



Grass grub biology and non-chemical control

Introduction

The recent review of organophosphate insecticides by the Environmental Protection Authority set three, 10 and 15 year phase out periods for three important active ingredients used for chemical control of grass grub (*Costelytra zealandica*) in New Zealand. This means that phorate will not be able to be used after 2016/17, terbufos (Counter®) after 2023/24 and diazinon after 2028/29. Industry now has a window of time to plan and test alternative strategies for long term control of grass grub.

An understanding of grass grub biology and of non-chemical control options is important for long term management options. This Arable Extra summarises current relevant knowledge from a review of literature on the biology and life cycle of the New Zealand grass grub in arable cropping systems. Very few references in scientific literature were devoted solely to the control or management of grass grub in arable cropping systems. This Arable Extra should be read in conjunction with FAR Arable Update, Cereals No. 109 (2002).

Biology and dispersal

Lifecycle

New Zealand grass grub begins its lifecycle as eggs laid during November and December (Figure 1). It is generally accepted that female grass grub beetles lay the majority of their eggs at the point of primary emergence (in the same area where larval damage occurred) and that there is minimal population spread from flying females (Fenimore, 1965). Following the initial deposit of eggs, adults undertake 'feeding flights' where they consume foliage e.g. brassica plants, tree leaves. During these feeding flights a smaller batch of eggs can be laid some distance from the emergence point, leading to dispersal of the species. Very little information on flight distance is available and this is an area that requires further investigation to produce useful guidelines for growers.

Larvae hatch about three weeks after the eggs have been laid. They begin feeding on plant roots immediately, although they can also survive on non-living soil organic matter if required. There are three stages of larval growth, called instars. Newly hatched larvae are called first instars and they will generally develop into second instars from mid January to late February. At this stage they are capable of moving into the top 6 cm of soil. Third instars develop from February through until June, and these may move up to within 2-3 cm of the soil surface. When feeding is complete, the larvae burrow back down in the soil profile. This may occur during winter or spring depending on feed supply during autumn and winter. During this period they empty their gut before pupating in September/October. The pupae can be found from 10-25cm below the soil surface for four to six weeks before they emerge as adults.

There is generally only one complete life cycle per year, although cold temperatures, drought or food shortage can slow development. When the development of second or third instar larvae is slowed, they may carry over into a second winter and emerge as adults the following summer, thus creating a two year life cycle.

Key points

- Primary industries have between three and 15 years to investigate methods to control grass grub without three commonly used insecticides, including diazinon, the only current agrichemical option for post planting larvae control.
- A number of natural pathogens can control grass grub (biocontrol), however summer drought and cultivation can be detrimental to the survival of biocontrol organisms.
- Non-chemical control options include physical damage to grubs and pupa through cultivation, trampling and heavy rolling.
- Under a traditional one year life cycle, damage caused by grubs can occur any time from February to August depending on grub size and feed supply.
- If two year life cycle grubs are present, damage can occur from August to December e.g. late spring early summer damage in late planted peas.
- Each female grass grub lays one main egg batch close to where she emerges (the damaged patch) and may also lay a few eggs some distance from the emergence point during a feeding flight in November.
- Adult feeding flights are the main method of grass grub dispersal into new areas.

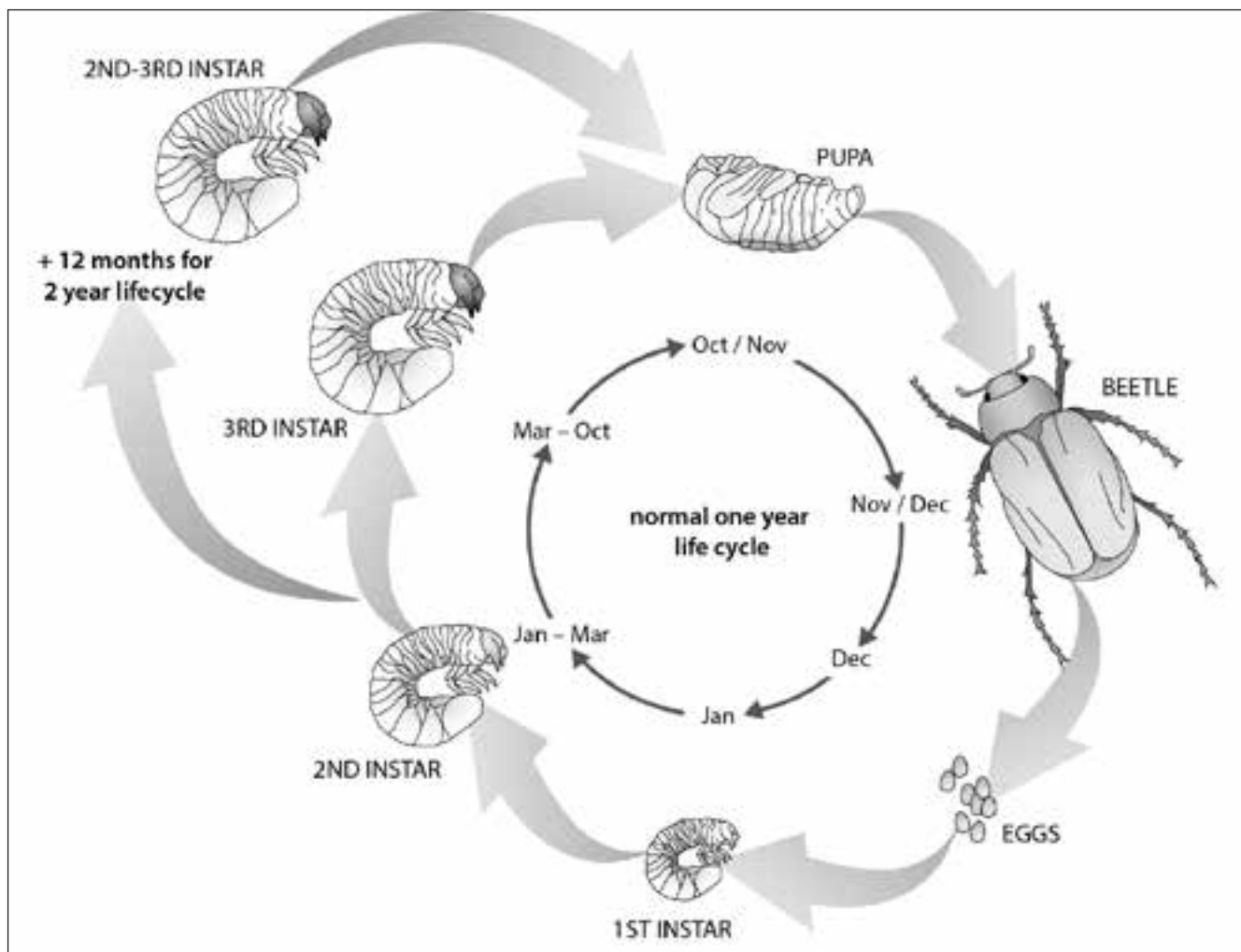


Figure 1. Life cycle of New Zealand grass grub (*Costelytra zealandica*) illustrating normal one year, and occasional two year, cycles.

Redistribution

The distances adults fly during feeding flights is unknown and hard to quantify, but confirmed observations suggest it can be in excess of 100 meters compared with 10-15 meters for mating flights. Farrell and Wightman (1972) suggested that eggs laid by females flying after laying their primary egg batch result in very minor populations of grass grub at the new location. It is the repeated egg laying in subsequent years that will form the basis of a new grass grub problem. Therefore, it is unlikely that populations will be large enough to cause significant damage as a result of one feeding flight alone.

The only way growers can discover a new population prior to crop damage from grass grub is to monitor areas close to known infestations by digging holes and counting larval populations.

Non chemical control options

Population studies suggest that soil moisture, soil temperature and density dependent mortality factors (e.g. fighting) are the main determinant of grass grub population fluctuations. Dry early summers can be particularly detrimental to egg survival (Barlow, et al., 1996; Townsend, et al., 1993).

Cultivation

Spring cultivation can have a significant effect on grass grub populations, particularly at the vulnerable pre-pupae and pupal life stages, which occur in October and November (McLennan and Pottinger, 1976; Stewart, 1986). Inside the autumn cultivation window (March/April/May) larvae are usually in the 2nd or 3rd instar phases and the light cultivation/top working which is now common on New Zealand cropping farms, is unlikely to result in high mortality. However, deep ploughing and/or repeated cultivations can cause significant mortality. Therefore cultivation can be used as a management tool for grass grub control, particularly in the late spring. However cultivation is also detrimental to many of the pathogens which attack grass grub (Miln, 1982), possibly through exposure to UV light and the death of high numbers of grass grub larvae reducing the number of hosts. Thus cultivation may not be the best answer in the long term.

Growers should investigate the use of cultivation for grass grub control, especially when establishing crops in October (in Canterbury). When sowing autumn crops multiple passes may be required to cause mortality. For autumn cultivation, growers can investigate mortality by monitoring healthy grass grub numbers both prior to cultivation and then four to six weeks post cultivation. For late spring cultivation, mortality can be assessed by investigating grass grub larvae numbers the following autumn.

To ensure accuracy, assessment should occur at the same sites. Dig 8-10 spade squares to spade depth, place the soil on a sack and carefully sort and count any grass grub larvae. It is best to use the same spade or to make adjustments for spade size.

Rolling

Timely use of heavy rolling and/or treading by livestock can also reduce grass grub numbers when third instar larvae are close to the soil surface e.g. under direct drilling or at particular times during autumn/winter/spring. Research in the late 1970's and early 1980's suggested that heavy rolling in conditions where damage may occur to grubs (i.e. when they are close to the surface) could result in greater than 80% mortality. However, actual results ranged from 20-90% and generally it was rollers which moved a greater amount of soil that produced greater mortality (Stewart, et al., 1988; van Toor and Stewart, 1987). A more realistic expectation of mortality after rolling would probably be nearer the 20-40% range.

The effectiveness of cultivation and rolling can be assessed by counting grass grub larvae populations both before, and four to six weeks after treatment. Growers should investigate and experiment with the effectiveness of cultivation and rolling type treatments compared with diazinon based chemical applications now, as in 15 years this chemical option will not be available. This may involve treating small parts of paddocks now to gain confidence and experience for the future.

Natural controls

Pathogens are disease-causing organisms which can cause death or increase susceptibility to other pathogens. Disease in grass grub populations may cause a population to collapse, particularly when populations are high and food resources are low. In the North Island, protozoa (especially in Taranaki) and milky disease bacteria (*Bacillus popilliae*) (Photo 1) are mainly responsible for the collapse of grass grub populations. In the South Island, amber disease (*Serratia* sp.) (Photo 2) is the dominant pathogen.

The fungal species *Metarhizium* sp. (Photo 3) and *Beauveria* sp. have been implicated in grass grub population collapse in the Waikato region.



Photo 1. Grass grub larvae showing sign of the bacterial infection, milky disease (L) with white liquid emitted from leg compared with clear liquid and a fat healthy grass grub (R).

Photo supplied by AgResearch.

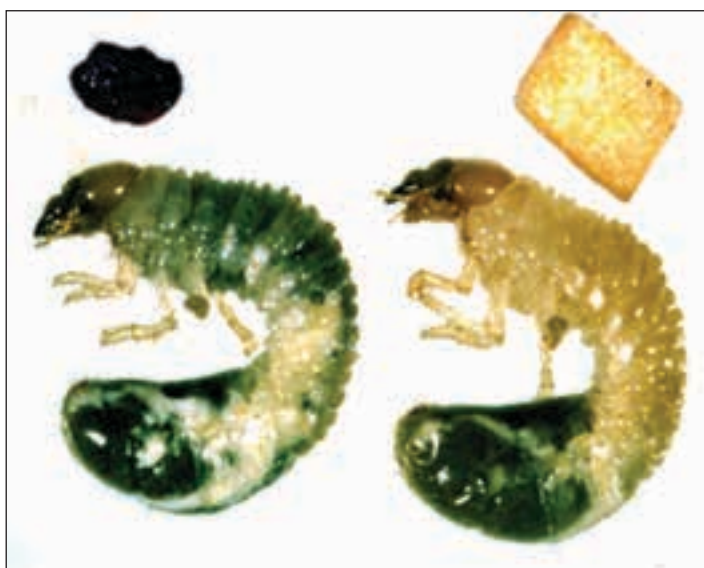


Photo 2. A healthy grass grub (L) compared with an amber diseased grass grub (R). Non feeding caused by the *Serratia* species of bacteria.

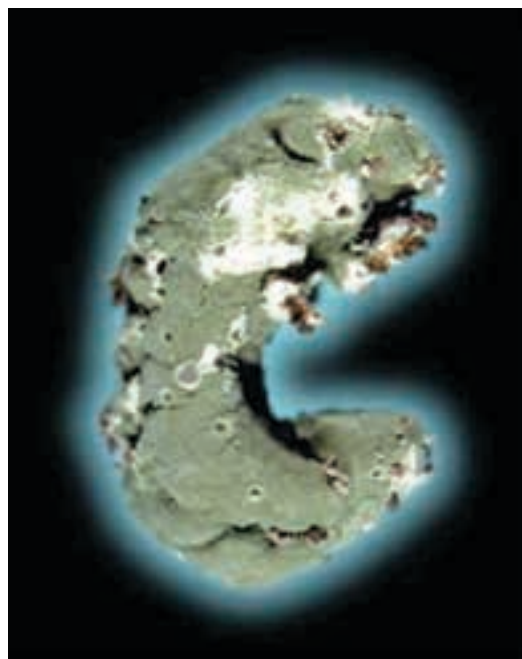


Photo 3. A grass grub killed by the fungus *Metarhizium* sp., identified by the presence of the white and green fungal spores.

Drought, insecticide application and cultivation all disrupt the natural regulation of grass grub populations by pathogens (Miln and Carpenter, 1979). This exposes crops to a high risk of large and very damaging populations of grass grub. Where crops are maintained without control measures for between two (e.g. 2nd year ryegrass or clover), and five years (e.g. pasture), it is likely crops will benefit most from introduced natural control measures.

Growers can investigate the presence of natural pathogens in areas where insecticide has not been applied by examining grubs. The use of insecticide make it difficult to determine the cause of unhealthy grubs. For example, the symptoms of amber disease are similar to the effects of insecticide. The use of irrigation to avoid drought and reduced tillage practices are likely to favour pathogens in the long term and to increase grass grub mortality. However they also may increase the overall food supply for grass grub, resulting in higher populations.

Summary

In summary, there is little available data around non-chemical control of grass grubs in cropping situations. The recently introduced phase out period for phorate, terbufos and diazinon mean that industry and growers must start developing and testing alternative strategies for long term control of grass grub.

FAR and industry partners are currently investigating new methods of grass grub control for the arable sector. These include the role of precision agriculture, bio-control and making the most from the agrichemicals which will remain post 2030.

References

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Acknowledgements

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