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Integrated control of soil insect pests of potatoes

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One of the more difficult aspects of growing potatoes in Western Australia is controlling soil insect pests. These pests have become more troublesome because the highly effective and persistent organochlorine insecticides previously used to control the main soil pests, African black beetle and whitefringed weevil, were deregistered for agricultural use in 1987.

Entomologists from the Department of Agriculture and CSIRO in Western Australia are collaborating to develop new management strategies for these pests that rely less on the use of chemical insecticides.

About the potato industry

The Western Australian potato industry is worth about $30 million annually. With the establishment of a potato-processing plant at Manjimup by Edgell-Birds Eye in 1987, the value of the industry has increased dramatically. Gross returns to growers range from $7,000 to $14,000 per hectare, depending on time of sowing and whether the potatoes are grown for the processing or ware (table) trade.

Potatoes are grown commercially in the higher rainfall area (more than 700 mm average annual rainfall) from Gingin to Albany, and never more than about 80 km from the coast. The Manjimup and Pemberton areas account for about 40 per cent of production, while most of the seed for the industry is grown in the Albany area.

With the exception of potato crops grown in the Gingin and Perth metropolitan areas, which account for about 10 per cent of the State’s production, potatoes are attacked by a range of soil insects. Most of these insect pests occur in pastures and cause damage when potatoes are sown there.

Main soil insect pests

The main soil insect pests of potatoes in Western Australia are whitefringed weevil (Graphognathus leucoloma) and African black beetle (Heteronychus arator).

Other soil insects that do cause damage to potato tubers, but over much smaller areas, include small lucerne weevil (Atrichonotus taeniatus), garden weevil (Phlyctinus callosus), apple weevil (Otiorhynchus cribricollis) and Fuller’s rose weevil (Asynonychus cervinus).
African black beetle damages potato crops in two ways. Adult beetles feed on plant stems resulting in poor crop establishment and reduced yield; for example in an area of unprotected summer-sown potatoes in 1990, yield fell by about 60 per cent because of severe damage to stems. Adults and larvae of African black beetle also feed directly on tubers. Such feeding results in cosmetic damage to tubers and these are rejected by the trade.

The only damaging stage of whitefringed weevil is the larva which feeds on tubers. This direct feeding on tubers is highly important in the ware (table) market where consumers demand blemish-free produce. Where crops have not been protected from soil pests, 30 to 50 per cent of tubers have been lost. Even when soil is treated with insecticide, and if dense insect pest populations are present, 10 to 20 per cent of tubers may still be lost. The reasons for this are discussed below.

For the processing/French fry market, the criteria for rejection are less stringent, but sound potatoes are needed.

Potato growers have relied on insecticides, particularly the organochlorine insecticides, to protect their high value crops from such potential losses. The insecticides gave good control, but were not without problems. The persistence of organochlorines, their greatest attribute for controlling insects in soil, was also the cause of contamination in other farm products, notably beef.

Furthermore, use of the organochlorines heptachlor and dieldrin over a number of years led to African black beetle becoming resistant to them, and hence levels of protection in the field were reduced.

The less persistent organophosphate insecticide chlorpyrifos was registered in their place. Although this insecticide controls African black beetle when applied at planting, it has poor persistence and such applications will not provide protection from beetles that fly into a crop during its growth.

After the deregistration of organochlorines for agricultural use in 1987, growers lost their most effective insecticide for protecting crops from whitefringed weevil larvae.

Insecticide screening trials by the Department of Agriculture which started 10 years before, failed to identify an equally effective alternative. Chlorpyrifos gave the most consistent crop protection by a non-residual insecticide in these trials. It is the only insecticide registered at present for the control of both whitefringed weevil and African black beetle in potatoes.

New approaches to control

African black beetle comes from southern Africa and whitefringed weevil from South America, both being accidental introductions to Australia 50 to 60 years ago. African black beetle has been studied closely in New Zealand, where it is a pest of pasture, but little is known there about whitefringed weevil. Under Australian climatic conditions, there is little basic information about the biology and life cycle of either insect.

In 1988, the Western Australian potato industry, through the Potato Growing Industry Trust Fund, provided financial support for a project by the Department of Agriculture and CSIRO to study soil insect pests of potatoes and their control. Its contribution was matched by grants from the Australian Special Rural Research Fund initially, and later by the Australian Horticultural Research and Development Corporation.

The objective of the research is to develop a range of measures that will lessen dependence on insecticides and give growers assured crop protection.
Gathering information

To establish the extent of soil insect pest problems, the Department of Agriculture surveyed all potato growers in the State. Information was gathered on pest distribution, cultural practices, losses caused by soil insects and methods of insect control.

Meanwhile, CSIRO is studying the basic biology of African black beetle and whitefringed weevil in Western Australia’s potato growing areas to determine the links between their life cycles and potato cropping.

To sample the various life cycle stages of the insects, CSIRO scientists use a process called differential flotation in a salt solution to separate insects from soil. In this way, scientists are collecting accurate, detailed information about life cycles of the insects and their abundance, even for the extremely small early larval stages of whitefringed weevil (see photo on page 155 indicating the range in size of whitefringed weevil larvae).

Work on the basic biology of African black beetle is complete. The biology of whitefringed weevil is proving to be complex, and further studies are needed.

The Department of Agriculture and CSIRO scientists also are sampling numerous 50 cm lengths of potato ridges during the life of a crop to determine the timing and extent of insect damage. Potatoes growing in an unprotected area and an adjacent area treated in the normal commercial way with insecticide are being sampled.

Potato seed pieces, stems and tubers, as well as the various life cycle stages of the insects, are recorded in different positions of the ridge as shown in the cross section in Figure 1. Damage to stems and the location of insect attacks on tubers (top, bottom or edge) are also recorded. In this way, the details of insect occurrence and abundance can be linked to the growth of the crop to determine the type, timing and levels of damage.

Comparison between insecticide-treated and untreated crops reveals how insect abundance, location and damage change when insecticide is used. The objectives of these studies are to reveal limitations in control methods, for example by showing the depth to which insecticide incorporation in the soil is effective, and the duration of control which can be expected in the crop cycle.
Control methods

Insecticidal control may be improved by examining various types of insecticides in screening trials, by applying them at more strategic times in relation to the life cycle of the pest, and by using insecticides more efficiently - for example, by injecting them into the planting furrow.

One aspect of control of whitefringed weevil that is being studied is the possibility of disinfesting pasture before sowing potatoes. This approach has been used with some success in New Zealand pastures by using non-residual contact insecticides to kill adults before they lay eggs. Although this method would appear to have most promise against whitefringed weevil adults which are found on the surface and cannot fly, it is also being tested against African black beetle adults which are mostly underground dwellers.

Potato crops are either grown following pasture or almost always adjacent to pasture. It is this close association with the pasture in which the insects occur that makes potatoes prone to damage by soil insects.

Investigations on African black beetle and whitefringed weevil elsewhere have shown that African black beetle prefers to live in grass-based pastures, whereas whitefringed weevil favours legumes. Therefore if pasture could be ploughed out and replaced with less favourable plant species before sowing potatoes, the pest population might decline. The possible types of rotations that would fit in with local farming practice are shown in Figures 2a and 2b.

CSIRO's Division of Entomology in Canberra is also studying fungal diseases and nematode parasites that may be effective biological control agents against larvae of African black beetle, as well as fungal diseases that may be effective against larvae of whitefringed weevil. Many strains of fungi and nematodes are being tested, only some of which will usefully attack a particular target insect. The most virulent strains for a particular pest are screened in a laboratory before field trials start.

Laboratory screening has so far revealed three strains of the fungus *Metarhizium anisopliae* active against larvae of African black beetle. They have been tested in a small field trial in Western Australia with encouraging results. If the fungus is to be successful in the field, more virulent strains need to be identified and better application methods developed.

Strains of the parasitic nematodes *Heterorhabditis* spp. and *Steinernema* spp. as well as strains of the fungus *Metarhizium anisopliae* are also being screened for their activity against larvae of whitefringed weevil, but so far no suitable ones have been found.

With the continuing pressure on use of insecticides all possible alternatives for managing insect pests of potatoes must be pursued. We believe that the broad-ranging approach adopted by the Department of Agriculture and CSIRO is the most effective way of making progress in the battle against such difficult potato pests as soil insects.

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**Figure 2a and b. Diagrammatic representation of crop rotations to be studied to reduce African black beetle (top) and whitefringed weevil populations.**