
Healthy Plants
Safe Food
BASF
The Chemical Company

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EDITORIAL

Dear Reader,

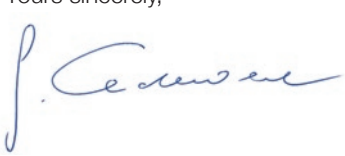
We all expect to eat healthy, safe food. However, many consumers continue to be concerned about pesticide residues in food and do not trust food safety regulations. This worry comes up repeatedly in our conversations with customers, environmental organizations and journalists.

For over 100 years, BASF has partnered with farmers to design sustainable solutions. Scientists agree that today's food system is safer than it was a generation ago but as an industry, we still struggle to fully address consumers' concerns.

Our goal is to contribute to a system of agriculture that is safe, sustainable, and innovative – one that creates value, addresses consumer concerns, embraces science and technology, and protects natural resources. Like you, we are passionate about food safety.

We are keen to hear your views. Your opinion matters and will help us to deliver better products and services.

Yours sincerely,



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SECTION 1

CONSUMER CONCERNS AND EXPECTATIONS

Over the last forty years, scientific advances have provided consumers with a wide range of affordable, high-quality food. However, the modernization of agriculture and food production has also raised new concerns amongst consumers.

While consumers in the developed world enjoy a huge variety of affordable food all year round, food spending continues to decline as a percentage of household income. However, a plentiful and affordable food supply cannot be taken for granted in the future. Volatile food security is top of the political agenda everywhere. According to the 2011 UN Global Hunger Report[1], food prices are likely to continue to fluctuate and most probably increase, making economically disadvantaged farmers, consumers, and countries more vulnerable to poverty and food insecurity.

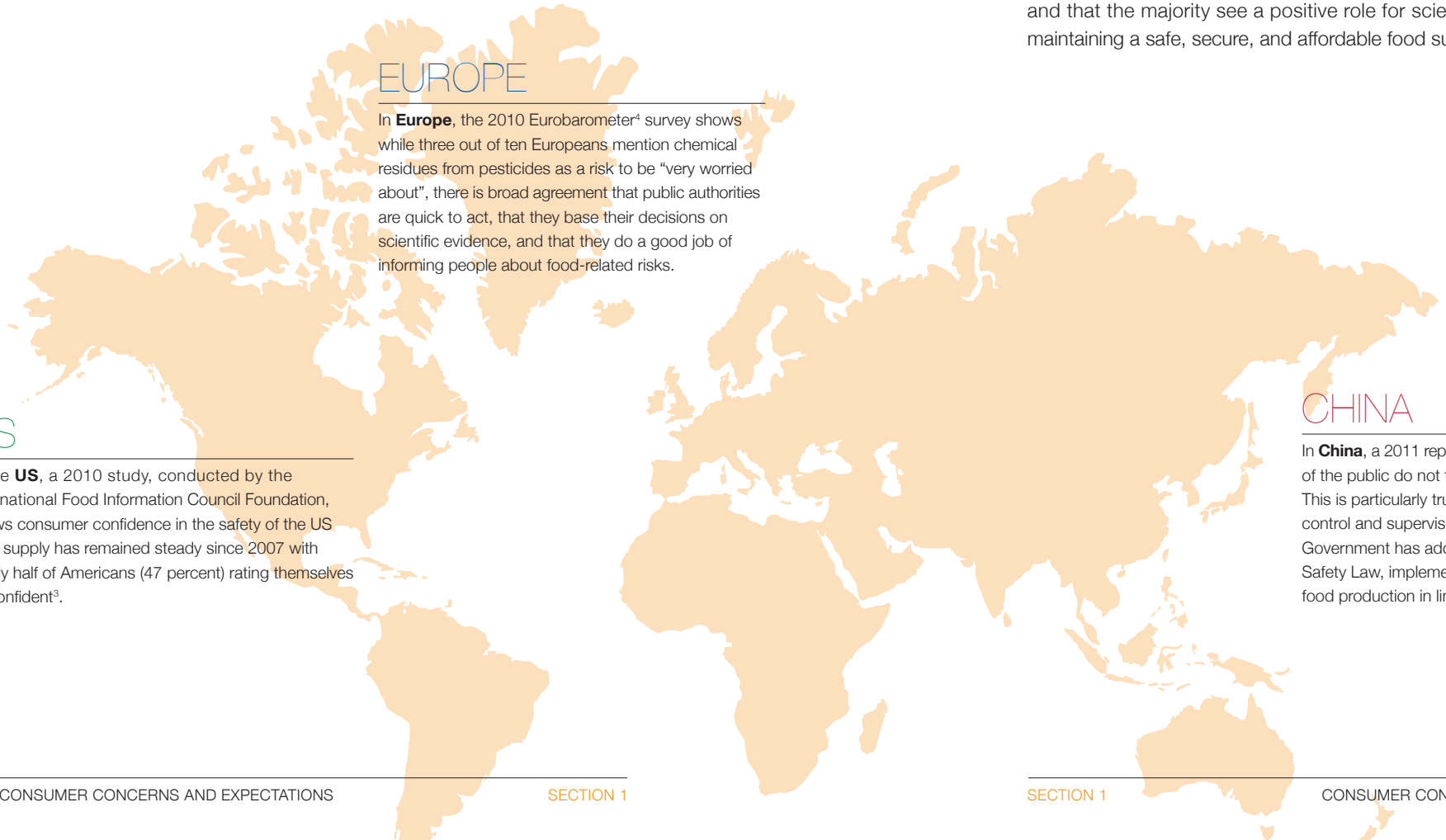
Today, the majority of consumers would like to have choice, quality, and low food prices but the intensification of modern farming, the use of pesticides, and the way food production has become industrialized are also major causes for concern.

BASF FARM PERSPECTIVES STUDY

As part of the BASF Farm Perspectives Study[2], more than 1,800 farmers and 6,000 consumers from across Brazil, India, France, Germany, Spain, and the US were interviewed. The study shows that the majority of consumers view farming as a vocation and have great respect for farmers and the work they do. However, they also recognize that there is a need to strengthen the environmental role that farmers play.

Globalization is yet another driver of change. We have an ever-increasing range of food products available, delivered from all corners of the world. However, while food can now be sourced anywhere, consumers also want to know how food is produced and what environmental and social standards have been applied.

All these developments have combined to alter consumers' perception of food safety and affect their overall confidence in public authorities. But perceptions also vary significantly, as illustrated by examples from the US, China, and Europe.



US

In the **US**, a 2010 study, conducted by the International Food Information Council Foundation, shows consumer confidence in the safety of the US food supply has remained steady since 2007 with nearly half of Americans (47 percent) rating themselves as confident[3].

EUROPE

In **Europe**, the 2010 Eurobarometer[4] survey shows while three out of ten Europeans mention chemical residues from pesticides as a risk to be "very worried about", there is broad agreement that public authorities are quick to act, that they base their decisions on scientific evidence, and that they do a good job of informing people about food-related risks.

Meanwhile, the greater availability and variety of food has been accompanied by an increase in consumer information and food labeling. Consumers are right to demand such transparency. Whilst this is a positive development, the industry still has some way to go. A 2011 study, carried out by the UK Department for Environment, Food and Rural Affairs[6], reveals that while people want to buy healthy, local food, they still find it confusing to know what products to select. Price remains the most important factor while other preferences do not always influence the ultimate buying decision.

At a broader level, consumers are also becoming more knowledgeable about food issues. Consumer research in the UK[7] shows that consumers are now more informed about the global factors affecting food prices and availability, and that the majority see a positive role for science and technology in maintaining a safe, secure, and affordable food supply.

CHINA

In **China**, a 2011 report showed that nearly 70 percent of the public do not feel confident about food safety[5]. This is particularly true in rural areas that lack real control and supervision. In response, the Chinese Government has adopted a comprehensive Food Safety Law, implementing hundreds of standards of food production in line with international norms.

SECTION 2

THE CHALLENGES FARMERS FACE

Fruit and vegetables thrive when they have sufficient sunlight and water. Unfortunately, so do pests and diseases. Farmers find it challenging to deliver high yields and at the same time meet the high standards of consumers and retailers.

Given consumer concerns, why do farmers still persist in using pesticides? We all know from personal experience that disease and pests can destroy a kitchen garden or home allotment. The same also holds true for those working in professional agriculture.

Crops must compete with 30,000 species of weeds, 3,000 species of nematodes and 10,000 species of plant-eating insects[8], all of which can seriously impact harvest yield. Weeds feature at the top of the list, depriving crops of nutrients, water, and light. Naturally occurring fungal diseases also threaten unprotected plants. These are not only capable of causing drastic harvest losses, but foodstuffs can also be contaminated by mycotoxins, highly toxic substances produced by the fungus itself.

BASF PHEROMONE DISPENSERS CONTROL PESTS

Larvae, associated with grape and apple moths, diminish the quality and yield of fruit and vines. Responding to this need, BASF designed special biological scent dispensers that control pests without any physical contact with the fruit. These emit sexual pheromones that stop mass propagation as the male insect becomes confused and is unable to locate the female.

Today, while many emerging countries still experience problems, major crop failures or famines in countries with well-developed agricultural sectors have thankfully been confined to history. However, farmers still lose 20 to 40 percent of their annual harvest due to competing weeds, pests, and plant diseases. Without crop protection, experts estimate that this figure would be twice as high with obvious consequences to the availability, quality, and price of food.

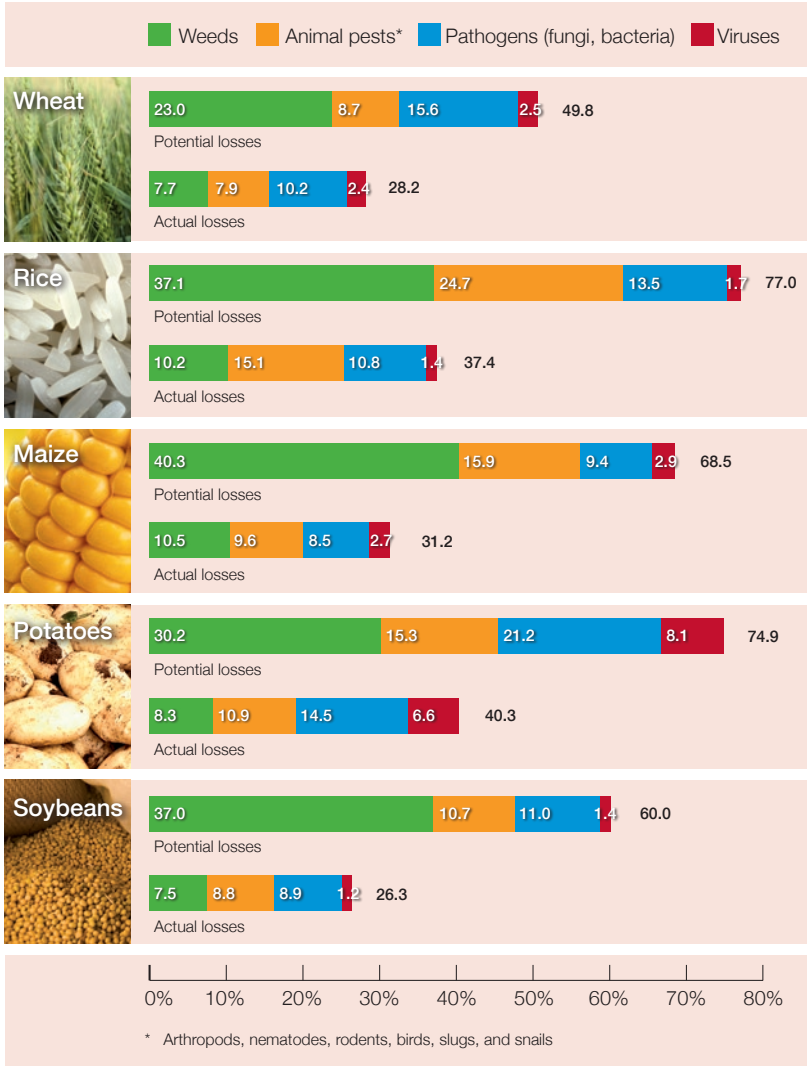
Of course, the ability to increase and secure yields using crop protection depends on local conditions. If a plant is already suffering from a lack of nutrients or water, the impact of crop protection is low. However, if plants enjoy favorable conditions, preventing weeds and pests through both chemical and non-chemical crop protection measures (for example, mechanical weeding) can have a significant and positive impact on both the health of the plant and on overall yields.

PESTICIDES OCCUR NATURALLY

The concept of pesticides actually comes from nature. Plants produce tens of thousands of different natural pesticides as a defense mechanism against pests and diseases. However, the very process of cultivation reduces this natural defense mechanism. For example, in the case of oilseed rape, natural pesticides cause a bitter taste, rendering the plant unsuitable for human consumption. Today, these bitter compounds have been significantly reduced through breeding with the result that the plant, while edible, is less effective in defending itself naturally. Synthetically produced pesticides protect plants from pests and disease and are often derived from natural substances.

CROP LOSSES WITH AND WITHOUT CROP PROTECTION

Potential losses: without crop protection
Actual losses: with the current use of crop protection



Source: Oerke, Dehne, 2005

SECTION 3

HEALTHY CROPS MEAN SAFE FOOD

Damaged or diseased crops are unable to benefit from fertilizer or water as the plant is limited in its ability to absorb nutrients. Pesticides – together with other crop protection measures – safeguard crops from pests and diseases, not only in the field as they grow but also during storage and transportation.

According to a study[9], carried out by the University of Piacenza, Università Cattolica del Sacro Cuore and Horta Srl.[10], pesticides play a critical role in the control of the *Fusarium* species of fungus which deposits mycotoxins on cereal crops. If these toxins entered the food chain, they would pose a serious risk to human and animal health.

BASF SPRAY PROGRAMS COMBINE CHEMISTRY AND BIOLOGY

Naturally occurring bacteria can help tackle a whole range of pests, especially those affecting our food crops. However, while biological fungicides alone cannot control infection rates adequately, chemical fungicides, while offering sufficient control, cannot be applied shortly before harvesting. In response, BASF has combined the best of both worlds by developing a spray program that starts with chemical fungicides and then uses a biopesticide closer to the harvesting period. Innovations like this protect the crop throughout the whole growing period but allow more time for any potential residues to degrade before harvesting.

Healthy crops produce high-quality food with an attractive appearance and a good shelf life. While wilting or discolored lettuce can affect the taste and appearance of a salad, crop protection products can actually improve lettuce plant health. Plants show signs of increased vitality, use water more efficiently and stay fresh for longer. Consumers enjoy better quality while the farmer benefits from higher crop yields as well as more efficient water usage.

Food wastage is also reduced – an important factor in a world where about one third of all food produced for human consumption is lost or wasted. According to a 2011 UN report[11], consumers in rich nations waste a combined 222 million tons a year – almost as much as all the food produced in sub-Saharan Africa. Of course, healthy crops are just one part of the overall solution. We also need to address the problem of food storage and the fact that many of us buy more food than we need.

HERBICIDES KEEP RAGWORT OUT OF SALAD

In recent years, some farmers have specialized in the production of rocket salad. However, the weed, *Senecio*, commonly known as ragwort, while resembling the leaves of the rocket plant, contains alkaloids that can cause life-threatening liver damage and even cancer. An incident in 2009 in Germany, where a ragwort stalk was found in salad packages, led to concerns about food safety, prompting the recall of 9,000 packages of rocket salad. Herbicides reduce this risk by helping to control ragwort and other weeds.

DIFFERENT NEEDS IN THE FOOD CHAIN: HOW CROP PROTECTION CONTRIBUTES

FARMER

- Protect crops
- Produce food according to legal standards and retailer requirements
- Support successful, sustainable farming

RETAILER

- Fulfill legal standards
- Provide high-quality food and ensure consumer satisfaction

CONSUMER

- Enjoy safe, healthy, and affordable food
- Buy visually attractive fruit and vegetables

SECTION 4

SAFETY STANDARDS AND REGULATIONS

Crop protection products are controlled by government regulation just like human medicines. Safety studies are reviewed by independent authorities before any product is ever allowed to be used on crops.

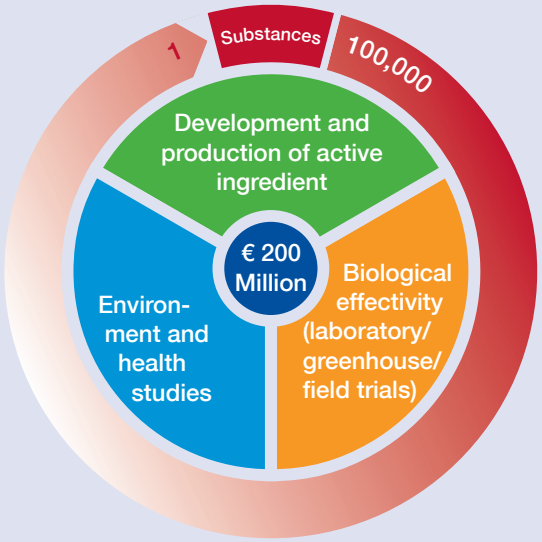
For farmers, pesticides are an important tool in the overall crop management portfolio. Farmers comply with good agricultural practice (→ GAP), following the principle of using pesticides only as required and then, as little as possible. This concept is also called “Integrated Pest Management” (→ IPM).

Pesticides are only authorized if an independent, expert risk assessment – undertaken under a set of unfavorable circumstances and incorporating high safety margins – consistently verifies that any residues remaining after proper use of the product are below the safety levels for consumers (→ ADI,→ ARfD, see p.18).

BASF TESTING FOR FOOD SAFETY

Pesticides undergo a comprehensive registration process – that is why the development of an active ingredient (→ A.I.) takes up to 11 years, involving more than 200 studies and adressing around 800 key questions. Apart from efficacy and environmental safety, food safety is a critical area. Some of the tests, conducted in the laboratory and the field, identify residues that can remain on the food under unfavorable conditions, and in these cases, assesses if the toxicity gives any reason for concern. These toxicological assessments include long-term and short-term effects (chronic and acute toxicity). Only candidates that do not pose a risk to human health and the environment are considered for further development.

DEVELOPMENT OF A NEW PESTICIDE



Source: Industrieverband Agrar e.V. (IVA)

In addition to the safety standards, separate trading standards, called Maximum Residue Levels (→ MRLs) are also in place to check whether a pesticide has been correctly applied.

EXPLANATIONS

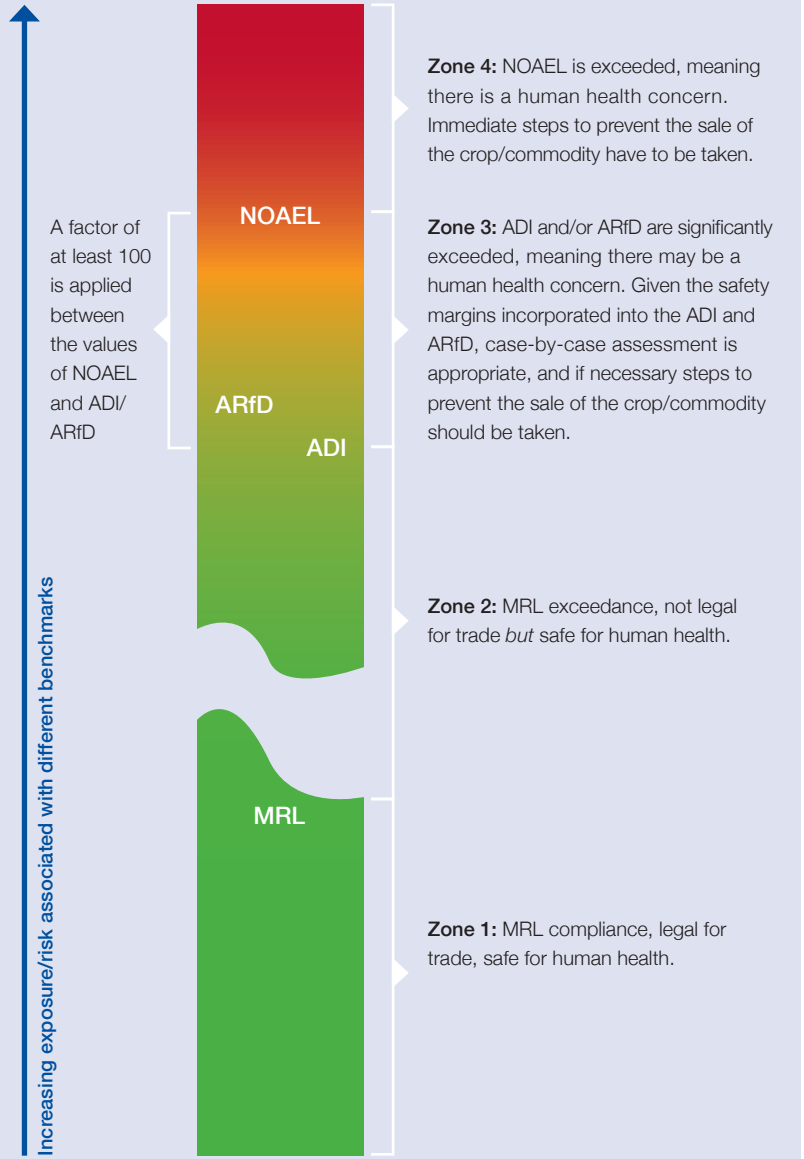
NOAEL (No Observed Adverse Effect Level): The highest exposure level at which no adverse effects can be identified in tests.

ARfD (Acute Reference Dose): A toxicological safety limit specifying the amount of a substance which can be ingested on a single day without any effects on the health of the consumer.

ADI (Acceptable Daily Intake): A toxicological safety limit specifying the amount of a substance which can be ingested every day over an entire lifetime without any recognizable risks to the health of the consumer.

MRL (Maximum Residue Level): A legally fixed maximum concentration for a particular active ingredient in a particular crop. A trade standard, intended primarily as a check that a pesticide has been applied correctly.

BENCHMARKS FOR FOOD SAFETY



Source: European Crop Protection Association (ECPA)

Whether residues – traces of crop protection products on or in the harvested product – actually occur depends on a variety of factors:

WHAT INFLUENCES RESIDUE LEVELS?

- **PROPERTIES OF THE ACTIVE INGREDIENT AND FORMULATION**
  All crop protection products degrade with time. Different active ingredients and formulations lead to different degradation rates.
- **REGIONAL CULTIVATION AND SITE CONDITIONS**
  Factors like hours of sunlight, temperature, and rainfall influence degradation and thus residue levels.
- **PERIOD OF TIME**
  More time between the application of a crop protection product and the harvest usually means more time for degradation, resulting in reduced residue levels.
- **TYPE OF CROP**
  The type of crop is also an important factor. For example, the roots of potatoes and carrots are protected from direct spraying as they are below the surface of the soil.
- **PEST INFESTATION**
  Pest infestation influences the timing and rate of applications.

When used according to label instructions and Good Agricultural Practice (→ GAP), residues do not normally exceed Maximum Residue Levels. However, as these MRLs are not harmonized worldwide, exceedances can often be traced back to different MRLs being used in the export country.

MRLs IN INTERNATIONAL TRADE

An MRL is usually only established when a pesticide is needed for local farmers to control weeds, pests, and diseases. For example, the UK has no pesticides authorized for use on bananas as the fruit is not grown locally.

Other reasons for MRL differences are due to local conditions – for example, a wetter climate may result in heavier fungal infestation, requiring different levels of fungicide application.

In these cases, the import country can set MRLs to match those of the export country. Called “import tolerances”, these MRLs have to comply with the same high safety standards, and facilitate international trade.

Exceeding the Maximum Residue Levels does not usually pose a risk to health as these trading standards are normally far below safety limits, which, in themselves, include wide safety margins. However, it does indicate that the pesticide has been incorrectly used. This is illegal and means that the food product cannot be marketed. The crop protection industry views any violation of trading standards as unacceptable practice and is committed to eliminating this problem.

SECTION 5

INDEPENDENT MONITORING FOR CONSUMER SAFETY

Once a pesticide is authorized, regulatory authorities monitor the food supply for residues on an ongoing basis. Independent Government testing consistently reveals that around half of all fresh produce and the vast majority of processed foods have no detectable residues whatsoever.

Scientists now have analytical technology that can detect even the most minute residue traces. Levels capable of detection are typically to the order of 10 parts per billion – this is equivalent to one person out of a group of 100 million.

In addition to comprehensive national testing programs at country level, the latest results from the EU coordinated program, released in 2011[12], show that in 2009, 98.8 percent of all 10,533 samples tested either had no residues or had minute traces in compliance with legal levels (MRL).

BASF TRAINING PROGRAMS FOR FOOD SAFETY

BASF training activities are designed to help eliminate MRL exceedances and contribute to a reduction in overall residue levels.

For example, in India, as part of the **Samruddhi project**[13], BASF employees educate farmers about fertilization, seed rate, spacing, and the appropriate use of pesticides through field demonstrations.

In 2009, BASF initiated the disease and pest management program **“Uvas sin fronteras”** (“Grapes without frontiers”) to help table grape producers in Chile to fulfill the strict requirements of export markets regarding residue limits. “Uvas sin fronteras” not only meets these standards, it also controls pests and diseases, increases grape quality, and reduces potential resistance, all of which help farmers economically.

RESULTS OF THE EU COORDINATED MONITORING PROGRAM FOR RESIDUES IN FOOD

Note: Identical food commodities were analyzed in both years but more pesticides were included in the 2009 analysis.

Source: EFSA, 2011

This situation is mirrored in other key countries. The latest report from the US Department of Agriculture shows that 97 percent of the samples tested complied with legal limits (MRLs)[14]. In Australia, the latest annual National Residue Survey (NRS) from 2011 showed that 99 percent of crop samples tested for pesticide residues were within legal limits[15].

Supermarkets and traders also check food safety regularly and perform their own analyses including the monitoring of pesticide residues.

In the EU, apart from ongoing monitoring, a Rapid Alert System for Food and Feed (RASFF) is in place to respond quickly to any potential concerns regarding food safety, including the withdrawal of foodstuffs from the market, if necessary. In 2010, RASFF showed 576 alerts (with 3 percent of these related to pesticides). The majority of reported risks related to the presence of pathogenic microorganisms (including salmonella and listeria), heavy metals, allergens and mycotoxins – naturally occurring, toxic substances produced by fungi[16].

Apart from acting as an additional safety net, the rapid alert system also helps the industry to identify and address any potential issues, ensuring the continued supply of safe, high-quality food for consumers.

WHAT HAPPENS WHEN DIFFERENT PESTICIDES COMBINE?

In recent years, pesticides have become increasingly specialized in order to target specific pests and weeds. Farmers also have to guard against resistance, which can occur if the same product is used too frequently. Consequently, a wide variety of pesticides are available on the market.

As a result, consumers are concerned that there are multiple residues in food that lead to a “mixture toxicity effect”, also called “cocktail effect”.

Current research shows that mixture toxicity – where the toxicity of the combination of chemicals is higher than the individual toxicity for each of the single components – is relevant only in those cases where chemicals have a common toxicity.

So what does it mean in terms of food safety? Industry’s current risk assessment for single substances factors in high safety margins. While this gives a high degree of confidence that any mixture effects are covered in the majority of cases, further action is necessary to reduce potential risks.

Using existing data from food consumption and residue monitoring programs, authorities and scientists from industry and academia are currently working to develop a science-based methodology to assess the risk of chemical mixtures in both the environment and diet. This should lead to a better assessment, ensuring the safety of diets and strengthening trust in food safety.

WE WELCOME YOUR FEEDBACK

Our goal is to facilitate an open debate about food safety, based on facts and a deep appreciation of the diverse needs and expectations of society.

This brochure – developed by a range of experts, including agronomists, biologists, chemists, food chemists, and toxicologists – has been designed to contribute to such a debate. We welcome your feedback.

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You can also participate in our **blog** www.farmperspectives.com or on **Facebook** www.facebook.com/basfcropprotectionglobal

Other brochures in this series:

- Minimize risk – maximize benefits
- Water and crop protection – a clear case
- Biodiversity and agriculture
- Registration of crop protection products: ensuring global safety

GLOSSARY

ADI (Acceptable Daily Intake): A toxicological safety limit specifying the amount of a substance which can be ingested every day over an entire lifetime without any recognizable risks to the health of the consumer. It is derived from the NOAEL.

A.I. (Active Ingredient): The substance in a crop protection product that is biologically active, e.g. intended to control diseases or to repel, attract, mitigate, or control a pest. Some products may contain more than one active ingredient.

ARfD (Acute Reference Dose): A toxicological safety limit specifying the amount of a substance which can be ingested on a single day without any effects on the health of the consumer.

GAP (Good Agricultural Practice): A collection of general guidelines for agricultural production, including e.g. the consideration of the approved label instruction, which states the application rate, the application time, and the maximum number of applications necessary for optimal pest, disease, and weed control.

IPM (Integrated Pest Management): The careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions at levels that are economically justified, and reducing or minimizing risks to human health and the environment. IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms.

MRL (Maximum Residue Level): A legally fixed maximum concentration for a particular active ingredient in a particular crop. A trade standard, intended primarily as a check that a pesticide has been applied correctly.

NOAEL (No Observed Adverse Effect Level): The highest exposure level at which no adverse effects can be identified in tests on animals. This basic value is then divided by a safety factor of at least 100 to account for any differences in sensitivity between test animals and humans as well as differences between individuals. These calculations yield the ADI and the ARfD limits.

Pesticide / Crop Protection Product: A product used to protect crops against various kinds of pests, weeds and diseases. Pesticides include fungicides against molds, herbicides against weeds, insecticides against harmful insects, acaricides against mites, molluscicides against snails, nematicides against nematode worms, and rodenticides against rodents.

FURTHER INFORMATION / LINKS

Authorities / Institutions
The European Food Safety Authority (EFSA) is an independent European authority. Its assignments include the assessment and communication of risks, and political consultancy: **www.efsa.europa.eu**
The EFSA publishes a yearly residue monitoring report.
http://www.efsa.europa.eu/en/topics/topic/pesticides.htm

The European Commission maintains an online portal for risk alerts, the RASFF (Rapid Alert System for Food and Feed)
http://ec.europa.eu/food/food/rapidalert/index_en.htm

The Environmental Protection Agency (EPA) is an agency of the federal government of the United States charged with protecting human health and the environment: **www.epa.gov**

The US Department of Agriculture (USDA) publishes annual reports of their Pesticide Data Program (PDP): **www.ams.usda.gov/pdp**

The Food and Agriculture Organization (FAO) of the United Nations deals with the sustainable use and safety of pesticides:
www.fao.org/ag/agp/agpp/Pesticid/Default.htm

The FAO sets international MRLs, so-called Codex MRLs
http://www.codexalimentarius.org/standards/pesticide-mrls/en/

Associations:
The European Crop Protection Association (ECPA) offers an information and discussion forum on the subject of crop protection:
www.pesticideinformation.eu

Crop Life International is the global federation representing the plant science industry: **www.croplife.org**

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