

# Pesticide Management in the Field and Its Relevance to Residues in Feed Grains

Bhadriraju Subramanyam (Subi), PhD

Professor

Department of Grain Science and Industry

Kansas State University

Manhattan, Kansas 66506, USA

Tel: 785-532-4092

Fax: 785-532-7010

E-mail: [sbhadrir@ksu.edu](mailto:sbhadrir@ksu.edu)

Website: [www.oznet.ksu.edu/grsc\\_subi](http://www.oznet.ksu.edu/grsc_subi)

17<sup>th</sup> Annual ASAIM Southeast Asian Feed Technology  
and Nutrition Workshop  
June 16-19, 2009  
Hue, Vietnam



# Contaminants and toxins in animal feeds

- Environmental pollutants
  - Pesticides
  - Industrial pollutants (dioxin, PCBs)
  - Radionuclides (Chernobyl accident 1986)
  - Heavy metals (pollution or fertilizers)
- Veterinary drugs
- Insects
- Microbes and byproducts of microbes
- Endogenous toxins from fodder plants
  - Lectins
  - Antigenic proteins (glycinin)

## Contaminants and toxins in animal feeds

J.P.F. D'Mello  
Scottish Agricultural College (SAC) in Edinburgh  
United Kingdom

This work was partly supported by funding from the Scottish Executive Rural Affairs Department (Project 627012).

In global terms, animal feeds and forages contain a wide range of contaminants and toxins arising from anthropogenic and natural sources. In this article, the distribution of heavy metals, radionuclides, mycotoxins, plant toxins, antibiotics and microbial pathogens in



## Fish Meal in Animal Feed and Human Exposure to Persistent Bioaccumulative and Toxic Substances

**Author:** Dórea, José G.<sup>1</sup>

**Source:** Journal of Food Protection®, Volume 69, Number 11, November 2006, pp. 2777-2785(9)

**Publisher:** International Association for Food Protection

### Abstract:

Persistent and bioaccumulative toxic substances (PBTs) that end up in fish are health hazards and the object of fish-consumption advisories. Some of these substances are present as extraneous contaminants, e.g., man-made lipophilic pollutants such as organohalogen pollutants, and others such as monomethyl mercury can be considered naturally occurring. Omnivores (e.g., poultry and swine) and especially ruminants that are fed contaminated fish meal can pass monomethyl mercury and organohalogen pollutants to eggs, meat, and dairy products. Differences in fish meal PBTs profiles and farm animal (e.g., poultry, swine, cattle, and farmed fish) physiology modulate PBTs in animal products. Fish-consumption advisories issued to protect human health do not extend to



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Animal Feed Science and Technology  
133 (2007) 84–108

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## The risk of contamination of food with toxic substances present in animal feed

C.A. Kan\*, G.A.L. Meijer

Animal Sciences Group of Wageningen UR, PO Box 65,  
8200 AB Lelystad, The Netherlands

### Abstract

Toxic substances such as dioxins, mycotoxins, heavy metals, pesticides, veterinary drugs and polycyclic aromatic hydrocarbons are almost ubiquitous in the environment. Thus, they are also present in ingredients for animal feed. Adequate risk management depends on knowledge of absorption, metabolism, carry-over and toxicological profile of these substances and on practical measures to reduce especially the latter two. Generally, toxic substances are metabolized before or after absorption through the intestinal tract. Depending on their physico-chemical characteristics, some substances are metabolized into naturally occurring and generally harmless constituents. Most veterinary drugs and feed additives fall into this group. Other substances are persistent and remain in the animal and in animal products, like dioxins. Heavy metals are not metabolized at all. Some metals irreversibly are bound to body tissues, e.g. lead to bone or cadmium to kidneys.

This review updates the information on carry-over of toxic substances from feed to food of animal origin (meat, organs, milk and eggs). This update is necessary and essential as exposure levels have dropped considerably and analytical as well as toxicological techniques have become much more sensitive. However, simple and cheap analytical techniques to check all suspect feeds or feedstuffs for all possible contaminants are not available. Furthermore, to improve risk management in the field of human nutrition, appropriate data on management and control of toxic substances in animal production chains are essential. The control of environmental contaminants that may cause residues in food of



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133 (2007) 109–136

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## Effects on poultry and livestock of feed contamination with bacteria and fungi

K.G. Maciorowski<sup>a,1</sup>, P. Herrera<sup>a</sup>, F.T. Jones<sup>b</sup>,  
S.D. Pillai<sup>a</sup>, S.C. Ricke<sup>a,\*</sup>

<sup>a</sup> Poultry Science Department, Texas A&M University, College Station,  
TX 77843-2472, United States

<sup>b</sup> Center of Excellence for Poultry Science, University of Arkansas,  
Fayetteville, AR 72701, United States

### Abstract

Animal feed may serve as a carrier for a wide variety of microorganisms. The primary mode of inoculation of feed materials is the transference of soil by wind, rain, mechanical agitation, or insects to standing crops. Some of the microorganisms are adapted to the desiccated and relatively nutrient-poor conditions in soil and survive in similar niches on growing crops. Gastrointestinal pathogens can also be introduced into the food chain by animals defecating in the farm environment or by fertilization of crops with manures. Other microorganisms are introduced during storage. In general, the amount of available water in the feed matrix determines whether a microorganism will grow or survive. Some microorganisms, primarily moulds, are adapted to the low amount of available moisture and grow actively within stored seeds and grains. Others will produce spores or enter survival state until the moisture is high enough for bacterial action. There are numerous ways contaminating microorganisms can affect feed quality negatively, including reducing dry matter and nutrients, causing musty or sour odours, causing caking of the feed and producing toxins. Finally, feed can act as a carrier for animal and human pathogens. The type of feed, processing treatments and storage conditions can all be factors that influence the population levels and types of microorganisms present. The incidence and variation in the microflora found in animal feed and feed materials are reviewed.

- 21% of feeds in UK contain pesticide residues (J. P. F. D'Mello 2007)
- Pirimiphos-methyl (Actellic), used in grain stores, was the most frequently detected pesticide residue

# Consequences of contaminants and pesticides in animal feeds

- May be detoxified by the animal
- Accumulate in the animal tissues
- Cause adverse effects
- Human exposure via food animals or animal products

# What is a pesticide?

- A pesticide is any substance or mixture of substances intended for:
  - Preventing, destroying, repelling, or mitigating any pest
  - Includes herbicides, fungicides, and various other substances used to control pests
  - It also includes any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant

# What is a pest?

- Insects, mites, ticks
- Rodents and other animals
- Unwanted plants (weeds)
- Fungi
- Microorganisms such as bacteria and viruses, and prions

# Pesticide classes

([http://www.alanwood.net/pesticides/summ\\_groups.html](http://www.alanwood.net/pesticides/summ_groups.html))

- **Organophosphates:** Affect the nervous system by disrupting the enzyme that regulates acetylcholine, a neurotransmitter. Most organophosphates are insecticides
- **Carbamates:** Affect the nervous system by disrupting an enzyme that regulates acetylcholine, a neurotransmitter.
- **Organochlorines:** Commonly used in the past; many have been removed from the market due to their health and environmental effects and persistence (e.g. DDT and chlordane)
- **Pyrethroids:** Developed as a synthetic version of the naturally occurring pesticide pyrethrin, which is found in chrysanthemums. They have been modified to increase their stability in the environment.



# Who regulates pesticides in the US?

- The Federal Insecticide Act-1910
- The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)-1947
- Administered by USDA until 1970
- Rachel Carson (1907-1964)-*Silent Spring*
- The Environmental Protection Agency (EPA)
  - Protects environment and public health



# Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)-1972

- Is a product licensing statute; pesticide products must obtain an EPA registration before manufacture, transport, and sale
- Registration based on a risk/benefit standard
- Strong authority to require data--authority to issue Data Call-ins
- Ability to regulate pesticide use through labeling, packaging, composition, and disposal
- Emergency exemption authority--permits approval of unregistered uses of registered products on a time limited basis
- Ability to suspend or cancel a product's registration: appeals process, adjudicatory functions, etc.

# The Federal Food, Drug, and Cosmetic Act (FFDCA)-1938

- Mandates strong provisions to protect infants and children
- Provides the authority to set tolerances in foods and feeds (maximum pesticide residue levels)
- Also provides authority to exempt a pesticide from the requirement of a tolerance
- Rule-making process required to set tolerances or exemptions
- Before a registration can be granted for a food use pesticide, a tolerance or tolerance exemption must be in place
- Mandates primarily a health-based standard for setting the tolerance--"reasonable certainty of no harm"
- Benefits may be considered only in limited extreme circumstances, very unlikely
- Pesticide residues in foods are monitored and the tolerances enforced by FDA (fruits and vegetables, seafood) and USDA (meat, milk, poultry, eggs, and aquacultural foods)

# The Food Quality Protection Act (FQPA)-1996

- Establishes a single safety standard under FFDCA by which we are to set tolerances
- Assessment must include [aggregate exposures](#) including all dietary exposures, drinking water, and non-occupational exposures
- When assessing a tolerance, EPA must also consider cumulative effects and common mode of toxicity among related pesticides, the potential for endocrine disruption effects, and appropriate safety factor to incorporate
- Requires a special finding for the protection of infants and children
- Establishes a [tolerance reassessment program](#) and lays out a schedule whereby EPA must reevaluate all tolerances that were in place as of August, 1996 within 10 years
- Requires review of antimicrobial actions within prescribed timeframes
- EPA must now periodically review every pesticide registration every 15 years
- Now required to set tolerances for use of pesticides under emergency exemptions (FIFRA Section 18)

# Pesticide tolerances

- **Tolerance:** The maximum amount of pesticide residue that may remain in or on foods marketed in the US (MRLs in other countries)
  - Raw commodities
  - Processed commodities
  - Exemptions
  - Temporary tolerance
  - For imported commodities (raw or processed)
- Tolerance limit for each pesticide is based on potential risks to human health
- EPA sets limit for each pesticide
- USDA enforces tolerances for meat, poultry and some egg products
- FDA enforces tolerances on processed foods and feeds

# Pesticide tolerances in food and feed

- Section 575.100 of FFDCA-Enforcement criteria
- Section 408 of FFDCA authorizes EPA to establish or exempt tolerances for pesticides in or on food
- Section 409 of FFDCA establishes pesticide tolerances in processed food
- Section 402 of FFDCA deals with food and feed adulteration with pesticides

# Section 402 of FFDCA

- Tolerances for pesticides on raw commodity also extend to processed form (21 CFR Part 193 & 561)
- Level of residue in processed commodity should be same or less than that on raw commodity
- Residues of a pesticide for which no tolerance has been established cannot be found in processed commodity
- Action levels have been set for unavoidable pesticide residues (21 CFR Part 109 & 509)
- Tolerance levels also apply to imported food and feeds

- The FQPA (1996) required EPA to reassess all tolerances
- Tolerance decisions were based on:
  - Anticipated residue levels of a pesticide in or on food as reflected in crop field studies or food processing studies
  - The actual levels that were found based on food monitoring studies



# Pesticide use and residues

- Use
  - To protect crops in the field
  - To protect harvested commodity in storage
- Residues
  - Legal vs illegal
  - Label directions
  - Pest severity
  - Crop phenology

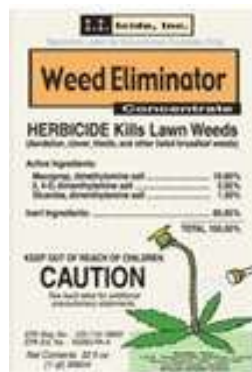
# Pesticide recommendations

- University extension personnel make recommendations for use of a pesticide
- Recommendations vary by region and crop
  - Research based recommendations to producers
- Some pests are common, some are sporadic
- Time of pesticide applications vary with crop, crop growth, and harvested commodity

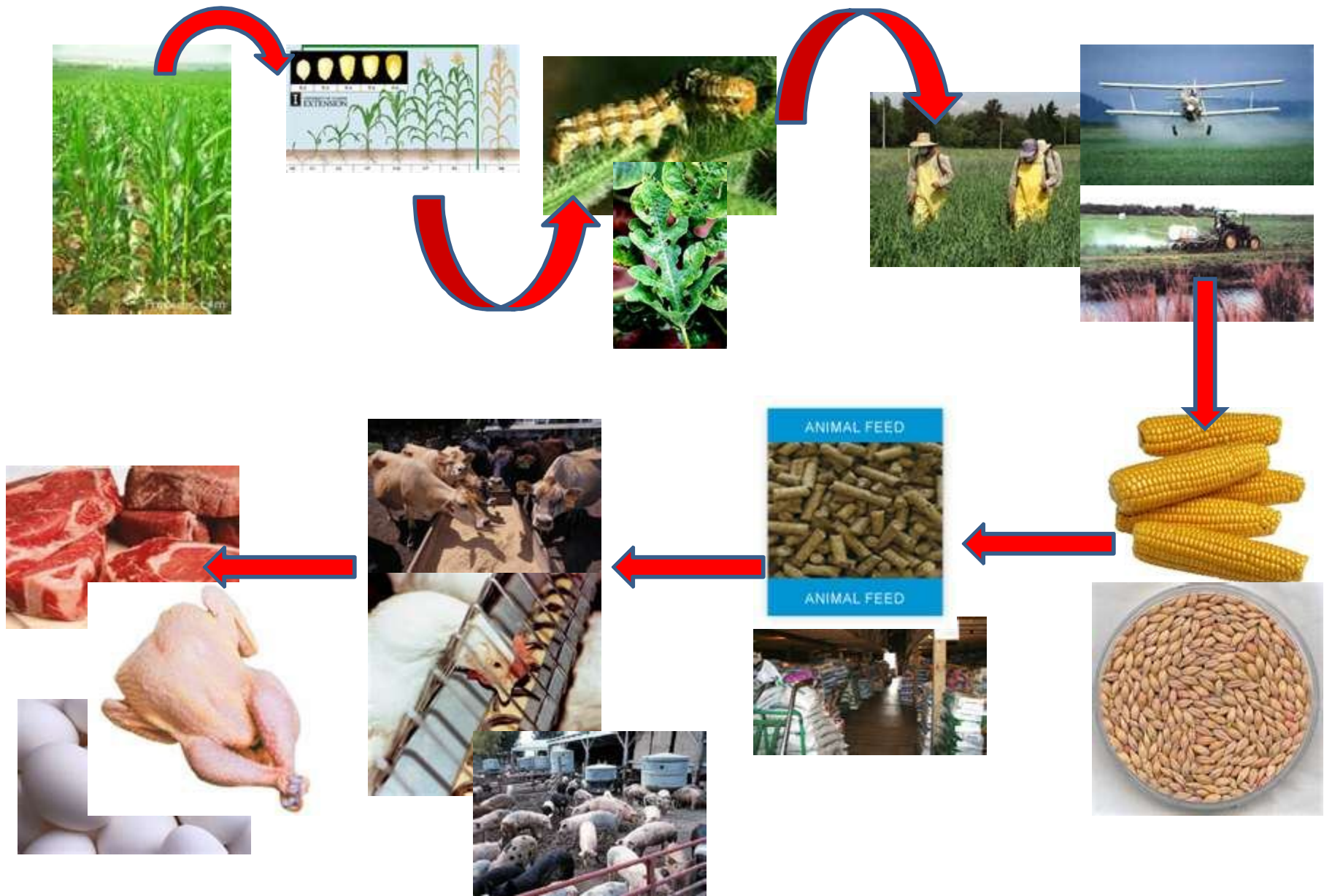


# The pesticide label

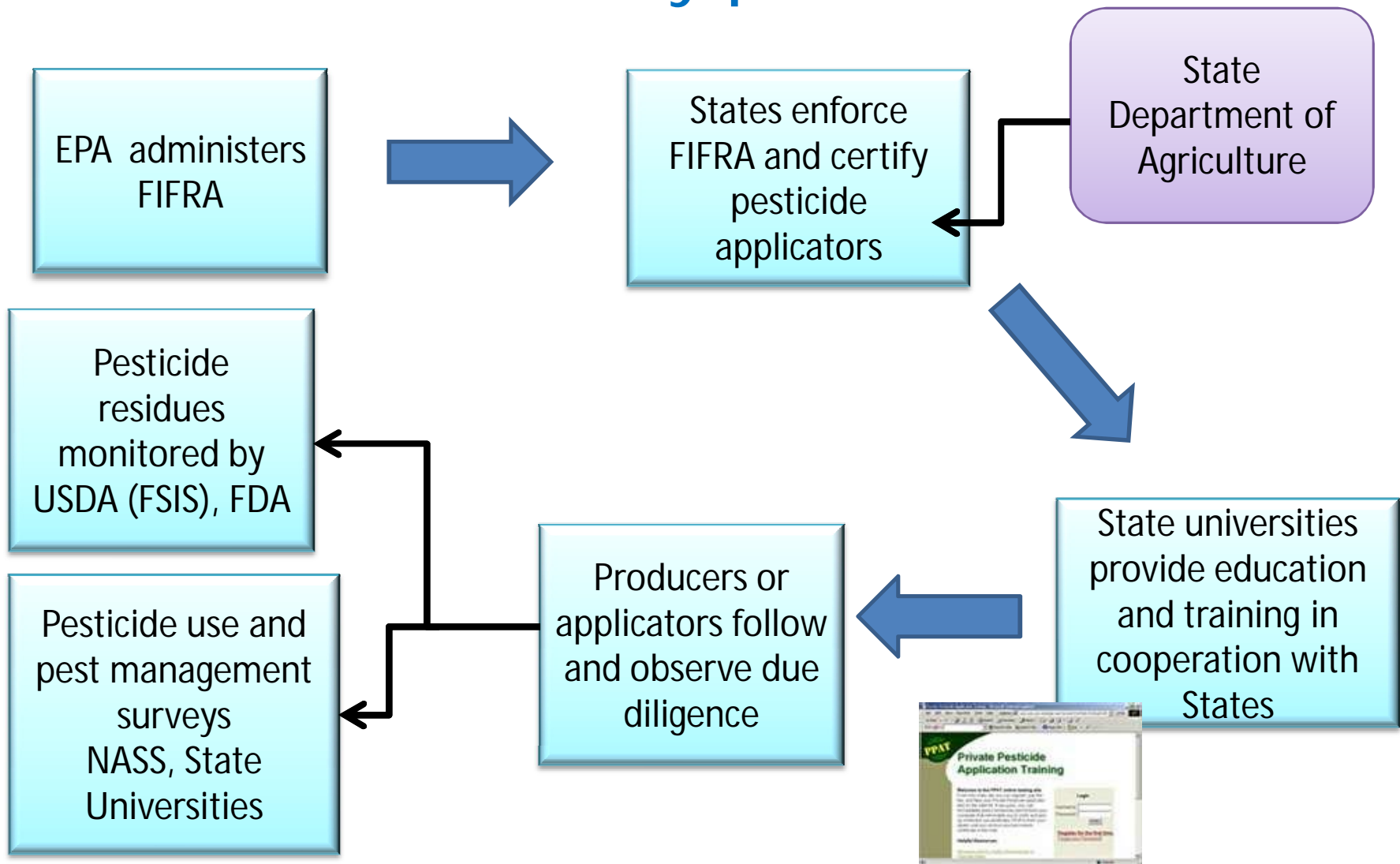
- *“It is a violation of the federal law to use this product in a manner inconsistent with the labeling”*
- **Labeling:** language on the label



# Pesticide residue cycle

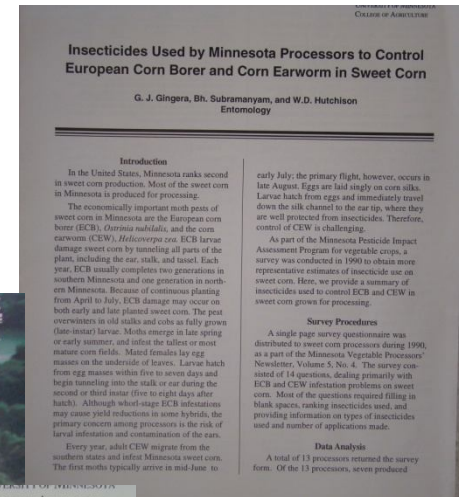
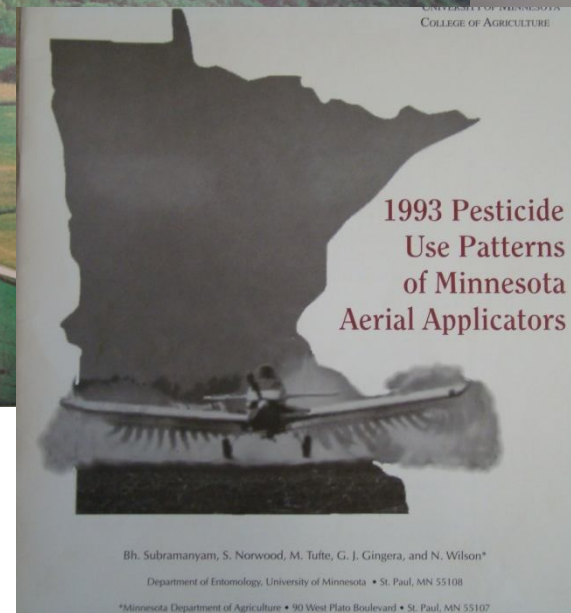
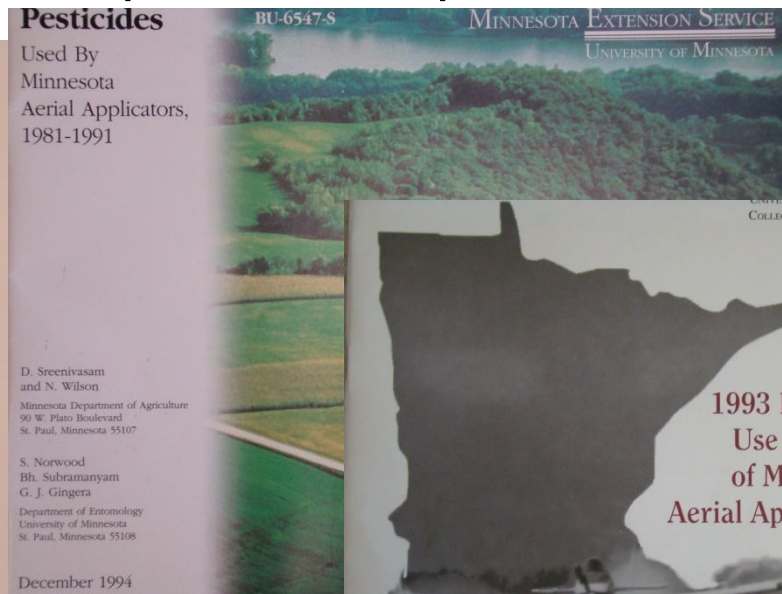
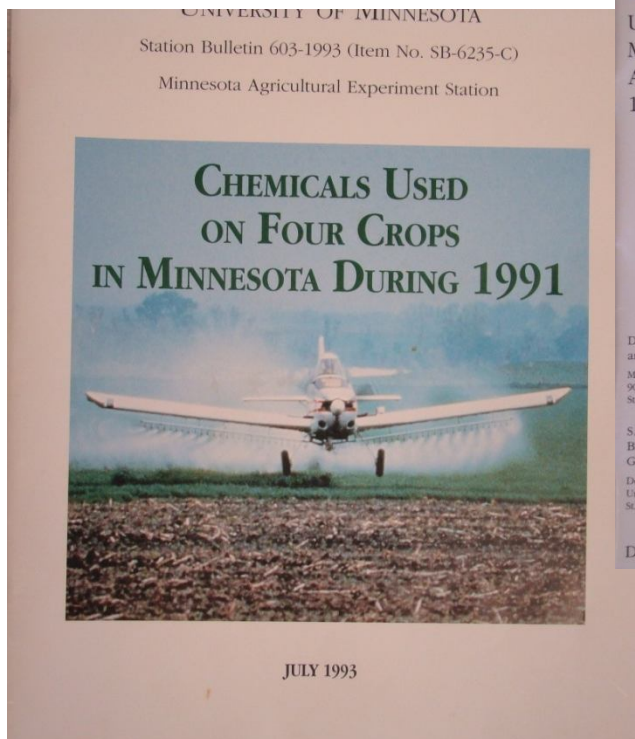


# The players involved in how pesticides are used by producers



# Pesticide use and pest management surveys

- Conducted by state universities
  - Pesticides used (types, frequency)
  - Pest management practices of producers



# Pesticide use surveys by NASS



- [www.nass.usda.gov](http://www.nass.usda.gov)
- Conducts agricultural census every 5 years
- Reports county, state, and national level data
- Production data
- Percent of crop acreage treated with chemicals (fertilizers and pesticides) and amounts of chemicals used

# USDA-Pesticide Data Program\*



- Started in May 1991
- Collect data on pesticides residues on food, highly consumed by infants and children
- Provide realistic pesticide dietary exposure assessments
- Fresh commodities (35), processed commodities (26), grains (8), dairy (3), meat, poultry, fish products (4), and drinking water (several states)
- Data shows type of pesticide, number of samples, percentage of samples with residue, ppb of residue, EPA tolerance level, and MRLs/EMRLs





# USDA-PDP Report, 2007: Corn grain

- 660 samples from 2006 crop year
  - 18% from trucks, 66% from hopper cars, and 16% from barges
- Checked for 104 pesticides and metabolites
- 14 out of 104 pesticides/metabolites residues were detected
- 0.2 to 37.9% of the samples had detectable residues
- Residue levels were much lower than the established tolerance levels
  - Malathion (37.9%) 0.6 ppm; tolerance, 8.0 ppm
  - Pirimiphos-methyl (2.4%) 0.002-0.049 ppm; tolerance 8.0 ppm

# USDA FSIS National Residue Program\*

- Program in effect since 1967
- Ensure and assure that USDA-inspected meat, poultry, and egg products do not contain illegal chemical residues
  - Imported and domestic products
- Tests for approved and unapproved pharmaceutical drugs, pesticides, antibiotics, and environmental contaminants

\*[http://www.foodrisk.org/commodity/animal/meat\\_poultry/general/contaminants.cfm](http://www.foodrisk.org/commodity/animal/meat_poultry/general/contaminants.cfm)

# FDA pesticide residue monitoring program\*



U.S. Food and Drug Administration



Department of  
Health and  
Human Services

CENTER FOR FOOD SAFETY AND APPLIED NUTRITION

- Program started 1987
- Conducts market basket studies and total diet studies
- Includes domestic and imported raw and processed products
- Samples and analyzes domestic and imported feeds for pesticide residues (FDA's CVM)
- Supports international efforts in implementing food safety



\*<http://vm.cfsan.fda.gov/~dms/pes99rep.html>

# Summary of 1999 domestic feed sample analysis

Type of feed	Total no. samples	Percentage of samples without residues	Percentage of samples exceeding guidance level
Whole/ground grains	173	69.9	1.2
Plant by-products	117	56.4	3.4
Mixed feed rations	99	39.4	1.0
Animal by-products	49	65.3	0.0
Supplements	13	61.5	0.0
Hay and hay products	12	66.7	0.0
<b>Total</b>	<b>463</b>	<b>59.2</b>	<b>1.5</b>

# Residues of pesticides reported, 1999

- Malathion, chlorpyrifos-methyl, chlorpyrifos, diazinon, methoxychlor, ethion, iprodione+metabolite, carbaryl, tribufos, imazalil, lindane, dieldrin, ethoxyquin, permethrin

# Summary of 2006 domestic and imported feed sample analysis\*

Type of feed	Total no. samples	Percentage of samples without residues	Percentage of samples exceeding guidance level
Whole/ground grains	138	88.4	0.0
Plant by-products	92	77.2	0.0
Mixed feed rations	66	62.1	0.0
Animal by-products	14	57.1	7.1
Supplements	14	85.7	7.7
Hay and hay products	11	90.9	0.0
<b>Total</b>	<b>335</b>	<b>78.8</b>	<b>0.6</b>

\*264 domestic samples and 71 imported samples

# Pesticide management tactics

- *“Judicious use of pesticides to maximize effectiveness while protecting environmental quality”*
- To minimize residues in feeds the following pesticide management tactics should be adopted:
  - Understand crop production practices and issues in managing pests in a given area
  - Determine how pests are currently managed
  - Explore pesticide and non-pesticide approaches for pest management (Integrated pest management [IPM] approaches)
  - Develop best management practices (BMPs) for crop production
  - Conduct research and educational programs to implement and sustain BMPs

# Novel pesticide management techniques

- Use pesticides as a last resort (basis for IPM)
- Use precision guidance and pesticide application techniques
- Use variable rate technologies to adjust pesticide rate for dynamically changing site-specific conditions
- Use “smart sprayers” that automatically sense and apply spray only where weeds are present
- Use chemical adjuvants to prevent pesticide drift



# Pesticide residues in feed and risk to cattle and sheep\*

- Study by Australian government
- Residues in animal meat and milk products were based on transfer factors and dietary burden
- 118 pesticides
- Assumptions
  - Good agricultural practices were followed
  - Crops treated at maximum rate
  - Shortest pre-harvest interval
  - The maximum rate of incorporation in ration/diet is 100%
- **Conclusion:** *“It is anticipated that animal product residues will be below limit of analytical quantitation”*

\*MacLachlan, D. 2006. Pesticide risk profile for the feeding of cereal grain to cattle And sheep. Australian Quarantine and Inspection Service, Department of Agriculture, Fisheries, and Forestry, Canberra, ACT. 57 pages.

# Summary and conclusions

- Pesticide residues can occur in animal feeds from use of pesticides in the field or in storage
- Types of pesticides and levels of residues found vary from crop to crop and region to region
- In the US, USDA and FDA monitor pesticide residues in feed
  - Percentage of samples containing residues is low
  - Amount of residues found were well below tolerances
- Coordination among various agencies and institutions exist in the US to ensure feed safety
- Infrastructure is needed in developing and under developed countries to track how pesticides are applied and the occurrence of residues in feed

- Several pesticide management tactics were outlined to reduce pesticide use
  - Integrated pest management practices
- Awareness, research, and education about proper pesticide use and best management practices for crop production are critical
- Pesticide management in the field and storage is key to preventing occurrence of pesticide residues in animal feeds, and subsequently in animal tissues and products

# Thank you



