



Risks and Benefits of Agricultural Pesticides in the Global Perspective

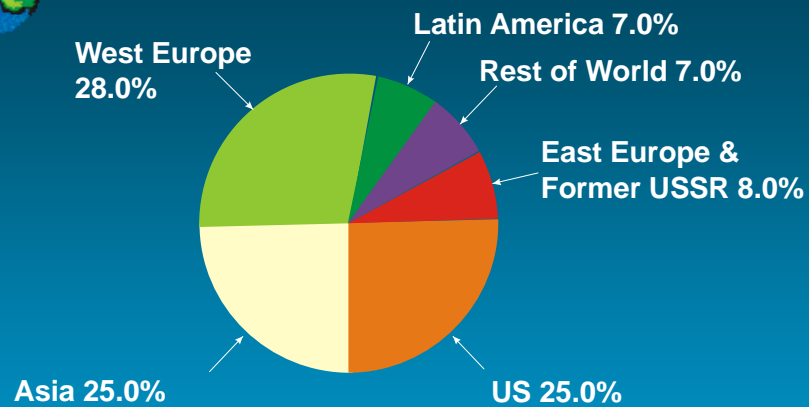
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WORLD PESTICIDE MARKET



Agricultural pesticides are immensely important in
developing as well as in industrialized countries

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Herbicides dominate world pesticide use for agriculture

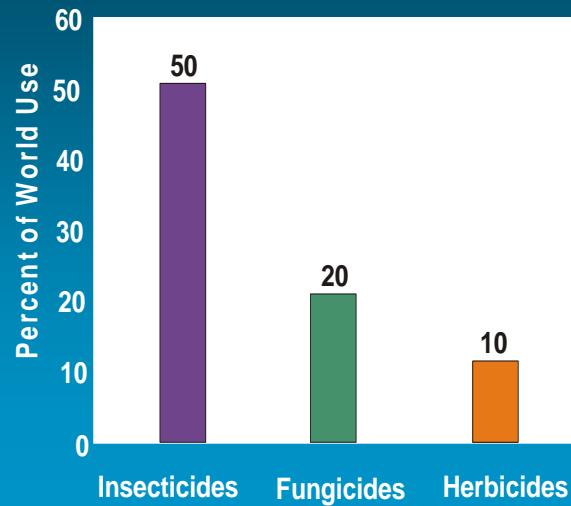
Herbicides	44%
Insecticides & acaricides	29%
Fungicides	21%
Nematicides and PGR's	6%

Glyphosate, a herbicide, may be the #1 pesticide in the world

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PERCENT OF WORLD USE IN DEVELOPING COUNTRIES



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Industrialized countries use most of the herbicides because farm labour for hand weeding and hoeing is so expensive

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PESTICIDE HEALTH RISKS

DEPEND ON

PESTICIDE TOXICITY X EXPOSURE

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Pesticide Toxicity & Health

- By definition, at appropriate doses, pesticides are toxic to the pests they are intended to control.
- We need to understand their potential effects at low doses on the health of humans or other non-target organisms?

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Principles of toxicology

For every chemical in any organism,

- There is a high dose that will be lethal
- There is a lower dose that may have chronic health effects
- There can be a lower dose that is stimulatory or beneficial
- There is still a lower dose that will have no effect

Paracelsus, 1500's

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This principle is true for most types of chemicals

Synthetic pesticides

Natural pesticides

Medicines

Herbal remedies

Vitamins etc.

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Examples

- The natural *Botulinus* toxin is perhaps the most toxic chemical that we know of. However, low doses are now being used as a medication for human diseases
- We don't think of water as a toxin. However, a woman recently died of its toxic effects in a water drinking contest.

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Pesticide Regulation

The goal of pesticide regulation is to assure that there are wide margins of safety for pesticide applicators, farm workers and consumers compared to 'no effect levels' in the most sensitive test animals

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In industrialized countries,



Most growers are trained and certified pesticide applicators

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Advances in sprayer technology are reducing risks



For the applicator and for the environment

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Pesticides are commonly applied with hand held sprayers in "Developing countries"



It is essential to establish effective training programs for applicators and farm workers in developing countries

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THE ENVIRONMENTAL RISKS OF PESTICIDES


Depend on their

- Persistence
- Mobility
- Non-target toxicity
- Volume of use

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ENVIRONMENTAL CONCERNS ABOUT PESTICIDES

1960's  Today

Insecticides	Herbicides
Biomagnification	Spray drift
	Soil residues

Herbicides now account for more than 50% of total pesticide use

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ROTHAMSTEAD SOIL STUDY SHOWS EFFECTS OF PESTICIDES IN SOIL ARE REVERSIBLE

- 17 months after applying five pesticides per year for 20 years
- No detectable residues of pesticides in the soil
- No differences in microbial activity in the soil
- No differences in barley yield

IPM with pesticides can be sustainable!

Evans, IUPAC, 1998¹⁷



The Rothamstead study was focused on older pesticides

Many of the newer pesticides are natural chemicals or close analogues of natural chemicals and are so specific in their toxicity to pests that application rates can be reduced 1000X from kg/ha to g/ha levels

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BENEFITS OF PESTICIDE USE IN AGRICULTURE?

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BENEFITS OF PESTICIDES -TO WHOM?

	<u>Numbers</u>
Growers	Small
Consumers & society	Vast

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**Growers have expected a \$4 return
on each \$1 spent on pesticides**



Is this still true?

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ECONOMIC BENEFITS TO FARMERS?

- Banning pesticide use in the USA would reduce agricultural output by 30%
- At pesticide & commodity prices in 1997
- There would have been a **\$3 to \$4** return for each **\$1** farmers spent on pesticides

Fernandez-Cornejo et.al., 1998

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What about economic benefits to society in the USA?

- The annual use of **\$6.5 billion** worth of pesticides
- Prevents **\$26 billion** in crop losses due to pests
- About a **\$4 return per \$1** spent on pesticides to the growers

Pimentel and Greiner, 1997

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Economic benefits to society in the USA?

- Estimated indirect costs of pesticide use is **\$8 billion** per year (regulation, training, health/environmental research)
- \$26 billion** in benefits/**\$14.5 billion** in costs equals about a **\$2 return to society** for each **\$1** spent on pesticides

Pimentel and Greiner, 1997

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Governments in a number of countries have set goals to reduce the use of pesticides in agriculture

Our Province of Ontario is a world leader in this effort

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In the 1980's we launched a program called,

**FOOD SYSTEMS 2002
ONTARIO, CANADA**

Objectives

- Reduce Agricultural Pesticide (kg) use by 50% by 2002
- Maintain or increase agricultural productivity

Methods – A shift to Integrated Pest Management

- Reduce preventive and broadcast applications
- More pest monitoring for better timing & placement
- More use of alternatives
- More grower education, training, certification

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FOOD SYSTEMS 2002

ONTARIO, CANADA

We wanted a 100% reduction, when we knew pesticides weren't needed to preserve crop yields, quality or safety

This is the correct approach for economic, biological and environmental reasons and it provides even greater margins of safety for human health

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The shift to new "low rate" pesticides would likely assure the success of this program

Quackgrass (*Agropyron repens*) control in maize

<u>Year</u>	<u>Herbicides used</u>	<u>Rate (g/Ha)</u>
1960's	atrazine	4,000
1970's	glyphosate	1,000
1990's	nicosulfuron / rimsulfuron	70*

* 98% reduction compared to atrazine

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Food Systems 2002, Ontario, Canada

Reduction in kg of pesticides used
51% between 1983 and 2003

Gallivan, Berges & McGee 2005

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Environmental Critics

Quickly charged that there was simply a
shift to more toxic and powerful pesticides

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ENVIRONMENTAL IMPACT QUOTIENT (E.I.Q)

$$EIQ = \left(\frac{c [(DT*5) + (DT*P)]}{3} + \frac{(C*((S+P)/2)*SY) + (L)}{3} + \frac{(F*R) + (D*((S+P)/2)*3) + (Z*P*3) + (B*P*5)}{3} \right) / 3$$

DT = dermal toxicity
 C = chronic toxicity
 SY = systemicity
 F = fish toxicity
 L = leaching potential
 R = surface loss potential

D = bird toxicity
 S = soil half-life
 Z = bee toxicity
 B = beneficial arthropod toxicity
 P = plant surface half-life

(Kovach et al., 1992).



Food Systems 2002, Ontario, Canada

48% reduction in E.I.Q / ha
between 1983 and 2003

Gallivan, Berges & McGee 2005



ECONOMIC BENEFITS OF PESTICIDES -TO WHOM?

	<u>Numbers</u>
Growers	Small
Consumers & society	Vast

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Economic trends during Food Systems 2002 (1998 vs 1983)

Total pesticides used (kg, a.i.)	Down 38%
Money spent on pesticides	Up 75%
Total crop value	Up only 23%
Returns "per pesticide dollar"	\$3.25 (1998) vs \$4.50 (1983)

**IPM is essential to preserve the economic
benefits of pesticide use!**

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BENEFITS OF PESTICIDES -TO WHOM?

	<u>Numbers</u>
Chemical companies	Very small
Growers	Small
Consumers & society	Vast

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AGRICULTURAL PESTICIDE USE SAVES ENERGY



HUMAN ENERGY

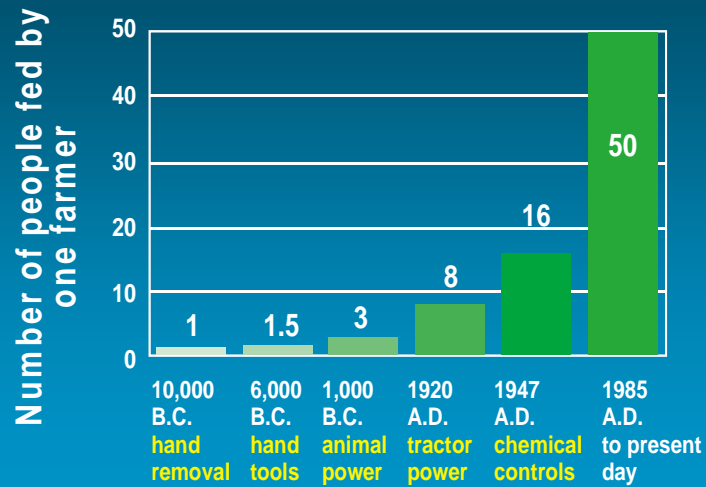


FOSSIL FUELS

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AGRICULTURAL EFFICIENCY IN RELATION TO ADVANCES IN WEED CONTROL



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PESTICIDES SAVE HUMAN ENERGY

Proportion of population involved in food production

N. America	2%	1 in 50
Brazil	20%	1 in 5
Mexico	25%	1 in 4
World Wide	50%	1 in 2*
Kenya	70%	2 in 3*

* Mostly women and children³⁸



In developing countries,



women produce 80% of the food !

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African women



spend half their waking hours,
working in the fields

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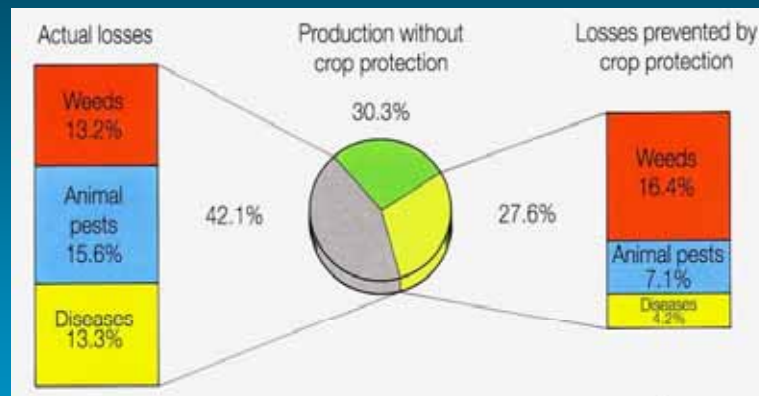
PESTICIDES REDUCE WORLD HUNGER



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Estimated the contribution of pesticides to the worldwide production of the eight principal food and cash crops for 1990 vs 1965



Oerke et. al., 1994

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Pesticide use doubled the yields of the world's eight principal cash crops between 1965 and 1990

However, pest related losses still ranged from 25% in Europe to more than 50% in Africa

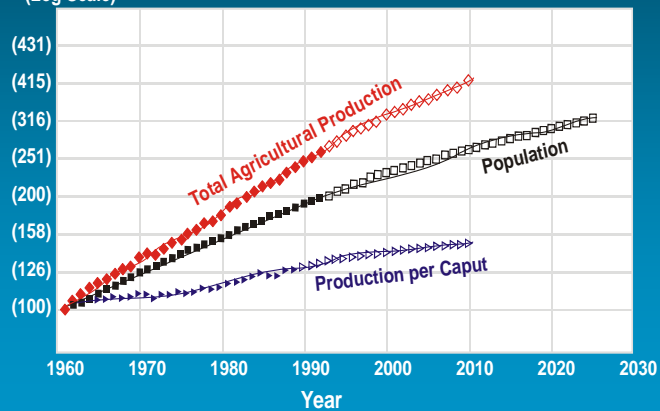
Oerke et.al., 1994

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TRENDS IN DEVELOPING COUNTRIES GROSS AGRICULTURAL PRODUCTION AND PRODUCTION CAPUT

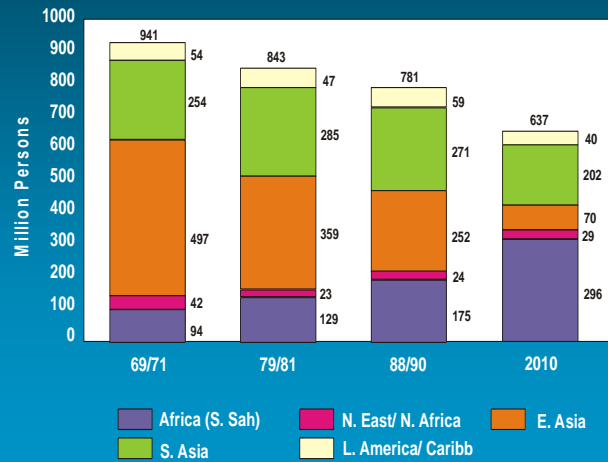
Index 1961 = 100
(Log Scale)



Klassen (ACS) 1995 44



NUMBERS (MILLIONS) OF UNDERNOURISHED PEOPLE IN DEVELOPING COUNTRY REGIONS: HISTORICAL AND PROJECTED TO 2010



Klassen (ACS) 1995 45



Pesticides increase food safety

By preventing pest damage to crops, applied pesticides (with documented safety), prevent the increase in natural pesticides / toxins in crops to levels that would be toxic.

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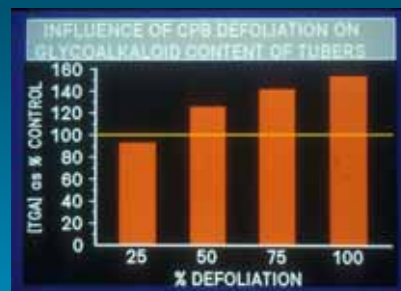
Potatoes exposed to light can become too toxic to eat because of increased levels of solanine and chaconine



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Pest damage can also increase solanine and chaconine in potatoes



Defoliation by potato beetle causes a 50% increase in these toxins which are potent natural insecticides and fungicides as well as teratogenic and fetal toxic in chickens (and probably humans)

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Pesticides can prevent the production of carcinogenic mycotoxins in our food



Corn ear mold (*Aspergillus flavus*) produces the carcinogen, aflatoxin in corn

This fungus can also produce aflatoxin in wheat and peanuts

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PESTICIDES HELP SAVE LAND

Since 1960, world agricultural production has tripled on 6 million square miles of land

Avery, 1997

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**“MANY PEOPLE ARE CONCERNED ABOUT
THE IMPACT OF
PESTICIDES ON THE ENVIRONMENT”**

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**We should be more concerned about the impact of
agriculture on the environment**

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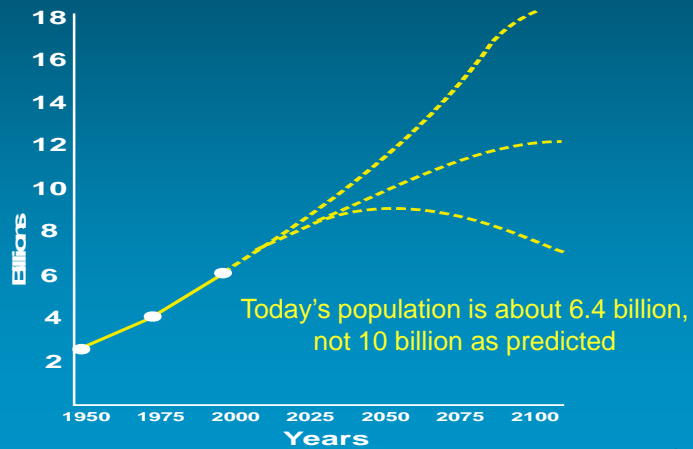
“If agricultural pesticides had not been used since 1950, we would have lost half of today’s forested land to food production”

Lester Brown, 2001

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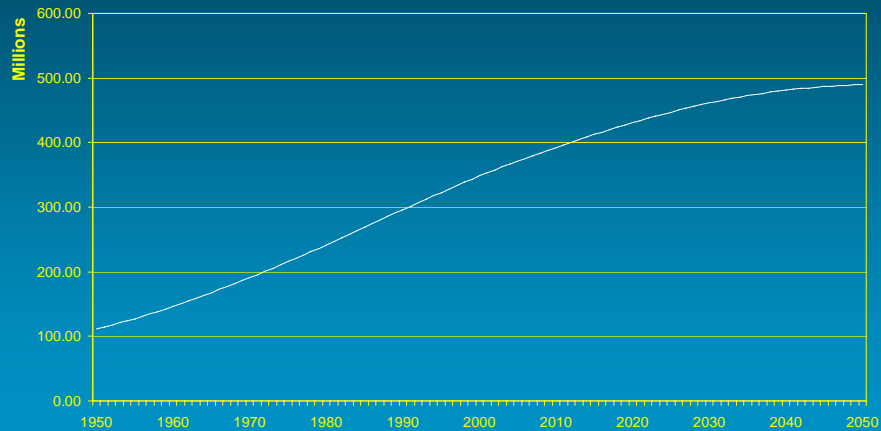
WORLD POPULATION TRENDS



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EXPECTED POPULATION TRENDS IN SOUTH AMERICA, 1950-2050



Source: U.S. Bureau of the Census, International Data Base.

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This is because populations are aging and the rate of increase is declining in most parts of the world

World population could peak in mid century and decline to 6-7 billion early in the next century

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Will world population actually decline after 2050?

Will politicians encourage women to resume having three or more children to sustain a growth economy? Baby bonuses etc.?

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Governments want to know how to sustain or even increase birth rates

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FOR MOST OF THIS 21ST CENTURY

50% more people will need food (9 vs 6 billion)

With industrialization, they may have 50% more buying power

There will be a need for **twice** as much food

Thompson, 1998

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If dietary trends in Japan and China are good examples, people will consume

- more soybeans, vegetables, fruits
- less rice, wheat, maize, sorghum
- more dairy products
- A little more meat

These trends will require much higher yields

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China has converted an area the size of England (19 million hectares)

from wheat & rice production



to fruit & vegetable production



in just the last ten years!

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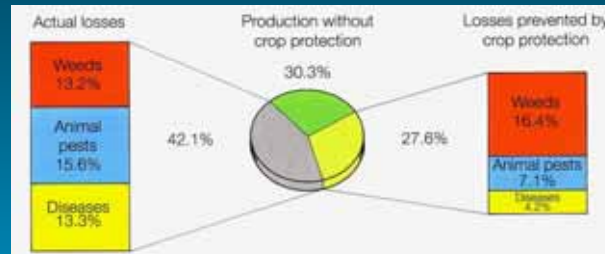
Agricultural land
is used for production of
food, fibre and now biofuels

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HOW CAN WE DOUBLE “NET” YIELDS OF FOOD CROPS AGAIN ON THE SAME OR LESS LAND AREA?

With better
IPM
throughout
the world



Oerke et. al.,

we may achieve 90% instead of 60% of our theoretical yield?

This would amount to 50% more food!

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“We will need

both pesticides and genetic technology

to double food production on the same or
less land than we are using now.”

Thompson, 1999

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“Technically, this may be possible”

“Psychologically, it may be impossible”

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“The Mental Affluence Trap”

Hans Mohr, Univ. Freiburg, 1990

The more healthy & affluent people are, the more they oppose the technology that got them there

“The young, the hip, and the wealthy” want to decrease pesticide use and purchase more organic food to **preserve their health and prosperity**

Conversely, people in developing countries will use more pesticides to **improve their standard of living.**

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We must help developing countries grow more food

If developing countries increase pesticide use,

we must help them develop regulations and training programs to prevent health and environmental problems

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REDUCING PESTICIDE USE?

I favour a 100% reduction in pesticide use when & where they aren't needed to increase crop yields.

However, is prohibiting "needed pesticide use" morally correct in view of world food needs?"

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We hear that Germany may have
50% organic farming by 2012



I do not favour a **large** shift to organic farming
in industrialized countries so that farmers can
make more money by catering to the affluent

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Our GOAL FOR THIS 21st CENTURY

**Should be to prevent human hunger
without irreversible harm to the
world environment**

This will be easier to achieve with better
IPM than with a shift to organic farming

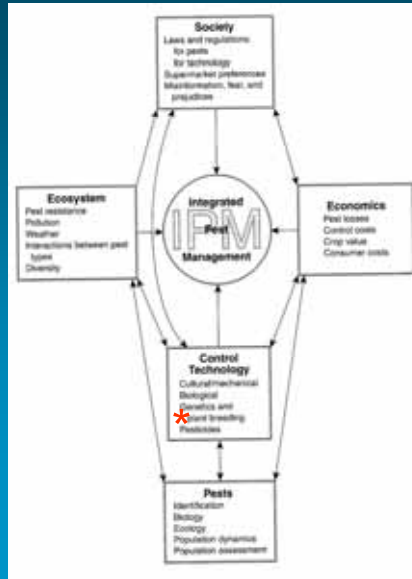
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IPM vs ORGANIC FARMING

What is the difference?

Both are dynamic, multi-faceted approaches to pest management. One allows pesticides to be one of the many tools, the other does not.



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WORLD POPULATION

If world population peaks at 9 billion in 2050 and declines to 6 billion or less in the 22nd century

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Future generations may have the choice between organic farming or reducing land for agriculture

It would be very selfish and narrow-minded to think that we have that choice today!

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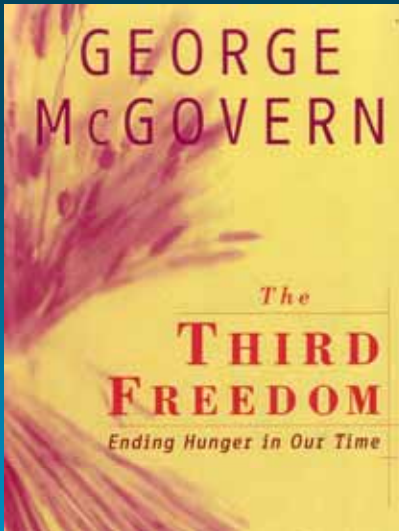
If we shift to a less productive agriculture that does not allow pesticide use in IPM

What about the increased risks for human starvation and violence as the world population increases to 9 or 10 billion people?

What will the environmental impacts be if we have to use forested or wilderness land for agriculture?

Global warming etc.

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U.S. Senator, presidential candidate, & ambassador to the U.N.

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McGovern agrees that we will have the technology to eliminate world hunger

Other challenges involve,
Women, Water and War

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CONCLUDING THOUGHTS

To again double food production during this century, we need worldwide advances in the development and application of both

INTEGRATED PEST MANAGEMENT and CROP GENETICS

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Thank you

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