comparing our results to those found in last years greenkeeper questionnaire survey. The questionnaire concentrated on problems of earthworm control four years after chlordane had been banned and at a time when its residual effects were diminishing. The survey allowed information to be gathered from nearly 300 golf courses across the UK.

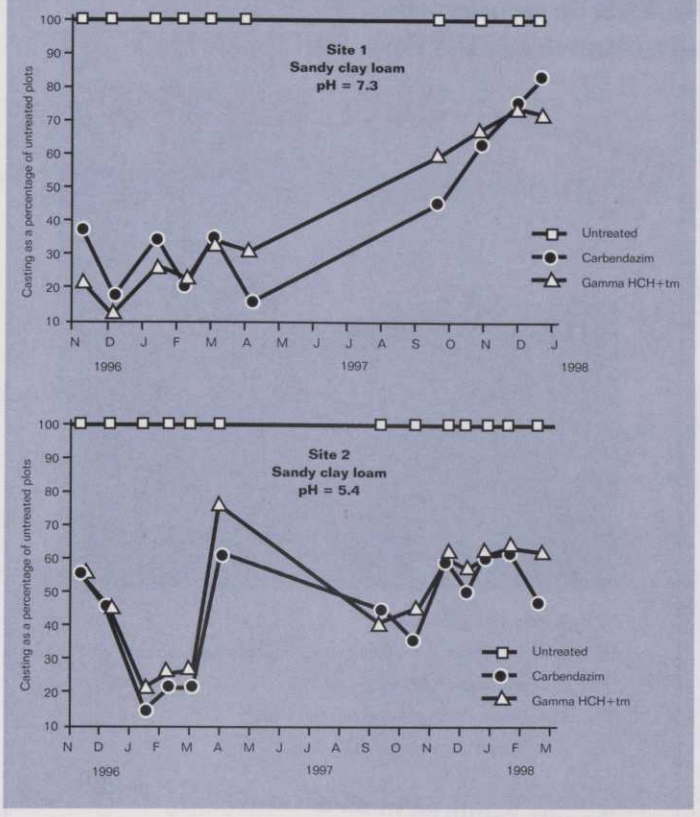
There is some indication that carbaryl gave less suppression than carbendazim or gamma-HCH + tm (Table 2), although strictly no statistically significant differences were found. Most greenkeepers reported casting suppression tended to last one to three months after chemical control and only about 30% of responses suggested reasonable suppression for three months or more. The differences between the questionnaire results and those found in our detailed monitoring may be one of definition. Our tests are looking for significant differences in the amount of casting between treated and untreated

TABLE 1
Application rate and concentration of the three worm killers

Material	Concentration (gl $^{-1}$)	Application rate (l ha^{-1})
Carbendazim	500	4
Carbaryl	240*	16.5*
Gamma-HCH + triophanate methyl	triophanate methyl=500 lindane=60	10

* At this rate carbaryl no longer has approval for use as a lumbricide.

FIGURE 1
Rates of earthworm casting over time, expressed as a percentage on untreated plots



plots, whereas greenkeepers are possibly considering that control has stopped when one or two casts are seen on treated areas.

The questionnaire responses also suggested that annual expenditure on pesticides for earthworm control increased from an average of £400 per golf course in 1994 to £525 two years later. In 1996 14% of golf courses were spending over £1000 per year on pesticides and over one-fifth of respondents suggested that casting by earthworms is currently a much greater problem than in the years before 1992 when chlordane was available.

On turf areas, earthworm activity brings about many advantages, particularly in terms of soil structural development and the recycling of organic matter, which, in turn, controls the build up of thatch.

Careful consideration should, therefore, always be given as to whether earthworm control to reduce casting outweighs the loss of the benefits listed above.

Indeed management techniques such as brushing or switching to disperse casts or heavier rates of top dressing to dilute fine material expelled at the surface must also be considered. However, severe casting will affect sward quality, playing quality and maintenance inputs and are therefore unacceptable.

When faced with this situation, intensity of casting is such that chemical control is almost essential.

Many of the methods of chemical control that have been used in the past have had important environmental consequences in terms of toxicity to non-target organisms and their persistency. Indeed traces of lead from the days when lead arsenate was used can still be found on some greens. This article has assessed the current chemical methods available to lower casting levels but further consideration of management strategies is still needed. In next month's issue we will focus on the cultural methods available to us for earthworm control.

TABLE 2
Greenkeepers' assessment of the effectiveness of three different pesticides used for casting control. The table shows the percentage of greenkeepers responding to a question on the effectiveness of chemical control on casting activity.

	Carbendazim		Gamma-HCH+tm		Carbaryl	
	Frequency	%	Frequency	%	Frequency	%
Little suppression	21	14.2	35	18.3	24	22
Reasonable suppression for less than 1 month	15	10.1	28	14.7	20	18.3
Reasonable suppression for 1-3 months	68	45.9	68	35.6	34	31.2
Reasonable suppression for 3-6 months	31	20.9	38	19.9	20	18.3
Reasonable suppression for 6 months or more	13	8.8	22	11.5	11	10.1
Totals	148	100	191	100	109	100