The worm TURNS

Counting the number of surface casts on the STRI acidification trial using a frame quadrat

The banning of Chlordane has raised the threat of earthworms causing course closures. The STRI is working on alternative means of combating them. Dr Stephen Baker, Senior Research Offcer, reports.

Earthworm control on golf courses has an interesting history. In the 1920s and 1930s earthworm casting was recognised as one of the biggest problems facing golf greenkeepers. Heavy casting brought about problems in wet weather of smeared and slippery fairways and approaches. The profusion of casts made putting surfaces uneven and the expelled soil also formed ideal seedbeds for weed invasion and this contributed to a further reduction in the quality of the playing surface. Indeed it was problems such as this that contributed to the foundation of the Board of Greenkeeping Research (now the Sports Turf Research Institute) in 1929.

Even before the foundation of the Institute there were a number of methods that were recommended for earthworm control. For example the famous Charles Darwin in his book The Formation of Vegetable Mould Through The Action of Worms published in 1881 refers to gardeners using lime water to remove earthworms from their lawns.

In the first 30 years of the Institute's history a lot of research effort was devoted to problems of earthworm control. In 1929 the first volume of The Journal of The Board of Greenkeeping Research was published and included an article on the use of four materials for earthworm control on golf courses. Methods were described for using perchloride of mercury, mowrah meal (seed residues from an East Indian tree), copper sulphate and mowrah meal plus acetic acid. Derris dust, which has rotenone as its active ingredient, was also used for earthworm control during this period.

In the 1960s chlordane was introduced and along with materials such as lead arsenate, this gave effective control of earthworm casting for three or four years and sometimes more. However these materials are toxic to many other soil organisms and there were concerns about long term environmental effects because of persistency of these chemicals. Initially lead arsenate for earthworm control was banned and it has been illegal to use chlordane since December 31, 1992.

The wheel has almost turned a full circle and we are rapidly approaching a situation reminiscent of the 1920s and 1930s where the quality of many courses could be substantially affected because of heavy earthworm casting. It has already happened in Germany where the use of chemical control is even more restricted. After a major tournament there, former Open Champion Tony Jacklin was quoted of saying, "Last year, in Stuttgart, I found a total infestation. It was unbelievable, worm casts everywhere."

EARTHWORM CASTING

There are about 25 different species of earthworm in Britain but only a small proportion of these are responsible for problems of casting. The culprits are primarily the deeper burrowing species that ingest large quantities of mineral soil, rather than near surface dwelling species which feed on material of high organic matter content. The three main casting species are: Aporrectodea longa, Aporrectodea caliginosa and Lumbricus terrestris. However other species have been recorded as producing surface casts, ie. Aporrectodea rosea, Allolobophora chlorotica and Lumbricus rubellus, particularly in compacted soil condition. Compacted soils have fewer large internal pore spaces in which earthworms can cast therefore they are forced to cast more frequently at the surface. This is of course of relevance to sports areas because of continual trampling that they receive.

In natural grassland, densities of 250-500 earthworms per square metre are not uncommon and in these circumstances around 40-50 tonnes of soil per hectare can be brought to the surface by casting. This is equivalent to a layer of three-four mm of soil per year. In Connecticut, USA, Schread estimated that over two tonnes of soil were cast on the surface of a 465m squared golf green.

CULTURAL CONTROL

If chlordane and other persistent worm control chemicals are not available, the first control measure that must be considered is the manipulation of soil condi-

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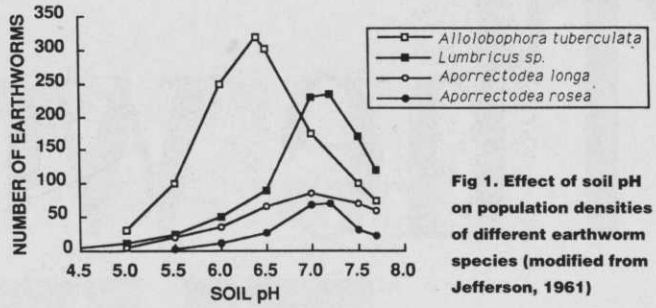

Fig 1. Effect of soil pH on population densities of different earthworm species (modified from Jefferson, 1961)

tions to ensure that they do not favour heavy earthworm activity. Research on management methods during the 1920s and 1930s indicated that is was possible to modify the soil and turf environment making it less attractive for earthworms. There are two main factors influencing earthworm populations which can be controlled, these being food supply and soil pH. It was shown that the supply of food could be reduced by boxing off mown clippings and using inorganic fertilisers. Observations in the 1930's indicated that heavy dressing of organic fertilisers such as poultry manure, rape or castor meal should be avoided as they were a source of available organic matter. Removing clippings undoubtedly decreases earthworm activity. R.B. Ferro, writing in the 1937 Journal of the Board of Greenkeeping Research, showed that boxing off of clippings on bentgrass turf reduced the rate of casting by 58%. Reduction of thatch by regular aeration and scarification should also further restrict the supply of food.

A reduction in soil pH generally results in a lowering of the earthworm population, as well as encouraging the more desirable bent and fescue grass species. Work by Jefferson given in Figure 1 clearly shows the theoretical response curve of earthworm numbers to soil pH. In particular the important casting species Apporectodea longa and A. caliginosa known to be intolerant of acid soil conditions.

The use of acidifying fertilisers such as ammonium sulphate or ammonium nitrate will tend to decrease soil pH and hence reduce earthworm activity. Conversely fertilisers such as nitrochalk, sodium nitrate or basic slag induce alkalinity or a neutral reaction and should generally be avoided on sites where excessive earthworm casting is likely to be a problem. Iron sulphate also tends to reduce earthworm casting and in some circumstances sulphur and aluminium sulphate can be used to manipulate soil pH.

Addition of lime will normally increase earthworm numbers and thus lime-rich top dressing materials should be avoided. The early work by Ferro (1937) showed that rates of casting on plots top dressed with a lime-rich sea sand were almost double that of turf dressed with a lime-free river sand. In general rootzone mixes and top dressing materials should have a calcium carbonate content <0.5% otherwise they can raise pH causing problems with weeds, disease as well as earthworm activity.

RESEARCH TRIALS

Thanks to financial support from the R&A we have already started a number of trials to start examining methods of earthworm control now that the use of chlordane is illegal. Firstly, we are examining methods of chemical control that can still be used. Three chemicals (carbaryl, carbendazim and gamma-HCH plus thiophanate-methyl) are still approved for use in earthworm control. We are evaluating the effectiveness of these chemicals at three sites and in particular examining the required application frequencies.

Secondly, we are examining acidification techniques. As mentioned above, earthworm activity is strongly influenced by the pH of the soil and for example the over zealous use of lime on golf fairways in the past undoubtedly contributed to problems of casting. Certain earthworm species eg. Dendrobaena octaedra and D. rubida are tolerant of acid conditions but two of the main casting species Apporectodea longa and A. caliginosa will not tolerate acid conditions. A pH of about 5.0 represents their lowest tolerance and this can be used as a method of cultural control on golf courses. If the pH gets too low it will obviously affect grass growth but a balance with a slightly acid soil which permits the healthy survival of the finer turf grasses but decreases earthworm activity is an advantage. To this extent we are examining the use of sulphur and aluminium sulphate to modify the pH of fairway soils looking at both application rates and application frequency. For example two applications of sulphur and aluminium sulphate at the highest rates in the trial in autumn 1993 and spring 1994 brought the surface pH down from 5.8 to 4.5 and casting rates from October to December 1994 were typically only 25% of those of untreated plots. However care has to be taken on application rates because of problem of scorch and weakened grass growth so further work is still required on this trial.

A second trial is examining surface acidification by iron sulphate, in particular its application frequency and interaction with carbaryl, carbendazim and gamma-HCH plus thiophanate methyl.

EXPELLANT MATERIALS

In the past expellant materials, eg. Mowrah meal and potassium pernanganate were used, being applied to turf and thoroughly watered in. The material acted as an irritant causing the earthworms to rise to the surface where they could be brushed into piles and remove by wheelbarrow. If future legislation on earthworm control becomes even more stringent we may be forced into adopting these time consuming and undoubtedly messy procedures. We have thus started some preliminary investigations of expellent techniques using potassium permanganate, formaldehyde, mustard and even vindaloo curry powder, but contrary to some press reports, we are still a long way from the stage of recommending a visit to the local Indian take-away as a source of worm control materials!

REMEMBER THE ADVANTAGES OF EARTHWORMS

On areas other than greens, earthworms have many advantages most notably with respect to the development of soil structure, soil fertility and the breakdown of organic matter. If a decision is made to control earthworm activity, careful thought should take place beforehand to ensure that the advantages of reduced casting outweighs the potential disadvantages of structural deterioration and thatch development. Nevertheless heavy rates of casting bring problems to the greenkeeper and golfer alike and it is hoped that this research will lead to more environmentally acceptable methods to reduce the casting problem.