By Des van Heerden, Syngenta and chairperson of the South African Diamide Working Group, IRAC

Insect resistance to the diamide group of insecticides

Des van Heerden.

Local and international scientists have expressed concern over the incorrect use of insecticides, in particular the diamide group. This misuse leads to widespread insect resistance. The Diamide Working Group focusses on insect resistance to this chemical group and forms part of the Insecticide Resistance Action Committee (IRAC) in South Africa.

Objectives of the working group

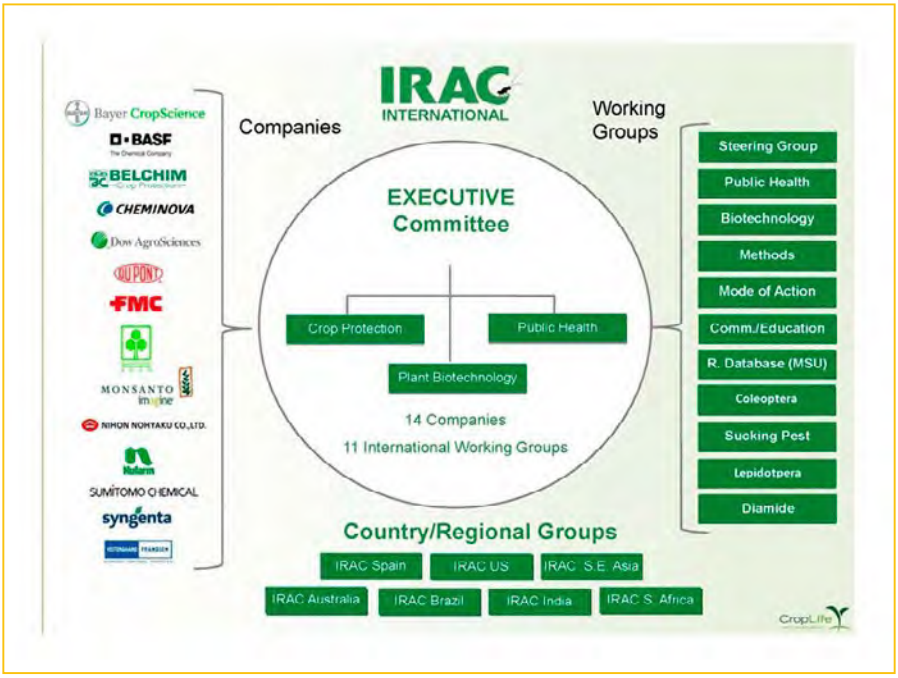
IRAC SA looks at the possible development of insect resistance against locally registered insecticides. The group consists of entomologists with specialist technical expertise from companies, research institutions such as the Agricultural Research Council (ARC) and universities. However, any interested parties may attend meetings. IRAC SA and the working group report to the international IRAC and CropLife SA, the umbrella body to which most agrochemical companies belong.

IRAC is involved in training and precaution against the overuse, misuse or indiscriminate use of chemical agents that can result in a sensitivity shift or the development of resistance. Problem cases and poor control of specific treatments are reported to the group.

The international group consists of several working groups that study insect groups such as *Lepidoptera* (moths and butterflies), sucking insects or beetles, and groups that are involved in biotechnology, communication and training, resistance databases as well as a group that specifically investigates diamides. The group came into being after the susceptibility of insects to building up of diamide resistance came to light.

Countries and regions with designated IRAC groups include the United States (US), Spain, Brazil, Australia, South East Asia, India and South Africa. The local group annually receives good feedback on their activities, and companies are collaborating to address problems and establish measures to combat the rapid increase in resistance.

Figure 1: The diamide group is a relatively new chemistry with a unique mode of action.



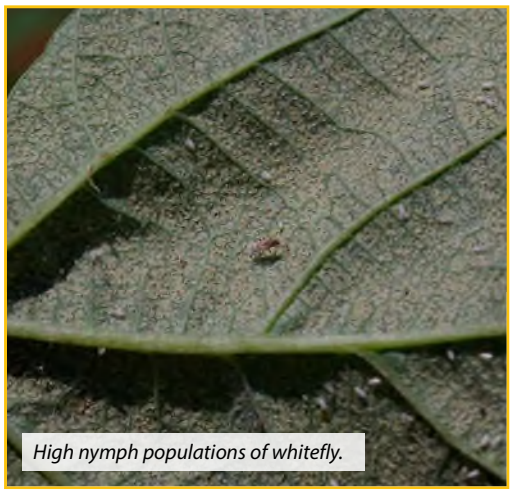
Purpose of diamides

On the front label of each pesticide an insecticide group code is displayed which is linked to the chemical agent's specific mode of action. IRAC classifies each product's mode of action in groups. Diamides belong to group 28, the ryanodine receiver modulators, that affects the nervous system of insects and the release of calcium in the muscles.

The group controls a wide spectrum of insects which includes the potato tuber moth (*Phthorimaea operculella*), stalk borer (*Papaipema nebris*), sugarcane stem borer (*Lep.: Noctuidae and Pyralidae*), tomato leafminer (*Tuta absoluta*), cutworms, armyworms, diamondback moth (*Plutella xylostella*), bollworm, false codling moth (*Thaumatotibia Cryptophlebia leucotreta*), large cabbage moth (*Pieris brassicae*), codling moth (*Cydia pomonella*), litchi moth (*Cryptophlebia illepida*), carob moth (*Ectomyelois ceratoniae*), fruit pitch moths, leafrollers (*Tortricidae*) and plum snail.

The group also controls fruit flies,


Leafminer damage.


High nymph populations of whitefly.

Diptera or fly leafminers and pumpkin flies, thrips excluding the flower thrip (*Frankliniella occidentalis*), whiteflies and the stink bug complex (bagrada bug and antestia bug). There is also an effect to aphids and leafhoppers.

It can be sprayed on crops such as lucerne and pasture (green and hay), sweetcorn, maize, vegetables such as lettuce, cucurbits, the chilli group, potatoes, cabbage crops, tomatoes, brinjal, legumes, tuber crops, tobacco, grain sorghum, pome fruits, nuts and sugar cane.

Scope of the resistance problem

However, the main concern currently is leafminers, whitefly and looper. Especially weak to zero control has been recorded with leafminers and whitefly on tomatoes and potatoes.

Diamide insecticides offer excellent control of all larval stages and lowers the chance for eggs to hatch. It has a unique mode of action and is an excellent agent to alternate with. However, they must used judiciously and correctly.

Unfortunately, we cannot say for certain that there is diamide insecticide resistance in South Africa, but we can refer to a sensitivity shift as no experts currently work on resistance and it cannot therefore be confirmed with trials or laboratory tests. The working group, however, has received numerous complaints and can say with reasonable certainty that no chemical agent in the Sandveld control leafminer any longer. In Limpopo problems have also been encountered with semi-looper and looper control, and whitefly has also been an increasing problem, with no remedy offering more than 80% control.

Diamide resistance cases worldwide have already highlighted resistance in 13 insects, including army worm (*Spodoptera*), diamondback moth (*Plutella xylostella*), leafminers (*Liriomyza*), rice stalk borer (*Scirpophaga*), *Leocinodes* borer, *Maruca* fruit borer, *Chilo* stalkborer, bollworm, Colorado potato beetle (*Leptinotarsa*), *Pseudoplusia* looper, *Chrysodeixus* looper, *Tuta* leafminer and apple leafroller.

The first cases were recorded in less than 18 months after launch in ten crops: potato, tomato, rice, beans, cabbage crops, soya beans, scallions (green onion and spring onion), apples, brinjal and chilli groups; and in 15 countries: the US, Australia, Brazil, Canada, Italy, Japan, Malaysia, India, Mexico, Vietnam, Thailand, Philippines, Taiwan, China and Indonesia.

Since the diamide group of insecticides initially work so well it is not alternated by different modes of action but used repeatedly. The subsequent insect population is then exposed to the same extermination action. In each insect population, there are always extremely susceptible individuals and those who are resistant. The susceptible individuals are soon killed, and over time the population consists of individuals that are more resistant.

These mate with each other and expected control is not achieved. It is a vicious cycle, and often dosages are then increased or spray intervals reduced with the expectation that good control will be obtained, something which of course is not the case. The practice is then to simply select more for resistance in insects. Diamide also unfortunately lead to the rapid development of resistance.

Development of resistance

Insects generally have very short life cycles, and in the case of whitefly it takes only eight days at 27˚C to develop from adult to adult again. Leafminers take approximately 18 days, mites only 10 days and larvae about 28. Insects often also have a large number of descendants and natural mutations can occur. Major population explosions can occur swiftly.

Chemical agents that do not function well allow for a great deal of survivors, and if poor administering also occurs,


Leafminer flies.


A healthy field.


Red mite.


Feeding punctures.

one can soon encounter big problems. Treatment such as diamides also control many different insects, and loopers can be sprayed as a target but at the same time expose whitefly and leafminer to the same chemistry. The treatment also has a long after-effect, and in case you spray with the same group every week, you are in fact selecting for the development of resistance.

The large-scale misuse of the diamide group of insecticides can result in considerable expenses for vegetable farmers in future. The responsible use of the diamide group of insect pest control products is key.

By misusing the diamide group of insect pest control agents, repeated use and poor administering thereof, resistance can be selected. Unfortunately, this is already a reality and we are experiencing problems in regions where pests such as leafminer are very poorly controlled or not at all. There are also no prospects for new treatments in future. There is also the possibility of cross resistance against second-generation diamides. These are active ingredients that have not yet been registered in our country, and which can bring problems with weaker-than-expected control as soon as it is indeed registered in future.


Stalk borer.

Administering chemical agents

Careful adherence to the guidelines on labels is of utmost importance. Not only is it a legal document but the specific dosage, method of administering, whether it is by foliar spray, administering by drippers or pivots or soil drenching have all been researched and confirmed in the developmental stages.

Substantial research goes into every product to make sure that it is the dosage that offers the best control and will also ensure that no residue problems will occur in the crop. The withholding period is also stated on the label and is linked to the registered dosage. By adhering to the label directions, alternating chemical agents and following an integrated management approach, long-term resistance can become a reality.

With overdosing, resistance is often selected for more swiftly, because the susceptible individuals in the population are soon exterminated by the treatment and those that survive mate with each other and multiply. The product will then no longer have the desired effect. With underdosing more individuals can survive and there is a larger pool of potential mates that can cause the colony to rapidly increase in numbers. Therefore, we potentially face tougher, hardy insects or a much larger uncontrolled group.

Adjacent crop plantings and time intervals for application must be carefully planned. It is extremely important to devise a plan in advance and to decide on spray programmes, especially for alternation between chemical agents to combat resistance. A major problem arises when adjacent fields are, for instance, planted every three weeks and then the same chemical agent is used with every planting. In case an agent such as diamide is used to treat the planting through drippers, Field 1's leafminer is exposed to the treatment for three generations because of the long after-effect of the product.

The adjacent Field 2 is then planted and in effect also receives treatment with a long residual action, as the flying insects easily move around. The chance that too many generations are exposed to the same chemical agent then continues to increase. IRAC suggests that window treatments are preferably carried out where, for instance, the entire farm is sprayed twice with a particular treatment, and then switching to a completely different chemical agent for two follow-up treatments and diamides then only sprayed at 60 days again.

It is vital to adhere to the label, dosage, spray intervals and registered method of application. Alternating between extermination methods and chemical groups is essential. Planning in advance instead of combatting the problem after it occurs is also advisable. A producer knows his farm and its history and there are no miracle cures or quick fixes. Lending your ears to so-called experts who deviate from the instructions provided on product labels can be dangerous. Such advice may initially work but have detrimental consequences in the long run. Acting responsibly is key.

Producers should prepare meticulous and well-planned annual insect pest management programmes. In case plans are devised in advance and a programme is drawn up, the farmer has options. We need to learn from others' mistakes and from solutions that are followed elsewhere in the world.

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