

8. New technology helps horticulturalists in sustainable management of land & water

When horticulturalists set out to buy a pesticide they usually think about two things – ‘how effective is it?’ and ‘what does it cost?’ Now thanks to the *GROWSAFE[®] Calculator* they can also assess its environmental impact – tailored for their production unit.

Pesticides are important tools used to grow high quality fruit and vegetables, but when sprayed onto crops they suffer several fates. They may degrade into harmless chemicals, volatilise into the atmosphere, runoff to surface water, accumulate in the soil, and leach into the groundwater. The actual fate of the chemical will depend on its properties, but the fate is also determined by the crop cover, climate and soil characteristics, and the amount and timing of the applications.

When pesticides attach to soil particles and accumulate in the soil, then soil biological activity and fertility may decline. This fate is a special concern for permanent crops where the same chemicals may be applied every year. Those pesticides which do not attach strongly to soil particles but which have longer half lives are likely to move with any water draining below the crop and eventually into the groundwater.

Horticultural managers need a decision support tool that will help them determine which pesticides are best suited to their crops, without downgrading the soil and water environment. Other criteria such as price, efficacy and food safety must be factored into the purchase decision and choice of agrichemicals to use on their properties.

The development of the *GROWSAFE[®] Calculator* involved a partnership of science, industry and regional authorities working together over a two year period. This innovative decision support tool (DST) integrates our science knowledge of:

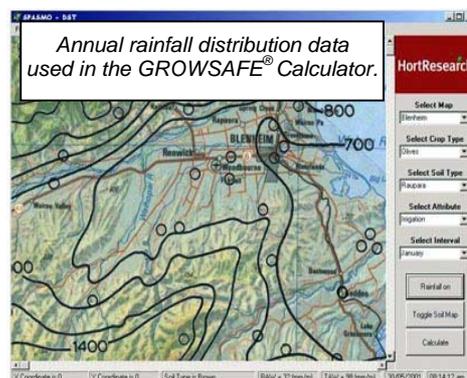
- how water moves into and out of the root zones of crops, and how it is stored within the soils and used by plants,
- the properties of the key soil groups and the long-term climate information for the region,
- the properties of the chemical pesticides that are available to horticultural managers for application to their crops.

This information was integrated with information about the spray practices used by the various horticultural sectors and predicts what residual impact and leaching risk a particular pesticide will have for a particular crop grown in a particular region on a particular soil type.

The Calculator covers 34 crop types and ranks all pesticides available in New Zealand for their environmental friendliness across 13 regional authorities. The model handles more than 28,000 combinations of crop, region, soil type and agrichemicals. The *GROWSAFE[®] Calculator* is available free on CD to all growers and regulatory authorities.

Global customers for New Zealand’s fresh and processed fruit and vegetables need assurance that all food products are safe for human consumption. However, there is also a growing interest among the global consumers in ensuring that food production systems used by producers, both in their home country and New Zealand, are sustainable. The *GROWSAFE[®] Calculator* is a valuable tool to assist horticultural producers in making management decisions which minimise the impact of pesticides on the environment.

This is proving to be a valuable tool for the Regional Councils and other regulatory authorities within New Zealand who need to determine whether current horticultural practices are sustainable, especially with regards to the long-term health of the soil and water.



1. Background

During the past decade a number of drivers have emerged that have focused the attention of fruit, vegetable and flower producers on the need to develop production systems that do not impact on the soil and water environment. These drivers have the potential to make a significant economic impact on the horticulture sector.

Supermarkets within New Zealand's export markets require that both imported and locally produced food is safe. Their customers also have a growing interest in ensuring that the horticultural food production systems used by the growers are sustainable.

¹EUREPGAP® - The global Partnership for Safe and Sustainable Agriculture requires that producers use Environmental Protection Good Agricultural Practices, which are designed to minimise any negative impacts of Agricultural (and Horticultural) Production on the environment. "Demonstrated need....." is key plank in the EUREPGAP® requirements when considering inputs to the production system. The EUREPGAP® producer checklist asks two questions with regard to the impact of farming on the environment:

1. Does the farmer (grower) understand and assess the impact his/her farming activities have on the environment?
2. Has the farmer (grower) considered how he/she can enhance the environment for the benefit of the local community and flora and fauna?

Regulatory authorities within New Zealand need decision support tools to determine whether current horticultural practices are sustainable, especially with regards to the long term health of the soil and water. In general, New Zealand's surface and ground water resources are currently still of high quality, but they are coming under pressure. Decision support tools that help land managers to adopt best practice in using agrichemicals will be an invaluable resource in maintaining soil and water quality. There are regions in other countries where the use of pesticides has already reached an unsustainable level and pioneering science is required to protect the soil and water from further contamination, and remediate current contamination.

Horticultural managers require the decision support tools that enable them to consider the environmental impact of agrichemicals along with price, efficacy and food safety when choosing which chemicals to use on their properties.

The initial development of the *GROWSAFE® Calculator* has been underpinned by science studies of water storage and flow within and through soils; of water use by annual crops, as well as individual trees and vines; and the chemistry and behaviour of the pesticides used within horticultural production systems. These studies were carried out in New Zealand during the 1970s and 1980s and provide a quality knowledge base that to be applied to the development of the calculator. The expertise and innovation of these scientists is internationally recognised.

The development of decision support tools that could be used by growers to improve pesticide choice and develop sustainable spray practices began under a Sustainable Management Fund (SMF) project in 1998. The project was supported by the Ministry for the Environment (SMF), Marlborough and Tasman District Councils, Hawkes Bay and Canterbury Regional Councils and Montana Wines. The outcome was the "Guidelines for the Sustainable Application of Agrichemicals" produced in 2000 which incorporated two knowledge-based decision support tools:

PESTPROP – a database which contains the chemical properties of the range of pesticides used in New Zealand horticulture and the active ingredients of each

¹ EUREPGAP® - Euro-Retailer Produce Working Group. This is an equal partnership of agricultural producers and their retail customers, whose mission is to develop widely accepted standards and procedures for the global certification of good agricultural practices (GAP). Enza, Pipfruit Growers and Zespri International Ltd. are supplier members. Agriquality is an associate member.

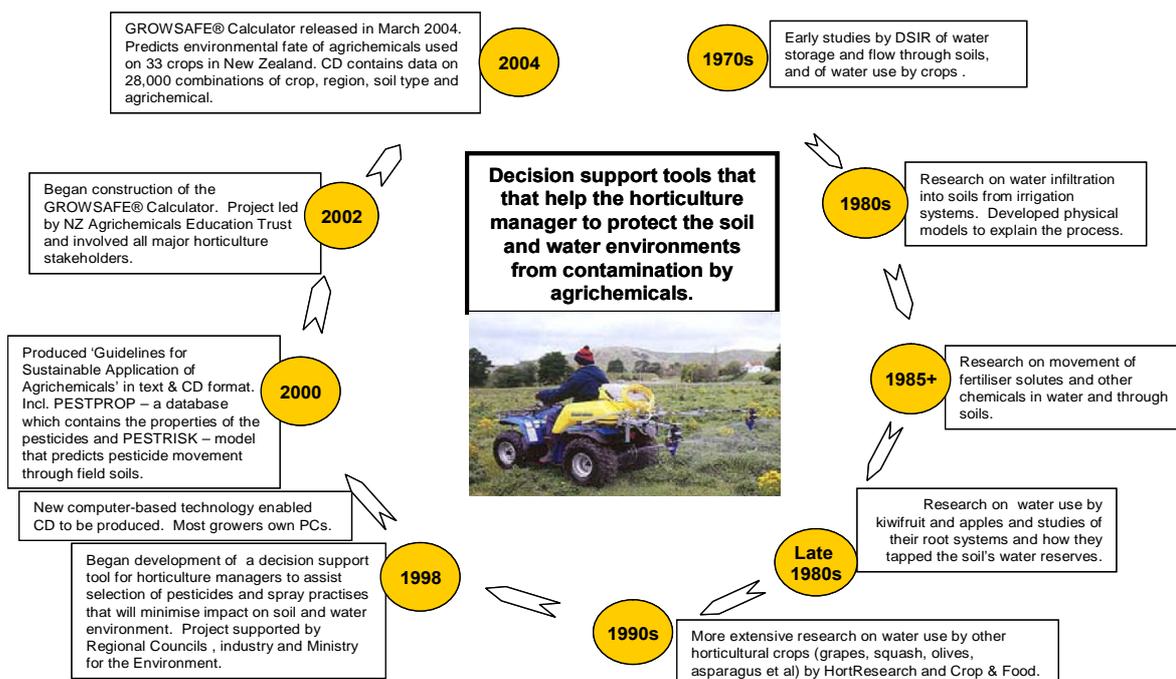
registered product. The model is able to predict the vulnerability of groundwater to the various pesticides. PESTRISK – a scientific model that predicts pesticide movement through field soils and is able to assess the risk in more detail. PESTRISK takes account of soil layers, ‘fast’ and ‘slow’ pathways of flow for the pesticide in the soil, the exchange of pesticide with soil organic carbon, and the degradation of pesticide with time.

Next step by HortResearch was to develop a comprehensive Soil-Plant-Atmosphere-System-Model (SPASMO) which describes the movement of water through horticultural (and agricultural) production systems. The core of SPASMO is a daily water balance using crop characteristics and daily weather to calculate crop growth and water use, runoff and drainage of water from the system, and leaching of any chemicals that move with the drainage water. HortResearch has used SPASMO in several risk assessment projects involving water resources and agrichemicals, with several Regional Councils.

In 2001 several leading winegrowers in Hawkes Bay recognised the need to protect the special Gimblett Gravels as a sustainable locality for the production of quality wines. This was the trigger for industry to look for decision support tools that would help all land managers to maintain the quality of the water and soils on which their production systems were dependent. Working in partnership, industry and science determined that the science knowledge and resources were available with which to construct a decision support tool that could be used by growers to make informed environmental decisions about the agrichemicals that they use. The work was led by the NZ Agrichemical Education Trust - GROWSAFE® and involved all the major horticulture sectors.

The GROWSAFE® Calculator was released in March 2004. It is a unique decision support tool on the international scene. The CD predicts how agrichemicals will leach or accumulate in the soil, thereby providing a tool that enables managers to make informed decisions about their choice of agrichemicals, as well as providing information to regulatory authorities.

2. Timeline



3. Science and innovation features:

The GROWSAFE® Calculator is an innovative decision support tool that predicts the long term fate of agrichemicals commonly used in horticultural production systems. The development of the calculator is firmly based on our current science knowledge of:

- how water moves into and out of the root zones of crops, and how it is stored within the soils and used by plants,
- the properties of the key soil groups and the long term climate information within the region,
- the properties of the chemical pesticides available to New Zealand horticultural managers for use on their crops.

This knowledge was developed over the preceding 20 years. It would have been impossible to develop the calculator within this timeframe from a 'cold' start.

The calculator uses information about the spray practices employed by the various horticultural sectors. These data were gathered from the spray diaries of growers and supplemented by the knowledge of horticultural consultants.

The calculator is available on CD free of charge to all growers and regulators. Recent advances in information technology enabled the production of this CD-based tool. The calculator covers 34 crop types and ranks all pesticides available in New Zealand for their environmental friendliness and handles more than 28,000 combinations of crop, region, soil type and agrichemicals. We understand that the GROWSAFE® Calculator is a unique tool on the international scene, which is not surprising in that the underpinning science meets or exceeds best international practice.

A further innovation was the participatory learning and action (PLA) process used in the development of the GROWSAFE® Calculator, which involved stakeholders, science, industry and end users. The PLA process is particularly appropriate for the development of decision support tools to be used in sustainable production systems and is to be preferred over traditional technology transfer methods, because the process encourages ownership of these outcomes by those who will be responsible for their implementation.

4. Benefits

The GROWSAFE® Calculator can realise the following environmental and economic benefits:

- Growers are able to access information that will enable them to choose environmentally friendly agrichemicals for pest control. Environmental information can be integrated into their decisions about price, efficacy and food safety.
- Exporters have information that can be used to convince purchasers that sustainable production systems are being used to produce New Zealand horticultural export products.
- New Zealand regulatory authorities will have a scientific basis on which to determine environmental standards.
- The calculator shows that current viticultural practices have very low environmental risk. The management tool is to be incorporated into the Sustainable Winegrowing NZ programmes. These tools will enable grape growing to still be as environmentally sound and productive in 100 years as it is today.

- The calculator shows that current kiwifruit cultural practices have very low risk. The tool provides an assessment of the environmental impact of conventional agrichemical practices which are used in kiwifruit orchards.
- The calculator shows that most of New Zealand's horticultural crops have very low environmental risk. However, the use of this decision support tool will help to ensure that this situation continues, and improves as new chemicals and technologies, such as integrated fruit production come on stream. This is a modular system that can be easily updated to take account of new chemicals. The tool will be particularly useful to those managers who operate in the uncommon field situations which the environmental risks from pesticide use could be higher.

5. Quotes

"The wine industry has a very long term view on the environmental aspects of their high quality sites. These sites are important to us, and the last thing we want to do is stuff them up through poor management. In 100 years we want grape growing to still be as environmentally sound and productive as it is today. We have ended up with a very good environmental early warning system for soil and water. The model (GROWSAFE[®] Calculator) has showed us our current practices were already low risk."

Alan Limmer, grape grower and winemaker, Stonecroft Wines, Hastings.

"I have been checking it out for grower friendliness, and it's very simple to use. The amount of science and data behind the CD (GROWSAFE[®] Calculator) is incredible, I don't think anyone can argue with it. And anyone involved with the Resource Management Act and local authority plans and planning will find it useful."

Tony Ivceovich, tomato grower, chairman Fresh Tomato Sector, Veg Fed, Auckland.

"It gives the growers the ability to juggle their agrichemicals and know the chemicals will not have a negative environmental impact. As an industry we can show our growers are using sustainable production methods.....the industry came out of GROWSAFE[®] Calculator project 'pretty squeaky clean'....."

Stuart Kay, Zespri Innovation Company Ltd., Mt Maunganui.

"No single factor will be more critical to the future of the apple industry than the availability of irrigation water. Reliable irrigation is crucial to maintaining productivity and product quality.the fruit industry's own water practices must be above reproach. It must be able to demonstrate that it employs the best monitoring and control technology to assure that it uses the minimum water necessary."

World Apple Review – 2004.

6. Return on R&D investment

The return on investment was not assessed because there is a significant difficulty in obtaining a single causal relationship between the use of the GROWSAFE[®] Calculator and the sustainability of the soil and water environment where the horticultural crops are grown. Too many other factors have an impact on the sustainability of the soil and water resources. Also results will become apparent over a timeframe that is measured in years not months. However, the cost of failure through undesirable pesticides being detected in the soil and water environment could be serious and would damage the "Riches from a clean, green land" label which New Zealand promotes as a vital ingredient of its food production systems. "You can only lose your virginity once!"

Key information on the GROWSAFE[®] Calculator:

The financial support for the development of the GROWSAFE[®] Calculator was provided by the MAF Sustainable Farming Fund, Marlborough District Council, Tasman

District Council, Hawkes Bay Regional Council, Wellington Regional Council, Environment Waikato, Horizons MW Regional Council and Environment Bay of Plenty.

- The objective was to construct a decision support tool that will provide environmental protection to the soil as well as the surface runoff and groundwater. The model has been designed to fulfil the present EUREP-GAP requirements and market entry protocols.
- The calculator uses historical (30 year averages) climate information supplied by NIWA (at no charge) and regional soils data supplied by Landcare (at no charge).
- Information about spray practices was collated using spray diaries supplied by various horticultural sectors and augmented where necessary by consultation with key growers.
- Chemical properties were required for accurate simulation modelling of the leaching of these chemicals as well as their accumulation within the soil. Data were compiled from several USA sources and agrichemical companies.
- The GROWSAFE[®] Calculator assists managers to use pesticide best-practices in horticulture. These tools will enable managers to select pesticides and develop sustainable spray practices which will reduce the risk of horticultural production systems impacting on soil and water. These tools have also been used by regional authorities to assist the allocation of water resources for irrigating horticultural crops.
- The science models (e.g. SPASMO) developed for use within horticulture, have been found to have an immediate application to agricultural production systems.

7. Related activities:

Monitoring of nitrates on a dairy farm: The Hawkes Bay Regional Council sought an explanation of the recent trends in groundwater quality in relation to dairy farming. The study was undertaken on the Ruataniwha Plains where horticulture and intensive dairying is increasing and the unconfined aquifer is vulnerable to contamination. The SPASMO model was used to calculate the leaching loss of nitrate-nitrogen.

Crop water requirements for the Auckland region: In issuing annual water-right allocations the Auckland Regional Council used as a guide for orchards of 2.5 mm/day for 60 days; for market gardens 3.5 mm/day for 60 days and for greenhouses between 4 – 10 mm/day. However, the ARC noted that the measured usage did not match the allocation guidelines. HortResearch used a soil-plant-atmosphere system model to estimate the water requirements of the crops grown in the region and amendments to the guidelines were proposed.

The water demand of spaced out grapes: Marlborough is the largest grape growing area in New Zealand and vineyards are expanding rapidly. This expansion is a placing pressure on the water resources needed to irrigate these high value crops. There is a need to know how much water these crops require. The measurements and modelling approaches to water crop use undertaken by HortResearch have provided the information needed by the Marlborough District Council to use as a basis for their water allocation decisions.

8. Information sources:

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- "SPASMO-DST: A map-based decision support tool to aid irrigation allocation." July 2001. Chris Veale, Steve Green, Brent Clothier, Marc Greven, Sue Neal (HortResearch); Bartolo Dichio (University of Basilicata, Potenza, Italy); Peter Davidson and Helen Woodward (Marlborough District Council). WISPAS No. 79. Published by HortResearch.
- "Guidelines for the Sustainable Application of Agrichemicals". CD released to growers in 2000. Version 1.1.
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- EUREPGAP[®] - Euro-Retailer Produce Working Group. www.eurep.org
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This case study is one of a 21-part case study series aimed at demonstrating the value of science and innovation in New Zealand's leading edge bio-science industries... and their significance to New Zealand.

Martech Consulting Group is a strategic consultancy based in New Zealand. The growingfutures case study series was in part based upon Martech's extensive work with sector representative groups, science providers and organisations that interact with science providers to achieve consensus on co-ordinated actions, improve governance, develop sector-based strategies and improve innovation processes.

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