An Australian Approach to chemical residue management in grains – Programs and results

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Abstract

The National Residue Survey (NRS) is an operational unit of the Australian Government Department of Agriculture, Fisheries and Forestry. NRS has managed and operated residue testing programs (including meat products and grains) for over 40 years.

The NRS Grains Residue Testing Program is fully industry funded via a 0.015 % ad valorem levy on grain growers. This Residue Testing Program complements that undertaken by grain marketers / handlers from grower receivals to bulk storage. Noting that NRS does not have a regulatory role, the Grains Program is viewed as providing independent verification of the residue status of Australian grain at the point of out-turn for export and for receival at grain processors such as flour mills.

The Grains Program covers wheat, barley, oat, sorghum, canola, field pea, chickpea and lupin. By 2007, it is expected to extend to all tradeable grains including lentil, soybean, maize, triticale, sunflower, mung bean and faba / broad bean.

Each year, the Grains Program is independently reviewed and a prospective monitoring plan circulated to the Grains Council of Australia and State affiliates, and peak grain industry bodies for endorsement.

The Grains Program monitoring plan specifies that approximately 5,500 grain samples are collected per annum from export shipments and containers, flour mills, feedmills, feedlots and maltsters. About 4,000 samples are collected from export shipments where every hatch of every ship from every Australian grain export terminal is sampled during loading.

The monitoring plan stipulates that samples be sent to an accredited proficiency-tested laboratory and residue testing results reported to the grain marketer / handler within 14 days of sample collection. Grain samples are subjected to a chemical screen covering a range of insecticides, fungicides and environmental contaminants. These residue testing results are reported against Australian MRLs established by Food Standards Australia and New Zealand.

Key words: Australia, government, grain, pesticides, residue management, residue testing.

Introduction

Agricultural chemicals (pesticides) are used in Australia as an essential tool in broadacre farming. Pesticides can be used during crop production from seeding through to post-harvest protection from stored grain pests, to maximise production and improve productivity through weed, insect and disease control.

The gross value of Australia’s annual farm...
production now exceeds $30 billion, as primary producers have the option of using pesticides to protect their crops from pests and disease.

These chemicals are registered for use by the Australian Pesticides and Veterinary Medicines Authority (APVMA) which takes into account the potential risks from the incorrect use of pesticides. Accordingly, Australian governments have, for many years, had a key role in the regulation of pesticides to ensure they work as claimed and are safe to humans, targeted animals and plants, and the general environment.

The APVMA has responsibility to ensure that agvet chemical products registered for use in Australia are suitably formulated and properly labelled and, when used according to instructions, are:

- safe to the host, the user, consumers and the environment;
- efficacious (that is, the product does the job it claims it shall do); and
- not unduly prejudicial to trade.

Registration helps to ensure that unacceptable residues from the chemicals used in agriculture do not appear in food for human or animal consumption in Australia or in Australia’s export markets.

As part of the registration process, APVMA recommends maximum residue limits (MRLs). MRLs reflect the maximum residues of agvet chemicals that may occur in foods when registered chemicals are used in accordance with Good Agricultural Practice (GAP). GAP is defined as the nationally recommended, authorised or registered use-pattern of chemicals, that is necessary for effective and reliable pest control under actual conditions at any stage of the production, storage, transport, distribution and processing of food commodities and animal feed. Further information can be obtained at www.apvma.gov.au.

MRLs are not health standards per se, however they are assessed against health standards, to ensure that foods containing residues at the MRL are fit for human consumption. These considerations apply to the current methodology used to set Australian MRLs, MRLs of other countries and the setting of Codex MRLs.

The specific pesticides registered for use in each country and GAP for the use of those chemicals vary from country to country. These differences reflect variation in the diseases and agricultural pests present in different countries and their significance in food production. Differences in the nature of agricultural business, geography and environmental considerations also affect GAP and the actual chemicals approved for use in food production.

Therefore, variances in MRL values for particular chemical-commodity combinations from country to country can be expected and commodity exporters need to be aware of those differences.

The key objective of Australia’s residue testing programs is to audit the effectiveness of the controls that are in place to ensure that agricultural chemicals are used according to GAP. This provides assurance to agricultural industries that farming practices are appropriate and that chemical residues in sampled agricultural produce do not pose a threat to human health and to trade. Moreover, the agricultural sector is becoming increasingly aware of overseas MRLs and overseas marketing requirements when considering pesticide use in crops and in post-harvest situations.

Given the high importance placed on food safety and market access, many agricultural industry sectors and government agencies conduct residue testing programs to verify the pesticide residue integrity of Australian agricultural produce from farm receival to point of export.

**Pesticide residue management in Australia grain**

The responsibility, in regard to pesticide residue matters in grain, is shared between the Commonwealth and State governments and the grain industry.

The Commonwealth government’s responsibilities
cover registration of agricultural chemicals, establishment of MRLs and the inspection and certification requirements for export. State government agencies are responsible for the control-of-use of agricultural chemicals and the inspection and certification requirements for the domestic market.

Grain marketers and bulk handling companies within Australia conduct rigorous testing from the first point of farm receiveal through grain aggregation into bulk storage facilities monitoring all grain quality parameters including pesticide residues.

Although the NRS Grains Residue Testing Program has been operating for over 40 years, it is only since 1993 that the program has been considered the primary residue testing program for Australian grain.

The NRS is a government agency, located in Canberra within the Australian Government Department of Agriculture, Fisheries and Forestry. Since 1993, the NRS has operated on the basis of full cost recovery. An agricultural industry may elect to fund a residue testing program due to a mandatory requirement for market access (in the case of meat) or because an industry makes a commercial decision to do so.

In 1993, the Grains Council of Australia (GCA), in full consultation with the grain industry, elected to establish an ad valorem grain grower levy to fund the operation of the NRS Grains Residue Testing Program. The grain industry requested that the program be operated primarily as a market access project focussed on collecting grain samples at the point of export and at the point of domestic receiveal for processing. For further information about GCA, see www.grainscouncil.com/. In addition to grains, the NRS manages residue testing programs for meat, horticulture, eggs, honey and fish commodities.

The grains pesticide residue testing program

The NRS Grains Program is designed to provide an unbiased estimate of the frequency of residues in Australian grain as a whole. The program requires randomised sampling of grain from as many grain streams throughout Australia as is possible. The NRS Grains Program consists of the following sub-programs:

- **Bulk Export:** All 18 grain exports terminals with a representative grain sample collected from every hatch loaded on every ship leaving Australia.
- **Export Container:** Representative grain samples collected whilst grain is loaded into bags and shipping containers destined for export.
- **Domestic - Milled Products:** Samples of wheat and corresponding flour and bran fractions are collected.
- **Domestic - Feed mills:** Samples of grain are collected during delivery of grain to feed-mill sites for processing into stockfeed.
- **Domestic - Maltsters:** Samples of barley are collected during delivery to malting barley plants.
- **Domestic - Feedlots:** Grain samples are collected during delivery of grain to cattle feedlots.
- **Domestic - Oat Processors:** Samples of oat are collected during delivery to processing plants.
- **Domestic - Oilseed Crushers:** Samples of canola are collected during delivery to crushing plants.

The NRS utilises a scientific and statistical risk-based approach to residue testing programs which takes account of Codex Alimentarius Commission sampling guidelines.

Each grain commodity sample, whether it be wheat, barley, oat, sorghum, canola, chickpea, field pea or lupin, is subjected to the same analytical program which is based on a risk profile that considers the following criteria:

- all agricultural chemicals registered for use in Australia and all known potential environmental contaminants;
- known use patterns including timing of application in the growing season and repeat applications;
- potential for residues in grain commodities
and perceived risks to international trade and overseas market concerns; and
- availability of suitable analytical methods, testing capacity and laboratory testing proficiency arrangements;
- For the period 2006-2008, the contract laboratory will subject each grain to the following analytical screen:
  - Organophosphates: azamethiphos, chlorpyrifos, chlorpyrifos-methyl, diazinon, dichlorvos, dimethoate, ethoprophos, fenitrothion, malathion, omethoate, pirimiphos-methyl, profenofos, phosmet, terbufos, trichlorfon
  - Other insecticides: bioresmethrin, bifenthrin, carbaryl, cyhalothrin, cyfluthrin, cypermethrin, deltamethrin, endosulfan, fenvalerate, fipronil, indoxacarb, methoprene, permethrin, phenothrin, piperonyl butoxide, triflumuron
  - Fungicides: flutriafol, hexaconazole, iprodione, propiconazole, penconazole, tebuconazole, triadimefon, triadimenol
  - Organochlorine contaminants: aldrin, chlordane, DDT and metabolites, dieldrin, endrin, HCB, HCH, heptachlor, lindane, PCBs.
  - Approximately 500 export grain samples will be subjected to a heavy metal screen covering cadmium, lead and mercury, while 100 samples will receive a phosphine test.
  - An additional herbicide screen will be established in 2006-07 to monitor herbicide residues in bulk and container export grain. The herbicides to be considered are as follows: 2,4-D, fenoxaprop, carfentrazone-ethyl, chlor sulfuron, MCPA, metosulam, clodinafop-propargyl, glyphosate, dicamba, clethodim, metsulfuron-methyl, tralkoxydim, diuron, haloxyfop, flamprop-M-methyl, triasulfuron, diquat, picloram, diclofop-methyl, glufosinate, triclopyr, paraquat, iodosulfuron-methyl-sodium, metolachlor, atrazine, clopyralid, fluazipof-P, diflufenican, simazine, trifluralin and pendimethalin.

The bulk export program

Grain is exported in bulk by four major handling /marketing organisations from 18 export terminals located around Australia.

The bulk export program accounts for at least 75 percent of the NRS Grains Program with an average of 3,500 grain samples collected per annum.

At each of the eighteen export grain terminals, NRS samples are collected using automated sampling equipment which allow composite samples of grain to be collected for every shipping hatch loaded with grain. Most terminals sample grain from the loading belt at an average rate of 1 kilogram per 300 tonnes out-turned.

A composite grain sample is taken from every hatch ‘sample bucket’ and placed in a NRS 750 mL jar with a tamper proof lid. The accredited sampling staff complete the NRS sample form with details which include date, grain commodity, grain terminal, ship name, export destination, exporter’s name and bulk handling company name. Each sample has a unique sample number to ensure that the identity of the sample is maintained from sample collection to reporting of the results. The contract laboratory enters the result onto the NRS database where it is verified by NRS before dissemination to the grain marketer and handler.

NRS provides grain samplers with all necessary sampling equipment including consignment notes which ensure grain samples are transported as soon as possible, via a national courier service, to the NRS contract laboratory for pesticide residue analyses.

Analytical laboratory proficiency

Pesticide residue and environmental contaminant analyses for the NRS Grains Program can be undertaken by private and government laboratories under contract with the NRS. Every two years, contract laboratories are selected from invited tenders through rigorous and structured evaluation processes.

NRS awards two year contracts to analytical laboratories on the basis of:
- Performance in a pre-requisite NRS
proficiency testing program;
- Assessment of laboratory management, quality assurance and control systems;
- National Association of Testing Authority accreditation for the relevant analytical test;
- Previous performance; and
- Value for money

The NRS laboratory performance evaluation activities are designed to maintain an up-to-date and continuing assessment of the proficiency of laboratories analysing samples for NRS.

In simple terms, proficiency testing involves sending verified residue-free grain samples, which have been spiked with known concentrations of pesticides, to analytical laboratories which have indicated interest in tendering for the NRS Grains Program laboratory contract. Analytical laboratories must demonstrate the capacity to identify and quantify all spiked pesticides in accordance with NRS performance standards.

Ongoing proficiency of contract laboratories is closely monitored by NRS through a structured quality assurance program that includes regular proficiency tests, random data and on-site facility audits and the use of ‘blind’ samples. Blind samples contain spiked residues and are indistinguishable from normal grain samples. These blind samples are sent to contract laboratories through the routine courier system in place for normal grain samples. Laboratories are also required to establish and maintain a monthly intra-laboratory check sample program for each NRS contract they hold. This intra-laboratory program is closely monitored by NRS to ensure it meets NRS requirements.

Failure to meet the required standard in analytical performance during a contract period can result in the termination of a laboratory contract.

Program review

From the commencement of the NRS Grains Program in 1994, a private and independent consultant has been engaged to conduct bi-annual reviews of the program. The consultant is required to contact all participants in the NRS Grains Program along with all known peak industry bodies to establish respective levels of satisfaction with the program and to accept industry proposals for improvements, modifications and other suggestions including additions to the pesticide analytical screen.

The outcomes of each review are reported to the NRS and forwarded to the Grains Council of Australia for information. NRS then undertakes to address concerns raised in the review process and report back to industry.

Reports

The NRS is bound by Australian privacy legislation which stipulates that detailed specific residue testing data must only be disseminated to the grain marketer and the grain handler. In some cases, the data can be forwarded to other government officials outside of the NRS.

By agreement with the grain industry, NRS is required to provide detailed specific residue testing result sheets within 14 days of an export sample being collected. This timeframe takes into account sample courier from grain establishment to the contract laboratory and a laboratory turn-around time of 5 days. Compliance with the 14 day turn-around times are closely monitored and appropriate corrective action taken where compliance falls below 90 percent.

The NRS Grains Program publishes a series of general results reports each financial year for each of the subprograms.

Each year, the NRS published its Annual Report which covers all residue testing program managed by NRS. These Annual Reports are available on the NRS website (www.daff.gov.au/nrs).

Quality assurance and traceback investigations

When a pesticide residue is detected in a grain
sample that is above an Australian standard (MRL), the contract laboratory immediately notifies NRS. Under NRS-laboratory contract arrangements, the contract laboratory is required to retest the grain sample to confirm the first result. After confirmation, the relevant Australian state or territory government and the grain owner/handler and marketer are notified of the residue violation.

Should the need arise, the NRS Grains Program includes a traceback investigation function which allows government officers, in cooperation with the particular grain company, to conduct an examination of any residue detection in grain over the MRL.

The investigators trace the grain sample back through grain handler to the property of origin to determine the cause of the residue violation.

Subsequent actions are in accordance with relevant state and territory government authority legislation and depend on both the chemical detected and the commodity in which it is found. Action can vary from simple advice to the company in the case of a minor problem to legal action where the residue violation has resulted from gross misuse of an agricultural chemical.

NRS is provided with report of the traceback investigation and general details are provided in annual reports to industry.

Results

As shown in Table 1, 4,213 grains samples were collected for analyses during the 2005-2006 financial year from throughout Australia as part of export and domestic residue testing programs.

<table>
<thead>
<tr>
<th>Program</th>
<th>Sample</th>
<th>Sample &gt; MRL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk export</td>
<td>2,953</td>
<td>0</td>
</tr>
<tr>
<td>Container export</td>
<td>90</td>
<td>0</td>
</tr>
<tr>
<td>Domestic</td>
<td>750</td>
<td>2</td>
</tr>
<tr>
<td>Flour mills</td>
<td>420</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>4,213</td>
<td>4</td>
</tr>
</tbody>
</table>

There were no residues detected above the Australian MRL in any export samples and 4 grain samples containing violative residues in the domestic programs. This represents a compliance rate of 99.9 percent.

There has been a progressive decline in the frequency of violative residues detected in Australian grain exported in bulk shipments as shown in Table 2.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sample</th>
<th>Sample &gt; MRL</th>
<th>Compliance %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996-97</td>
<td>5,746</td>
<td>22</td>
<td>99.6%</td>
</tr>
<tr>
<td>1997-98</td>
<td>4,420</td>
<td>20</td>
<td>99.5%</td>
</tr>
<tr>
<td>1998-99</td>
<td>4,972</td>
<td>6</td>
<td>99.9%</td>
</tr>
<tr>
<td>1999-00</td>
<td>4,758</td>
<td>13</td>
<td>99.8%</td>
</tr>
<tr>
<td>2000-01</td>
<td>4,559</td>
<td>2</td>
<td>99.9%</td>
</tr>
<tr>
<td>2001-02</td>
<td>4,436</td>
<td>0</td>
<td>100.0%</td>
</tr>
<tr>
<td>2002-03</td>
<td>3,233</td>
<td>0</td>
<td>100.0%</td>
</tr>
<tr>
<td>2003-04</td>
<td>3,822</td>
<td>0</td>
<td>100.0%</td>
</tr>
<tr>
<td>2004-05</td>
<td>3,659</td>
<td>2</td>
<td>99.9%</td>
</tr>
<tr>
<td>2005-06</td>
<td>2,953</td>
<td>0</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

The sharp decline in sample numbers from 2002-03 is the result of a change to sample collection requirements from a minimum of four samples per bulk shipment to the current one grain sample per loaded shipping hatch.

In the last 10 years, the compliance rate has been above 99.5 percent and in four of the last five years at 100 percent compliance.

These figures provide sound evidence of pesticide use in-crop and post-harvest applications being in accordance with GAP as specified on the agricultural chemical product label and instructions for use.

Moreover, the frequency of residue detections in grain analysed for pesticide residues has also declined over the last 10 years. In the year 2005-2006, 85.1 percent of bulk export grain samples were found to contain no residues.

In regard to residue detections, the frequency for each grain is shown in Table 3. The data
illustrates that all Australia grain exported in bulk contained residues below half the Australian MRL. In fact, 99 percent of all grain exported contained less than one fifth the relevant MRL.

The limit of reporting (LOR) is a NRS derived limit based on international standards and laboratory capabilities. LOR is equivalent to limit of quantitation.

In regard to non-violative residues, the distribution over the range of residues levels in bulk export grain for the period 1996 – 2006 is shown in Table 4.

Over the 10 year period, the percentage of nil residues and low level detection (\(< 1/5^\text{th} \text{ MRL}\)) has steadily increased as the percentage of violative residues and residues above ½ MRL has decreased.

<table>
<thead>
<tr>
<th>Grain</th>
<th>Sample</th>
<th>Nil Residue</th>
<th>LOR – &lt;1/5(^{\text{th}}) MRL</th>
<th>1/5(^{\text{th}}) MRL to &lt; ½ MRL</th>
<th>½ MRL to MRL</th>
<th>&gt; MRL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>2,045</td>
<td>1,728</td>
<td>291</td>
<td>26</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Barley</td>
<td>638</td>
<td>532</td>
<td>103</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Oat</td>
<td>20</td>
<td>16</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sorghum</td>
<td>32</td>
<td>26</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Canola</td>
<td>135</td>
<td>126</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Field pea</td>
<td>23</td>
<td>23</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Chickpea</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Lupin</td>
<td>54</td>
<td>54</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>2,953</td>
<td>2,511</td>
<td>413</td>
<td>29</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Tighter marketing controls and improved grain storage facilities have contributed to this nation-wide trend towards residue-free exported grain.

A NRS Phosphine Residue Testing Program has been conducted since 2002 with no residues detected in the bulk export grain.

**Discussion**

The approach taken by the Australian grain industry to manage pesticide residues has evolved over the past 12 years and, with the consultative framework established between government and industry, enhancements to the NRS Grains Program are expected to continue.

The expansion of the NRS Grains Program to
include all tradeable grains and to cover all trading streams will continue to help raise the program’s profile both within Australia and with trading partners.

The grain industry has progressively become more involved in managing pesticide residue issues. Residue testing data provided by the NRS Grains Program has assisted with on-farm quality assurance programs and enabled industry to demonstrate long term improvements in agricultural chemical management.

The residue testing results derived from the NRS Grains Program and the integration of this information into market access and quality assurance initiatives gives strong guarantees that Australia’s grain contains very low and ever declining levels of pesticide residues.