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BROADACRE PEST CONTROL AFTER DDT

By Phil Michael, Entomologist

DDT may no longer be applied to broadacre crops grown in Western Australia. It is being replaced by other effective chemicals and with new methods of pest control. DDT was the most effective chemical for the control of several major broadacre pests in this State and farmers may well wonder why this change was necessary and how they will manage without DDT.
Benefits of DDT

The outstanding effectiveness of DDT against a wide range of local pests was demonstrated soon after World War II when it became available for agricultural use (Jenkins 1945). It has since been used in this State against many broadacre crop pests such as webworm, armyworm, native budworm and redlegged earth mite.

World-wide and local usage of DDT for more than 40 years confirmed its efficacy against a wide range of pests and at a low cost. It has an excellent safety record for humans despite its massive use especially in campaigns against malaria and typhus. The benefits brought by DDT are recognised world-wide but, also on a similar scale, traces of this chemical in agricultural products and the environment have given rise to concern.

Persistence of DDT

Concern about the persistence of DDT increased during the 1960s and prompted several countries to impose severe restrictions on its use. Limits were set on the allowable residues of DDT in international agricultural products.

The persistence of DDT is well proven. Half the quantity of this chemical applied to soil is likely to be present after three years, though the life of the chemical is much shorter in exposed situations such as on crops or in litter. When ingested by animals, DDT is stored in the fatty tissue and is eliminated slowly.

Residues in food, while extremely small, lead to DDT in humans. No ill effects on human health have been linked with these residues, even when found in much greater than average levels such as in people employed in factories producing DDT.

Biological effects

Isolated cases of birds and fish being directly killed by large uses of DDT have been reported but the effect of small, non lethal residues has been of more concern. Progressively greater residues of DDT are found at each level of a food chain as each animal consumes its food together with the DDT it contains. For example, carnivorous birds at the end of the food chain are most at risk. DDT may also cause some birds to produce thin-shelled eggs which are more prone to break during the nesting period.

As DDT was effective against a wide range of insects, it sometimes reduced the numbers of predators and parasites even more than the pests. A period of rapid pest increase sometimes followed a DDT application. Continued use of DDT often resulted in the emergence of resistant populations which were able to survive increasingly large doses and DDT was no longer effective.

Use in Australia

The Australian Academy of Science study (1972) into the use of DDT in this country found that DDT residue levels in food were similar to those in other countries, and that levels in humans were at the lower end of the range found elsewhere. Certain uses of DDT had already ceased before the investigation. Following this there was a brief, intensive use on cotton in Australia with as many as 40 sprays per season against insecticide-resistant cotton bollworms. Apart from that, the use of DDT continued to decline. In recent years one of the major uses of DDT in Australia was for broadacre crops in Western Australia.

This continued usage in Western Australia resulted mainly from the adoption of reduced tillage planting methods which have provided weed control without the need for a fallow period. This method has favoured certain pests, especially the webworm, which is capable of surviving in densities 90 times greater than in crops planted after a three-week fallow period (Michael et al 1984). About 250 g/ha of DDT, a typically low rate, was often applied to effectively control this pest when reduced tillage methods were employed.

Farm surveys showed that soil residues of DDT as a result of this use were less than one part in a million. No consistent decreases in the numbers of predators were found in treated paddocks. Experiments showed that both an increased dose of DDT at 2 kg/ha active ingredient and an alternative chemical chlorpyrifos at 1 kg/ha active ingredient reduced the number of predatory beetles and the bdellid mite which preys on the lucerne flea (Figure 1). Residues of DDT applied at 2 kg/ha were found in the treated soil at six parts per million. Where the DDT was applied, the numbers of lucerne flea increased greatly, as expected from the results of earlier work (Wallace 1954), but chlorpyrifos effectively killed that pest (Figure 2).
A lucerne flea attacks a subterranean clover leaf, producing the typical "window effect" in the foliage.

Figure 1. Numbers of predatory beetles and bdellid mites remaining after sprays of DDT and chlorpyrifos.

Figure 2. Numbers of lucerne flea remaining after sprays of DDT and chlorpyrifos.
Table 1. Comparisons of three broadacre insecticides

<table>
<thead>
<tr>
<th>Chemical group</th>
<th>DDT</th>
<th>Chlorpyrifos</th>
<th>Fenvalerate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Organochlorine</td>
<td>Organophosphorous</td>
<td>Synthetic pyrethroid</td>
</tr>
<tr>
<td>Toxicity (dermal LD50)</td>
<td>2 500</td>
<td>2 000</td>
<td>&gt;5 000</td>
</tr>
<tr>
<td>(oral LD50)</td>
<td>113</td>
<td>135</td>
<td>451</td>
</tr>
<tr>
<td>Amount (g.a.i.) purchased for $5</td>
<td>540</td>
<td>150</td>
<td>23</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rate of chemical (g.a.i./ha required)</th>
</tr>
</thead>
<tbody>
<tr>
<td>armyworm</td>
</tr>
<tr>
<td>budworm</td>
</tr>
<tr>
<td>webworm</td>
</tr>
<tr>
<td>brown pasture looper</td>
</tr>
<tr>
<td>redlegged earth mite</td>
</tr>
<tr>
<td>lucerne flea</td>
</tr>
</tbody>
</table>

*Unregistered uses

g.a.i.—grams of active ingredient

Table 2. Effect of alternative chemicals to DDT on numbers of webworm and severed plants per square metre

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Cypermethrin</th>
<th>Deltamethrin</th>
<th>Chlorpyrifos</th>
<th>Unsprayed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate (g.a.i.)</td>
<td>11 g/ha</td>
<td>2.5 g/ha</td>
<td>510 g/ha</td>
<td>-</td>
</tr>
<tr>
<td>Webworm</td>
<td>1.3</td>
<td>3.6</td>
<td>0.9</td>
<td>113.6</td>
</tr>
<tr>
<td>Plants</td>
<td>1.6</td>
<td>0</td>
<td>0.3</td>
<td>62.5</td>
</tr>
</tbody>
</table>

Alternative chemicals

In the view of the world-wide concern about DDT residues and especially the detection of several residue violations in Australian meat, all DDT registrations have been cancelled. Alternative effective chemicals against broadacre crop pests are now available.

Unlike DDT which belongs to the organochlorine group, the chemicals that replace DDT are organophosphates, carbamate or synthetic pyrethroid compounds. These chemicals vary greatly in their insecticidal activity and their toxicity to mammals. All of them are broken down more rapidly than DDT.

Parathion was one of the first effective organophosphorous compounds, but it is extremely toxic to mammals. Dimethoate, maldison and chlorpyrifos are chemicals from this group which are used in broadacre pest control today.

Carbaryl is a well known chemical from the carbamate group, while pirimicarb is a useful chemical because of its selective action against aphids.

The most recent of these groups is that of the synthetic pyrethroids which are based on the natural pyrethrins extracted from flowers of two plant species. Several chemicals such as cypermethrin, fenvalerate and deltamethrin are used against broadacre crop pests. Table 1 compares the toxicity, insecticidal activity and cost of chlorpyrifos and fenvalerate, as examples of two of these groups, with DDT.

All the chemicals which replace DDT are eliminated rapidly from animals and they are much shorter lived in the soil than DDT. For example cypermethrin, applied to lupins at higher rates than normally used, almost disappeared from the plants after one month (Figure 3) and was not detected in seed at harvest.

These alternative chemicals are less persistent than DDT and smaller quantities are required as they are more "active" against insects. For example between 250 g/ha and 500 g/ha of DDT is required to control webworm whereas these other chemicals are effective at rates below 20 g/ha (Table 2).

Pea weevil is a most serious pest of field peas.
Figure 3. Maximum residues of DDT and cypermethrin on plants after application to lupins.

Budworm larvae attacking lupin pods. Note the colour variation of the larvae.

A cutworm larva and damage to wheat seedlings.
Toxicity

Most chemicals which replace DDT are less toxic to mammals though their toxicities differ greatly. The more toxic the chemical, the lower will be its LD50, which is the dose required to kill 50 per cent of animals (measured in mg/kg of bodyweight). This dose may be administered by mouth (orally) or through the skin (dermally). Thus demeton-s-methyl, which is used in Western Australia for aphid control, is more toxic than DDT and has an oral LD50 of 57 whereas maldison, which is used to protect stored-grain, has an oral LD50 of 2,800. Table 1 shows the toxicities of DDT and two other chemicals.

Target pests

Chemicals such as pirimicarb, which are active against only a few insects, such as aphids, are highly desirable as they do not destroy the beneficial species which help to keep the pests in check. In other situations it is better to use a chemical such as chlorpyrifos which will control two or more pests (Table 1). Chlorpyrifos, when applied at the rate required to control webworm in cereal seedlings, will also control redlegged earth mite and lucerne flea. When fenvalerate is used at the rate required to control webworm, it will give some control of redlegged earth mite, but it will not control lucerne flea. Another insecticide must also be applied to control this pest.

Cost

DDT was a cheap insecticide at the doses required to kill many pests. Alternative chemicals for most uses will be somewhat more expensive than DDT, though the low rates of some alternatives, which have recently been shown to be effective when used correctly, often cost little more. To control all the main pests that attack cereal seedlings, the cost of DDT with omethoate was about $3.30 per hectare. It costs about $3.90 per hectare to use fenvalerate with omethoate and about $5.00 per hectare to use chlorpyrifos alone. Other cost comparisons can be deduced from Table 1.

The future

Basic changes to this State's agricultural system may significantly alter the pest situation. This happened after the adoption of reduced tillage and may be repeated with changes such as the adoption of continuous cropping or the elimination of grasses. Some of these changes will favourably alter the pest situation, such as the control of webworm through the elimination of grasses, but the planting of non-cereal crops such as peas and rapeseed, and increased cropping in the high rainfall areas using long-season varieties and higher nutritional inputs, will undoubtedly lead to more serious problems.

The agricultural industry would be wise to avoid a heavy reliance on chemical control alone for insect pests, even though the newer chemicals seem to be more acceptable than DDT. The emergence of resistant strains of insects is always a possibility especially if chemicals are used frequently. On economical grounds alone chemicals should only be applied when there is impending serious damage. An accurate knowledge of the effect of pests, together with warning systems and practical sampling methods, is required.

The development of plant varieties which are less susceptible to insect attack or which are able to tolerate greater levels of damage, and an increase in the degree of biological control of insects, would benefit long term broadacre pest control. Such methods should be sought and used together with chemicals when necessary if pest management in the future is to be as successful as it was in the DDT era.

References


