Both ENDS Information Pack

Nr. 20

Pest control in cut flowers

Both ENDS offers a wide range of services to **NGOs** in Africa, Asia, Latin America, Central and Eastern Europe, and the Newly Independent States who are working in the field of environment, development and social justice.

Our **standard information service** includes information packs on a wide range of topical environment issues. These packs have been written mainly for Southern NGOs. They are to enable (beginner) environmental organisations to get familiarised with an important environmental subject in a short period of time.

Contents:

- A general overview of the theme
- A listing of useful contacts in North and South
- A list of publications
- A choice of websites

We are making an effort to **regularly update** the information included in these packs. But since people and developments are moving fast, we will inevitably lag behind somewhat. The information presented is meant as an introduction. If you require more specific information, please feel free to **contact us**.

You can **download** the information packs from our website or you can request an e-mail printed version. They are free of charge for NGOs in the South and the CEE countries

We welcome any suggestions or comments, which help improve this information pack.

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Table of Contents

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More information on the flower campaign can be found at:
www.flowercampaign.org

The following Information Packages are available at Both ENDS:

1. Desertification
2. Sustainable Energy
3. Tourism
4. Dams and the Environment
5. Oil
6. Coastal Zone Management
7. Mining
8. Gender, Environment and Development
9. Trade and Environment
10. Local Forest Management
11. Multilateral Financial Institutions
12. Analog Forestry
13. River Management
14. Gene technology
15. Natural Disaster Management
16. The Cotonou Agreement
17. The Rio Conventions
18. Sustainable production of cut flowers, plants and foliage
19. Negotiations: Negotiated Approach and Multi-Stakeholder Dialogue
20. Pest control in cut flowers

What are pesticides?

'Growth' and 'progress' are among the key words in our national vocabulary. But modern man now carries Strontium 90 in his bones ... DDT in his fat, asbestos in his lungs. A little more of this 'progress' and 'growth,' and this man will be dead.
Morris K. "Mo" Udall
American politician (1922 – 1998)

According to Encyclopædia Britannica[1], a pesticide is any toxic substance used to kill animals or plants that damage crops or ornamental plants or that are hazardous to the health of domestic animals or humans. All pesticides act by interfering with the target species' normal metabolism[2].

There are multiple ways of classifying pesticides:

1. They are often classified by the type of organism they are intended to control[3]:
   - Bactericides for the control of bacteria
   - Fungicides for the control of fungi
   - Herbicides for the control of weeds
   - Insecticides for the control of insects
   - Miticides or Acaricides for the control of mites
   - Molluscicides for the control of slugs and snails
   - Nematicides for the control of nematodes
   - Rodenticides for the control of rodents

2. Pesticides can also be classed as synthetic pesticides or biological pesticides, although the distinction can sometimes blur.

3. Broad-spectrum pesticides are those that kill an array of species, while narrow-spectrum, or selective pesticides only kill a small group of species.

4. Some insecticides and fungicides are systemic; they are translocated by a plant from the area of application to other plant parts, where they affect only pests that feed on the crop.

5. Non-selective pesticides can affect both the targeted pest and other organisms; selective pesticides affect only the target pest.

6. Persistent pesticides are those that remain in the environment for a long time. Persistent organic pollutants (POPs) are compounds that resist degradation and thus remain in the environment for years. Some pesticides, including aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, hexachlorobenzene, mirex, and toxaphene, are considered POPs. POPs have the ability to volatilise and travel great distances through the atmosphere to become deposited in remote regions. The chemicals also have the ability to bioaccumulate and biomagnify, and can bioconcentrate (i.e. become more concentrated) up to 70.000 times their original concentrations. POPs may continue to poison non-target organisms in the environment and increase risk to humans by disruption in the endocrine, reproductive, and immune systems; cancer; neurobehavioral disorders, infertility

[1] www.britannica.com
[2] The sum of the chemical reactions that take place within each cell of a living organism and that provide energy for vital processes and for synthesizing new organic material. (www.britannica.com)
[3] http://en.wikipedia.org/wiki/Pesticide

and mutagenic effects, although very little is currently known about these chronic effects. Some POPs have been banned, while others continue to be used.

Most pesticides control the pests by poisoning them. Some inadvertently affect other organisms in the environment, either directly by their toxic effects or via elimination of the target organism. Unfortunately, pesticides can also be poisonous to humans as well. Some are very poisonous, or toxic, and may seriously injure or even kill humans. Others are relatively non-toxic. Pesticides can irritate the skin, eyes, nose, or mouth. The most important thing to remember is that you should always use caution whenever you work with any pesticide![4]

History

Since before 2500 BC, humans have used pesticides to prevent damage to their crops. The first known pesticide was elemental sulphur dusting used in Sumeria about 4500 years ago. In 1200 BC, people were using lime and ashes of wood to protect harvest that was being stored from parasites. In those times, farmers also used plant extracts that prevent the crops from being damaged by insects. The Romans used sulphur and bitumen against leaf rollers in vineyards. By the 15th century, toxic chemicals such as arsenic, mercury and lead were being applied to crops to kill pests. In the 17th century, nicotine sulphate was extracted from tobacco leaves for use as an insecticide. The 19th century saw the introduction of two more natural pesticides, pyrethrum that is derived from chrysanthemums, and rotenone that is derived from the roots of tropical vegetables. In 1939, Paul Müller discovered that Dichloro-Diphenyl-Trichloroethane, or DDT as it is better known, was a very effective control against insects. It quickly became the most widely used pesticide in the world[5]. In the 1940s, manufacturers began to produce large amounts of synthetic pesticides and their use became widespread. Some sources consider the 1940s and 1950s to have been the start of the "pesticide era."

In the early 1960s, developments in agricultural production, sponsored by international funding agencies, led to what came to be called the Green Revolution. These developments emphasised hybrid seeds, mechanisation, and pest control as answers to the agricultural challenges of the South. High-yielding varieties (HYV) were promoted, as was the use of pesticides, and economies of scale of production, which could be successful only through mechanisation of agriculture. This initiative did result in much better production figures across a range of countries.

However, the Green Revolution has been criticised for resulting in environmental disasters in the countries where it was most effective. Mechanisation of agriculture, where successful, led to changing work and social patterns, an exacerbation of class divisions in society, and the displacement of minority groups like tribal peoples and politically marginalised groups such as women from agricultural production. Further, new types of crops were not resistant to local diseases and required high levels of pesticides which polluted local water bodies, depleted the land from fertility, and also increased the dependency of many Southern countries on the North with import of inputs as pesticides, HYVs and fertiliser. Moreover, the commercialisation of agriculture led to the exporting of food out of the local areas, increasing the dependence of producers on market

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[4] Cornell University, Pesticide Safety Education Programme, Pesticide Management Educational Materials, Module 4 Toxicity of Pesticides: http://pmep.cce.cornell.edu/facts-slides-self/core-tutorial/module04/index.html

[5] Paul Hermann Müller, a Swiss chemist working at Geigy Pharmaceutical, was awarded the Nobel Prize in Physiology or Medicine in 1948 "for his discovery of the high efficiency of DDT as a contact poison against several arthropods." www. nobelprize.org

forces that did not always benefit the majority of producers.[6] The Green revolution had also impact on agriculture in general, namely loss of knowledge of local farming systems, of biodiversity through the single use of imported seeds, of knowledge about indigenous seeds and through the use of expensive inputs, farmers had to rely on financial support which created more dependency on banks and more debts.

Pesticide use has increased 50-fold since 1950 and 2.5 million tons (2.3 million metric tons) of industrial pesticides are now used each year. Seventy-five percent of all pesticides in the world are used in developed countries, but use in developing countries is increasing.

In the 1960s, Rachel Carson wrote the best-selling book Silent Spring about biological magnification. After the publication of Silent Spring, the harmful effects of pesticides became recognised throughout the world. Because of their toxicity and persistence, organochlorine insecticides (DDT, Dieldrin, Aldrin) are a threat to wildlife, particularly birds. DDT is moving up to the food chain, from insects to insect eaters, to predators and meat consuming people. In this way, DDT accumulates per chain.

At this moment, many harmful pesticides are banned by national governments. However, as the spectrum of pesticides in the world is still wide and the combination of pesticides use is almost infinite, the (short-term and long-term) effects on people, animals and the environment are unknown.

A new trend is the release of a new pesticide in combination with a genetically modified organism that is genetically protected against this pesticide. The use of the genetically modified organisms, the crossbreeding with natural organisms, the patent or property rights, the use of higher doses of pesticides is very controversial.[7]

Uses and benefits

Pesticides are used to control organisms, which are considered harmful. *Insecticides* are used to kill mosquitoes in and around the house that can transmit potentially deadly diseases like West Nile virus and malaria. They can also kill bees, wasps or ants that can cause allergic reactions. Insecticides can protect animals from illnesses that can be caused by parasites such as fleas. Housing structures can be impregnated, with insecticides and fungicides to prevent termites and mold to destroy and damage the building. *Herbicides* can prevent vehicular accidents by clearing roadside trees and brush, which may block visibility for road users. Herbicides are applied in ponds and lakes to control algae and plants such as water grasses that can interfere with activities

Wise use

The Livelihood Improvement Through Ecology project that was led by the International Rice Research Institute has trained 2,000 farmers to perform experiments in their own fields, which demonstrate that insecticide can be eliminated, and applications of nitrogen fertilizer (urea) reduced without lowering yields. "To my surprise," reported Dr. Jahn, "when people stopped spraying, yields didn't drop -- and this was across 600 fields in two different districts over 4 seasons. I'm convinced that the vast majority of insecticides that rice farmers use, are a complete waste of time and money. In Bangladesh these chemicals were actually distributed free of charge at the expense of the government. So when something is free and there is a question of whether your crop is going to be destroyed maybe by a pest attack, of course you treat whether you need it or not.

Source: Interview with Gary Jahn of the International Rice Research Institute (http://radio.oneworld.net/mediamanage/view/5717?PrintableVersion=enabled). 'Bangladeshi Farmers Take on Role of Scientists and Banish Insecticides' by International Rice Research Institute (http://www.cgiar.org/enews/sept2004/story_01.html)

[6] The Concise Oxford Dictionary of Politics.
[7] http://nl.wikipedia.org/wiki/Chemisch_bestrijdingsmiddel

like swimming and fishing. Sport fields are kept green and grassy by herbicides that prevent weeds to invade. *Rodenticides* are used in houses, grocery stores and food storage facilities to prevent rodents, as mice and rats to infest food such as grain. *Fungicides* prevent decay of food products during long transport over sea.

Each use of a pesticide carries associated risks. Wise use of pesticides, based on the comparison of the 'no' use situation including the associated economic, social and environmental losses and the situation of 'do' use including the associated economic, social and environmental losses, decreases these associated risks to a level deemed acceptable and may increase quality of life and protect property and the environment.

Some scientists estimate that DDT and other chemicals in the organophosphate class of pesticides have saved 7 million human lives since 1945 by preventing the transmission of diseases such as malaria, bubonic plague, sleeping sickness, and typhus.[8] There are no figures on how many human lives are because of the use of pesticides.

Although the dangers of DDT are known, the World Health Organisation is suggesting to the resumption of the limited use of DDT to fight malaria. They called for the use of DDT to coat the inside walls of houses in areas where mosquitoes are prevalent. Dr. Arata Kochi, WHO's malaria chief, said, "One of the best tools we have against malaria is indoor residual house spraying. Of the dozen insecticides WHO has approved as safe for house spraying, the most effective is DDT."[9]

Regulation
In most countries, in order to sell or use a pesticide, it must be approved by a government agency. Complex and costly studies must be conducted to indicate whether the material is safe to use and effective against the intended pest. During the registration process, a label is created which contains directions for the proper use of the material. Based on acute toxicity, pesticides are assigned to a toxicity class.
Some pesticides are considered too hazardous for sale to the general public and are designated restricted use pesticides. "Read and follow label directions" is a phrase often quoted by extension agents.

Pesticides in agriculture in general

The more we pour the big machines, the fuel, the pesticides, the herbicides, the fertiliser and chemicals into farming, the more we knock out the mechanism that made it all work in the first place.
David R. Brower
Founder of Friends of the Earth (1912 – 2000)

Today overwhelmingly agricultural commodities are produced under so-called conventional agricultural methods. This includes a pest control strategy based on high input of synthetic pesticides as a sole means to tackle pests, weeds and diseases. It has been estimated that 90% of the pesticides that are applied do

[8] Sustaining the Earth, 6th edition. Thompson Learning, Inc. Pacific Grove, California. Chapter 9, Pages 211-216.
[9] WHO September 2006: WHO gives indoor use of DDT a clean bill of health for controlling malaria. http://www.who.int/mediacentre/news/releases/2006/pr50/en/

not reach the targeted species.[10] Associated with this way of production manifold problems arise. This chapter deals with those associated problems.

Effects on people

Farmers, farm workers, their families, and consumers are exposed to dangerous synthetic pesticides. Handling, storage and disposal of these chemical agricultural inputs can cause acute and chronic negative health effects, cause cancer and negatively influence reproduction or disrupt the endocrine system. Pesticide residues in food and drinking water can cause similar problems affecting an even greater number of people.

There have been many studies of *farmers* and *agricultural workers (and their families through contact with contaminated family members and their contaminated clothes)* with the goal of determining the health effects of pesticide exposure. The Food and Agricultural Organisation estimates that one to five million cases of pesticide poisoning occur every year, resulting in several thousand fatalities among agricultural workers and farmers. Most of these poisonings occur in the South where safe health standards can be inadequate or non-existent. Although these countries use only 25% of global pesticide production, they account for a staggering 99% of the related deaths.[11] Organophosphate pesticides (used as insecticide) have increased in use, as they are less damaging to the environment, because they degrade rapidly on exposure to sunlight, air, and soil. Their ability to degrade made them an attractive alternative to the persistent organochlorine pesticides. However, they have greater acute toxicity, posing risks to people who may be exposed to large amounts. Organophosphate pesticides are associated with acute health problems for workers that handle the chemicals, such as abdominal pain, dizziness, headaches, nausea, vomiting, as well as skin and eye problems. Additionally, many studies have indicated that pesticide exposure is associated with long-term health problems such as respiratory problems, memory disorders, dermatologic conditions, cancer, depression, neurologic deficits, miscarriages, and birth defects. Summaries of peer-reviewed research have examined the link between pesticide exposure and neurologic outcomes and cancer, perhaps the two most significant things resulting in organophosphate-exposed workers.[12]

Food crops, including fruits and vegetables, can still contain pesticide residues after being washed or peeled, which can be a danger for the health of *consumers*. Study indicates that there is a 70% increase in the risk of developing Parkinson's disease for people exposed to even low levels of pesticides.[13] Children are both more exposed to toxic substances in the environment than adults and more susceptible to many toxic chemicals. The National Academy of Sciences, in a pioneering 1993 report, clearly showed that children bear disproportionately high risks from USA's use of pesticides on food. Their report focused on children's dietary exposure to pesticides but looked only at children living in non-agricultural areas. For many children, particularly those from agricultural families, food represents only a small portion of their total daily exposure to hazardous

[10] http://www.cep.unep.org/marine-issues/plonearticlemultipage.2005-10-12.0116192785/plonearticle.2005-10-12.2879067841

[11] 'Farm workers need to be better protected against pesticides. FAO and UNEP call for stronger safety measures' press release FAO, 22 September 2004, Geneva/Rome. http://www.fao.org/newsroom/en/news/2004/50709/index.html

[12] 'Pesticide health effects on humans.' Cornell University, Pesticide Safety Education Programme, Pesticide Management Educational Materials: http://pmep.cce.cornell.edu/facts-slides-self/facts/gen-posaf-health.html

[13] 'Pesticide exposure and risk for Parkinson's disease' by Alberto Ascherio, Honglei Chen, Marc G. Weisskopf, Eilis O'Reilly, Marjorie L. McCullough, Eugenia E. Calle, Michael A. Schwarzschild, Michael J. Thun in Annals of Neurology, volume 60, no 2, p. 197-203: http://www3.interscience.wiley.com/cgi-bin/abstract/112660877/ABSTRACT and http://www.newscientist.com/article/dn9408-pesticide-exposure-raises-risk-of-parkinsons.html

pesticides[14]. A study from 2005 measured the levels of organophosphorus pesticide exposure in 23 school children before and after replacing their diet with organic food (food grown without synthetic pesticides). In this study, it was found that levels of organophosphorus pesticide exposure dropped dramatically and immediately when the children switched to an organic diet.[15]

Another exposure route than direct handling of pesticides and consuming food that contains residues, is *pesticide drift*. If pesticide spray reaches areas other than the intended crop, it is called pesticide drift. There is two ways pesticides can be carried downwind to non-target areas: vapour drift and particle drift. Pesticide drift is a danger to the safety and health of nearby people, to desirable plants and animals and users of pesticides must ensure that all reasonable precautions are taken to prevent spray drift.

Effects on society

The use of synthetic pesticides very often is connected to a vicious cycle of financial dependency and dependency of farmers on credits for these inputs. This agrochemical treadmill is leading to increasing indebtedness of farmers with immense negative effects for the economy of farm families and rural communities. Suicides committed because of debts are common. Other consequences of indebtedness are migration, loss of land and culture. The high input of synthetic pesticides in conventional agriculture creates a spiral of dependency as they destroy beneficial organisms and induce resistance, creating the need for new and more expensive pesticides. The total dependency on chemical pesticides and the pesticides industry results in a lack of choice for farmers and their families in terms of choice of crops, choice of seeds, choice of production system, and it contradicts the right to food sovereignty.
External costs for society due to pesticides impact on health and environment are not reflected in the costs of pesticides (e. g. costs for health treatment, costs arising from illness related lack of work, loss in biodiversity and costs for water treatment).

The biggest pesticide accident

The Bhopal Disaster took place in the early hours of the morning of 3 December 1984, in the heart of the city of Bhopal in the Indian state of Madhya Pradesh. A Union Carbide subsidiary pesticide plant released 40.000 kg of methyl isocyanate (MIC) gas, which is an intermediate chemical in the production of some insecticides. The disaster immediately killed nearly 3,000 people. According to the Bhopal Medical Appeal around 520.000 people were exposed to the leaking tables. Approximately 20.000 to this date are believed to have died as a result; on average, roughly one person dies every day from the effects. Today, over 120.000 people continue to suffer the effects of the disaster, such as breathing difficulties, cancer, serious birth-defects, blindness, gynaecological complications and other related problems. Bhopal is frequently cited as one of the world's worst industrial disasters.

Source:
www.bhopal.org
http://www.unioncarbide.com/bhopal/

Effects on the environment

Pesticides are nowadays found in virtually all natural habitats, including those where pesticides have never been applied. They have severe negative effects on natural flora and fauna, biodiversity, water resources and ecosystem functioning and the equilibrium of agricultural systems.[16]

[14] 'Trouble on the Farm, Growing Up with Pesticides in Agricultural Communities' http://www.nrdc.org/health/kids/farm/exec.asp
[15] 'Organic Diets Significantly Lower Children's Dietary Exposure to Organophosphorus Pesticides' by Chensheng Lu, Kathryn Toepel, Rene Irish, Richard A. Fenske, Dana B. Barr, and Roberto Bravo. http://www.ehponline.org/docs/2005/8418/abstract.html
[16] Pesticides Action Network: Alternatives to synthetic pesticides in agriculture - A PAN International Position Paper - Working Group 4, 18 June 2007

Use of pesticides can have unintended effects on the environment. Over 98% of sprayed insecticides and 95% of herbicides reach a destination other than their target species, including non-target species, air, water, bottom sediments, and food. Pesticide contaminates land and water when it escapes from production sites and storage tanks, when it runs off from fields, when it is discarded, when it is sprayed aerially, and when it is sprayed into water to kill algae. The amount of pesticide that migrates from the intended application area is influenced by the particular chemical's properties: its propensity for binding to soil, its vapour pressure, its water solubility, and its resistance to being broken down over time. Factors in the soil, such as its texture, its ability to retain water, and the amount of organic matter contained in it, also affect the amount of pesticide that will leave the area.

Air

Pesticides can contribute to *air pollution*. Pesticide drift occurs when pesticides suspended in the air as particles are carried by wind to other areas, potentially contaminating them. Pesticides that are applied to crops can volatilise and may be blown by winds into nearby areas, potentially posing a threat to other living organisms as plants, animals and humans. Also, droplets of sprayed pesticides or particles from pesticides applied as dusts may travel on the wind to other areas, or pesticides may adhere to particles that blow in the wind, such as dust particles. Ground spraying produces less pesticide drift than aerial spraying does. Farmers can employ a buffer zone around their crop, consisting of empty land or non-crop plants such as evergreen trees to serve as windbreaks and absorb the pesticides, preventing drift into other areas[17].

Methyl Bromide alternatives

Source:
Ozzy Ozone, Defender of our Planet: Ozzy Goes Farming, UNEP: http://www.unep.fr/en/info/publications.htm

The fragile shield of ozone is being damaged by chemicals released on earth. An important chemical that is *depleting stratospheric ozone* is Methyl Bromide, also known as Bromomethane. Methyl Bromide is used as a soil sterilant, mainly for production of seed but also for some crops such as in horticulture (strawberries and flower production). Methyl Bromide was also used as a general-purpose fumigant to kill a variety of pests including rats, insects. It has poor fungicidal properties. Since 1 January 2005, Methyl Bromide has been listed as a banned ozone-depleting substance of the Montreal Protocol, as even small amounts of Methyl Bromide cause considerable damage to the ozone layer.

Water

There are five major routes through which pesticides reach the water:

- It may drift outside of the intended area when it is sprayed;
- It may percolate, or leach, through the soil;
- It may be carried to the water as runoff, or;

[17] Such windbreaks are legally required in the Netherlands. http://www.sciencedaily.com/releases/1999/11/991119075237.htm

- It may be spilled, for example accidentally or through neglect;
- It may also be carried to water by eroding soil.

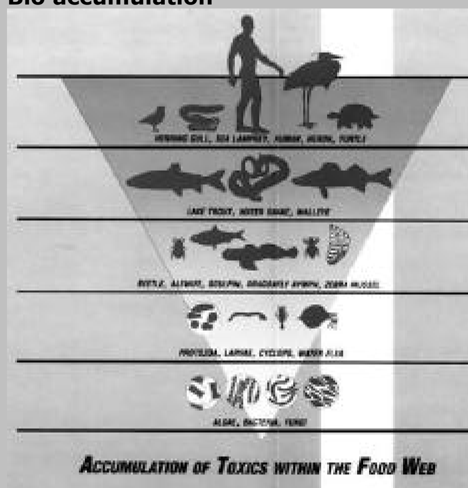
Factors that affect a pesticide's ability to contaminate water include its water solubility, the distance from an application site to a body of water, weather, soil type, presence of a growing crop, and the method used to apply the chemical. Sometimes, amounts of pesticides are found in drinking water (for people, but also for animals) that originating from surface water.

Soil
Many of the chemicals used in pesticides are persistent *soil contaminants*[18], whose impact may endure for decades and adversely affect soil conservation. The use of pesticides decreases life in the soil and therefore the general biological diversity in the soil.

Flora
Nitrogen fixation, which is required for the growth of higher plants, is hindered by pesticides in soil. The insecticides DDT, methyl parathion, and especially pentachlorophenol have been shown to interfere with legume-rhizobium chemical signalling. Reduction of this symbiotic chemical signalling results in reduced nitrogen fixation and thus reduced crop yields. Root nodule formation in these plants saves the world economy $10 billion in synthetic nitrogen fertiliser every year.
Pesticides can kill bees and are strongly implicated in *pollinator decline*, the loss of species that pollinate plants. Application of pesticides to crops that are in bloom can kill honeybees, which act as pollinators.

Fauna
Animals may be poisoned by pesticide residues that remain on food after spraying, for example when wild animals enter sprayed fields or nearby areas shortly after spraying. Widespread application of pesticides can eliminate food sources that certain types of animals need, causing the animals to relocate, change their diet, or starve. Poisoning from pesticides can travel up the food chain; for example, birds can be harmed when they eat insects and worms that have consumed pesticides. Some pesticides can *bioaccumulate*, or build up to toxic levels in the bodies of organisms that consume them over time, a phenomenon that impacts species high on the food chain especially hard. *Birds* are common examples of non-target organisms that are impacted by pesticide use. There is evidence that birds are continuing to be harmed by conventional agricultural practices and pesticide use. In the farmland of Britain, populations of ten different species of birds have declined by 10 million breeding individuals between 1979

Bio accumulation



Source
http://www.ijc.org/php/publications/html/11br/english/report/chapter2/index.html

[18] Soil contaminant is the presence of man-made chemicals or other alteration in the natural soil environment. This type of contamination typically arises from the rupture of underground storage tanks, application of pesticides, percolation of contaminated surface water to subsurface strata, leaching of wastes from landfills or direct discharge of industrial wastes to the soil. The most common chemicals involved are petroleum hydrocarbons, solvents, pesticides, lead and other heavy metals. This occurrence of this phenomenon is correlated with the degree of industrialization and intensity of chemical usage.

and 1999, a phenomenon thought to have resulted from loss of plant and invertebrate species on which the birds feed[19]. In another example, some types of fungicides used in peanut farming are only slightly toxic to birds and mammals, but may kill off earthworms, which can in turn reduce populations of the birds and mammals that feed on them because of decreased availability of food. The herbicide paraquat, when sprayed onto bird eggs, causes growth abnormalities in embryos and reduces the number of chicks that hatch successfully, but most herbicides do not directly cause much harm to birds. Herbicides may endanger bird populations by reducing their habitat.[20]
Fish and other aquatic animals may be harmed by surface runoff into rivers, streams and the sea. The negative effects of pesticides in the marine and coastal environments include changes in reef community structure, such as decreases in live coral cover and increases in algae and sponges and damage to sea grass beds and other aquatic vegetation from herbicides. Marine organisms may be affected either directly, as the pesticide moves through the food chain and accumulate in the biota, or by loss or alteration of their habitat. This, in turn, will lead to decreased fisheries production. Pesticides may cause fish kills in areas of poor water circulation.
Application of herbicides to bodies of water can cause fish kills when the dead plants rot and use up the water's oxygen, suffocating the fish. Some herbicides, such as copper sulphite, that are applied to water to kill plants are toxic to fish and other water animals at concentrations similar to those used to kill the plants. Repeated exposure to sub-lethal doses of some pesticides can cause physiological and behavioural changes in fish such as abandonment of nests and broods, decreased immunity to disease, and increased failure to avoid predators. This can cause reduction of populations.[21]
Areas under particular threat are those with little water exchange and circulation, where pesticide residues do not get flushed out quickly.[22] The faster a given pesticide breaks down in the environment, the less threat it poses to aquatic life. Insecticides are more toxic to aquatic life than herbicides and fungicides.[23]

Other side effects of pesticides
Pests may eventually evolve to become resistant to chemicals, which is called *pesticide resistance*. When sprayed with pesticides, many pests will initially be very receptive. However, some pests with slight variations in their genetic makeup are resistant and therefore survive. Through reproduction, the pests may eventually become very resistant to the pesticide. Pest resistance to a pesticide is commonly managed through pesticide rotation, which involves alternating among

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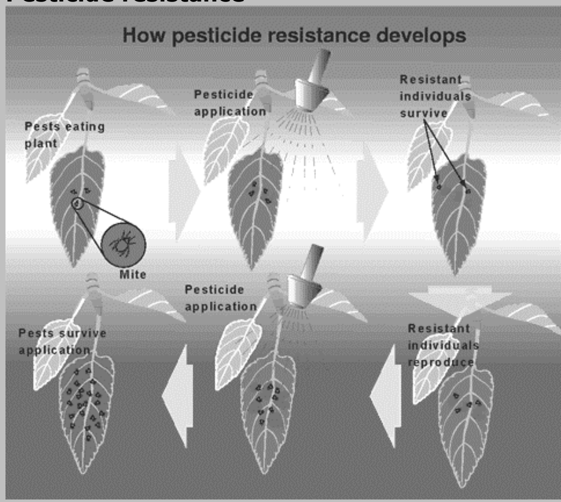
[19] "The second Silent Spring? The drive to squeeze ever more food from the land has sent Europe's farmland wildlife into a precipitous decline. How can agricultural policy be reformed so that we have fewer grain mountains and more skylarks?" by John R. Krebs, Jeremy D. Wilson, Richard B. Bradbury and Gavin M. Siriwardena in Nature, volume 400, 12 august 1999, www.nature.com
[20] 'Wildlife & Pesticides – Peanuts' by William E. Palmer, Peter T. Bromley, and Rick L. Brandenburg in http://ipm.ncsu.edu/wildlife/peanuts_wildlife.html
[21] 'Pesticides and Aquatic Animals: A Guide to Reducing Impacts on Aquatic Systems' by Louis A. Helfrich, Extension Specialist, Fisheries and Wildlife Sciences, Virginia Tech; Diana L. Weigmann, Director, Office of Science, Engineering, and Technology, Carson City, Nevada; Patricia Hipkins, Virginia Pesticide Programs, Department of Entomology, Virginia Tech; and Elizabeth R. Stinson, Virginia Department of Game and Inland Fisheries, Blacksburg, Virginia. Publication Number 420-013, June 1996. http://www.ext.vt.edu/pubs/waterquality/420-013/420-013.html#L4
[22] http://www.cep.unep.org/marine-issues/plonearticlemultipage.2005-10-12.0116192785/plonearticle.2005-10-12.2879067841
[23] 'Pesticides and Aquatic Animals: A Guide to Reducing Impacts on Aquatic Systems' by Louis A. Helfrich, Extension Specialist, Fisheries and Wildlife Sciences, Virginia Tech; Diana L. Weigmann, Director, Office of Science, Engineering, and Technology, Carson City, Nevada; Patricia Hipkins, Virginia Pesticide Programs, Department of Entomology, Virginia Tech; and Elizabeth R. Stinson, Virginia Department of Game and Inland Fisheries, Blacksburg, Virginia. Publication Number 420-013, June 1996. http://www.ext.vt.edu/pubs/waterquality/420-013/420-013.html#L4

pesticide classes with different modes of action to delay the inception of or diminish existing pest resistance[24].

Pesticide resistance



Source: http://grapes.msu.edu/pesticideResist.htm

Another side effect is *pest resurgence*. Pest resurgence occurs because the pesticides remove next to the pests their natural enemies. Either the natural enemies are killed or they leave the area since their food is no longer available. Consequently, there is an opportunity for the temporarily removed pests to reproduce before their natural enemies return. A related side effect is *secondary pest outbreak*, when a new species may become serious pests when their natural predators are killed. Spider mites, for example, caused havoc when DDT and other insecticides killed their predators.25 In both pest resurgence and secondary pest outbreaks, the presence of natural enemies is more determined by the pesticides than the pests themselves, which might result in a higher pest population than it was before the use of pesticide.

Pests in flower production and possible treatment

Each Valentine's day, when […] consumers purchase millions of flowers for their loved ones and deeply inhale the fresh aroma of roses and carnations, they rarely think about where the flowers come from or how they are produced. Yet, if these same people knew more about the high levels of agrochemicals used in flower production and the often less-than-rosy labour conditions under which flowers are produced, they might think twice about sinking their noses into the petals to smell the perfume.
Environmental Health Perspectives [Volume 110, Number 5, May 2002]

Many pests attack different parts of different flower crops. In this part, only the most common are being discussed. This chapter heavily depends upon the comprehensive website op the University of California, Agriculture and Natural Resources and their programme UC IPM Online: state-wide integrated pest management programme.[26]

1. *Aphids*, also known as greenfly or plant lice, are minute plant-feeding insects. They are found in Alstroemeria, Carnation, Chrysantheumum, Gerbera, Statice

[24] 'How pesticide resistance develops' Excerpt from Fruit Crop Ecology and Management, Chapter 2: Managing the Community of Pests and Beneficials by Larry Gut, Annemiek Schilder, Rufus Isaacs and Patricia McManus.
[25] "Pesticides" Online Ethics Centre for Engineering 7/6/2006 12:41:37 AM National Academy of Engineering Accessed: Wednesday, November 28, 2007 <www.onlineethics.org/CMS/profpractice/exempindex/carsonindex/pesticides.aspx>
[26] http://www.ipm.ucdavis.edu/index.html

2. *Spider mites* are members of the arachnid class and generally live on the under sides of leaves of plants, where they may spin protective silk webs, and they can cause damage by puncturing the plant cells to feed. Spider mites are found in Carnation, Chrysanthemum, Gerbera.
3. *Greenhouse whiteflies*, comprising only the family Aleyrodidae, are small bugs and more than 1550 species have been described. Whiteflies typically feed on the underside of plant leaves. The leave damage and the transmission of virus can cause economic losses. White flies are found in Alstroemeria, Chrysanthemum, Gerbera.
4. *Thrips* are tiny insects that have four featherlike wings, each consisting of a thick supporting strut with fine hairs on the front and hind edges. Thrips feed on a large variety of plant sources by puncturing them and sucking up the contents. Thrips are found in Carnation, Chrysanthemum, Gerbera.
5. *Leaf miners* are insect larvae that live within leaf tissue. Many cause damage to garden plants and crops. Leaf miners are found in Carnation, Chrysanthemum, Gerbera.
6. *Mealybug* is the common name of insects in Pseudococcidae, a family of un-armoured scale insects found in moist, warm climates. They are considered pests as they feed on plant juices of greenhouse plants, houseplants and subtropical trees. Mealybugs are found in Chrysanthemum.
7. *Root-knot nematodes* are plant-parasitic nematodes from the genus Meloidogyne. They exist in soil in areas with hot climates or short winters. About 2.000 plants are susceptible to infection by root-knot nematodes and they cause approximately 5% of global crop loss. Root-knot nematode larvae infect plant roots causing the development of root-knot galls that drain the plant's photosynthate and nutrients. Infection of young plants may be lethal, while infection of mature plants causes decreased yield. Nematodes are found in Gerbera, Gypsophilia, Rose, Statice.
8. *Powdery mildew* is the name given to diseases resulting from infection by fungi that produce a white, powdery appearance on the surfaces of leaves and sometimes other plant parts. Leaves may yellow, then brown and die. Infected tissues may be distorted and misshapen. Powdery mildew is found in Carnation, Chrysanthemum, Gerbera, Rose, Statice.
9. *Root rot* is a condition found in both indoor and outdoor plants, although more common in indoor plants with poor drainage. As the name states, the roots of the plant rot. Usually, this is a result of over-watering. In both indoor and outdoor plants, it is usually lethal and there is no treatment. Root rot is found in Alstroemeria, Carnation, Chrysanthemum, Gerbera, Gypsophilia, Rose.
10. *Rusts* are fungi of the order Uredinales. Many of these species are plant parasites. Rusts most commonly reproduce via asexual spore production. Their spores are airborne and can travel great distances. They mostly cause foliar infections, which look like the corrosion process of iron. Rust is found in Carnation, Gerbera, Gypsophilia, Rose, Statice.

Aphids

Aphids are distinguished from other insects by the presence of cornicles, tube-like appendages that protrude from the rear of the aphid. Adult aphids may or may not have wings. Winged aphids are produced because of crowding. Adult aphids give birth to live young. Generally, aphids begin giving birth when they are 7 to 10 days old, depending on temperature.

Aphids excrete copious amounts of honeydew, a sweet, sticky substance that they produce as they feed on the plants. The honeydew can cover leaves and other plant parts and cause the plants to become sticky. Black sooty molds then grow on the honeydew. The white shed skins of the aphids frequently are stuck to the plant surfaces by the honeydew and further detract from the plant's appearance. Sufficient feeding can cause foliage to become yellowed, and feeding on newly developing tissues can cause those parts to become twisted as they grow. Aphids are known to transmit plant viruses.

Aphid on a rose bud

Photo by Arne Heijenga

Because aphids feed on a large variety of plant species, keep production areas free of weeds, which can serve as hosts of aphid populations. Exclusion of winged adults can be accomplished by covering openings to the greenhouse with screens that have a pore width of 355 µm or smaller. Before starting a new crop, carefully inspect plants to ensure that they are free of aphids and other pests. Treat or rogue any infested plants.

To monitor aphids, yellow sticky cards are placed in greenhouses that will capture winged adults. However, aphids produce winged individuals in response to crowding so monitoring plants for infestations is an essential component of managing and detecting these pests before populations get too high. Use at least one sticky trap per 900 m^2 of growing area for monitoring aphids. Consider treating if an average of 5 to 10 aphids per card per week is present.

To control aphids biologically, predators such as lacewings (Chrysoperla spp.) and midges (Aphidoletes aphidimyza) are commercially available. Parasites, such as Aphidius spp., Lysiphlebus testaceipes, Diaeretiella rapae, and Aphelinus abdominalis, are also commercially available.

Two spotted spider mites

Spider mites at gardenia

Photo by Luxes

Two spotted spider mites are web-forming mites that pierce plant cells and remove their contents. All spider mites have two body segments and four pairs of legs as adults. Two spotted spider mite adults, as the name suggests, have two large dark spots on the sides of their yellowish green bodies. These mites lay round eggs that hatch into six-legged larvae. The subsequent stages, the proto-nymph and deuto-nymph stages, are eight-legged as are the adults. Since the entire life cycle can take as little as 8 (25-35°C) to 28 (10-20°C) days, spider mites have many generations per year and can rapidly increase in number.

Two spotted mites suck cell contents from leaves, initially stippling leaves with a fine pale green mottling. As feeding continues, the stippling increases and leaves turn yellow with bronzed or brown areas; damaged leaves frequently fall. Undersides of leaves may have many cast skins of mites, and the webbing on foliage is anaesthetic. Plants may become severely stunted when large mite populations are allowed to feed and the plants may die.

Because spider mites feed on a large variety of plants, keep production areas free of weeds, which can serve hosts to the mites. Carefully inspect plants being brought in to start a new crop to ensure that they are free of mites. Rogue or treat infested plants.

Monitor the crop regularly, as indirect sampling methods (such as sticky cards) are ineffective. Observe the undersides of leaves with a 10X hand lens, and watch for changes in plant foliage, which is characteristic of mite feeding.

Many different species of predatory mites are available for biological control of these mites under different conditions. Phytoseiulus persimilis is a commercially available predator of two-spotted spider mite, and it has been used to control mite populations in greenhouses and field situations. It can reproduce faster than its prey, yet best results have been obtained when it is released into the crop well before the spider mite populations have built up.

Greenhouse whitefly

White fly

Photo by Lisa Brown

The greenhouse whitefly adult is 0.9 (male) to 1.1 mm (female) long, with four wings, sucking mouthparts, a powdery waxy coating over the body, and wings that give the otherwise yellow body a white colour. The wings are held nearly parallel to the leaf and cover the abdomen when the adult is at rest. There are seven life stages: egg, four nymphal instars, pupal stage, and the adult. Females occasionally lay eggs in circles on the undersides of leaves of plants with smooth leaves. Eggs are partially inserted into the leaf, initially they are yellowish, but close to hatching, they turn a purplish brown. The first nympal instar is called a crawler and has functional legs, while the remaining instars are attached to the underside of the leaf and do not move. The end of the fourth instar is called a pupa. The pupal stage is the most important for determining whitefly species identification. Greenhouse whitefly pupae are oval and have vertical sides, giving the pupa a cake-like appearance from the side. Along the perimeter of the upper surface is a fringe of filaments and relatively large wax filaments project above the upper surface of the body. The greenhouse whitefly can complete one generation in 21 to 26 days at 27°C.

Whitefly adults and immatures feed on sap. As they feed, they excrete honeydew, a sticky substance that causes unsightly glistening and supports the growth of black sooty mold. Very large populations of whiteflies cause stunting of plant growth, and leaves may senesce and die. Physiological abnormalities, such as white stem on poinsettia, may also occur. Usually populations are not high enough to stunt ornamentals, and damage is mostly caused by honeydew, sooty mold, and nuisance populations of flying adults.

Because whiteflies feed on a large variety of plant species, keep production areas free of weeds, which can serve as hosts for whitefly populations. Exclusion of winged adults can be accomplished by covering openings to the greenhouse with screens that have a pore width of 405 µm or smaller. Before starting a new crop, carefully inspect plants to ensure that they are free of whiteflies and other pests. Treat or discard any infested plants.

To monitor whiteflies, yellow sticky cards are placed in greenhouses that will capture adult whiteflies. However, traps need to be used at a greater density, one per 90 m^2, than for other pests. Trap monitoring should be supplemented with inspection of leaves for nymphs and pupae. When monitoring plant samples, it is imperative to look on the undersides of leaves for adults and nymphs. Treatment thresholds vary with the crop. For example, cut flowers such as Gerberas can tolerate more whiteflies than poinsettias because only the flowers are harvested in the cut flower crop whereas the entire poinsettia plant is marketed.

Encarsia formosa, a tiny, sting-less parasitic wasp, is as an effective biological control for greenhouse whiteflies. Wasps are released once a week at a rate of two to five parasites per plant for 8 to 10 weeks of the growing season. This sort of release programme can be effective if long residual insecticides have not been applied in advance of the parasite release, and where the initial population of whiteflies is quite low (only a few whiteflies per plant). Greenhouse whitefly pupae turn black when parasitized by Encarsia, which emerge as adults through circular exit holes. Delphastus pusillus, a whitefly predator, has been used against silver leaf whiteflies. Eretmocerus eremicus is a commercially available whitefly parasite for silver leaf whitefly. It will also attack greenhouse whitefly, whereas Encarsia is ineffective against silver leaf whitefly.

Thrips

Thrip on finger

Photo by Open cage

There are two types of thrips important in flower production, namely western flower thrips and greenhouse thrips.
Western flower thrips have three colour forms (pale, intermediate and dark) that vary in abundance depending on the time of year. Western flower thrips usually feed in enclosed tissues such as flowers, buds, or growing tips. Adults also feed on pollen and on spider mites. The prepupa and pupal stages take place in the soil beneath infested plants. Females will lay male eggs if unmated and female eggs are produced once mating has occurred. Development times to complete one generation of western flower thrips varies from 11 days to 44 days. Adult greenhouse thrips are tiny, black, insects with whitish to translucent wings folded back over their thorax and abdomen. Legs are also a whitish colour. Nymphs are whitish to slightly yellowish in colour and produce a globule of faecal fluid at the tip of their abdomen. These globules of fluid increase in size until they fall off and another one begins to form, resulting in a characteristic spotting of the infestation area with black specks of faecal material.

Western flower thrips primarily feeds on flowers but also sometimes on new vegetative growth, whereas greenhouse thrips feeds primarily on foliage. Direct feeding damage includes streaking, spotting, and tissue distortion. On leaves, feeding often occurs along veins and appears as an outlining of the veins. Western flower thrips can vector tomato spotted wilt virus as well as many other viruses. Western flower thrips may cause premature senescence of flowers, such as African violets, because they prematurely pollinate the flowers. On orchids, western flower thrips feeding and egg laying will leave translucent 'pimpling' spots on petals and leaves. Greenhouse thrips stipple the foliage of numerous field and greenhouse grown plants. The stippling damage caused by thrips feeding on individual cells is often confused with mite stippling. Thrips feeding is often accompanied, however, by black, varnish-like flecks of dried excrement whereas mite stippling is often accompanied by webbing or shed skins.

Because western flower thrips and greenhouse thrips feed on a large variety of plant species, keep production areas free of weeds, which can serve as hosts for thrips populations. Most commercially available screens have pore sizes slightly larger than the width of the western flower thrips thorax (145 μm), meaning that some winged adults can penetrate these openings. However, covering openings to the greenhouse with fine screens does exclude most thrips. Be sure that the ventilation system on an existing greenhouse can accommodate the reduced flow caused by a fine screen or else the system will need to be modified. Carefully inspect plants being brought in to start a new crop to ensure that they are free of thrips and other pests. A holding area where plants are kept for about 11 to 12 days is useful so that plants can be inspected for any infestations that may develop. Treat any infested plants if necessary.

To monitor western flower thrips, blue sticky cards are most suitable, because this colour is attractive to western flower thrips. However, yellow cards are good predictors of western flower thrips populations, are easier to count and are more commonly used for general-purpose insect monitoring. Place yellow sticky cards vertically in the crop canopy, with the lower one-third of the trap in the leaves and the upper two-thirds above the leaves. As the crop grows, the traps will need to be raised. There is little research on the most effective trap density to use or on treatment thresholds. In greenhouses with many different cultivars, place traps in the most sensitive varieties, usually yellow or white flowers. In large greenhouses of the same or similar cultivars, there should be at least eight traps per 9000 m^2. The treatment threshold for roses is 25 to 50 thrips per card per week (25 for more sensitive yellow- and white-flowered varieties, 50 for reds). In other crops, place one card per 900 m^2. Consider treating if an average of 5 to 10 thrips per card per week is present. It is important to note that correct identification of pest thrips is essential in a monitoring programme. There may be several species of thrips present on a sticky card but only the western flower thrips and greenhouse thrips should be counted when making treatment decisions.

Three commercially available predators to help control western flower thrips are:

- The minute pirate bug, Orius tristicolor;
- The predatory mite, Neoseiulus cucumeris; and
- The predatory mite Hypoaspis miles.

Minute pirate bugs are feeding on many different kinds of food and will also feed on aphids, mites, and small caterpillars. Orius are released at a rate of 5000 to 7500 per hectare, while Neoseiulus cucumeris are released at a rate of 10 to 50 mites per plant for each of 2 to 3 weeks. These mites will also feed on spider mite eggs, pollen, and fungi. Hypoaspis miles are soil-inhabiting predators that feed on thrips prepupae and pupae in the soil. These mites are generally released in the soil at planting and are most successful at controlling thrips when there is plant-to-plant contact that facilitates movement of the predators between plants. A commercially available parasite of greenhouse thrips is Thripobius semileteus.

Leaf miners

Adult leaf miners are small, yellow and black flies that are about the same size and shape as fruit flies. They are often found on yellow flowers or objects. Females insert their eggs within leaves and puncture the leaf surface with the ovipositor to feed on damaged plant tissue.

When populations are high, stippling, caused by females puncturing the leaves with their ovipositor to feed and lay eggs, can be serious. However, most of the damage is caused by the larval mines that detract from the aesthetic value of the crop.

Leaf miner in rose leaf

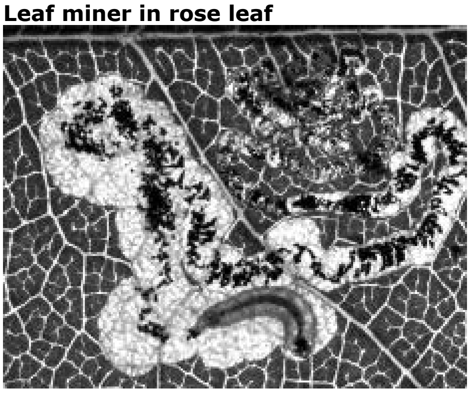


Photo by Losser, Brummen/ Zoölogisch Museum Amsterdam

Because leaf miners feed on a large variety of plant species, keep production areas free of weeds, which can serve as reservoirs for leaf miner populations. Leaf miners breed in weed or crop hosts outside of greenhouses, so weed management outside the greenhouse and exclusion of immigrating adults are especially valuable as management practices. Effective screens require a pore width of 600 µm or smaller. Carefully inspect plants being brought in to start a new crop to ensure that they are free of mines; discard infested plants or leaves. Steam planting beds immediately after removing infested plantings to eliminate leaf miner pupae in the soil.

To monitor leaf miners, yellow sticky cards are placed in greenhouses that will capture adults. Place one trap per 900 m^2 and monitor weekly.

Biological control normally keeps these species in check in outdoor situations. The parasites Diglyphus spp. and Dacnusa sibirica are commercially available to control leaf miners and may be useful in greenhouse situations, especially if greenhouses are screened to exclude adult leaf miner movement into greenhouses.

Mealybug

Mealybugs are slow-moving sucking insects that have a loose, waxy coating on the body, which gives them their "mealy" appearance. Mealybug infestations often occur underneath foliage and in hidden areas within dense foliage.

Mealybugs on leaf

Photo by C Dozo

Mealybugs remove sap from plants, which can cause yellowing of leaves and decline in vigour. Mealybug ovisacs and excreted honeydew are unsightly. Honeydew supports the growth of black sooty mold fungi and attracts ants; ants may then carry mealybugs to uninfested plants and tend them for honeydew.

Carefully inspect plants being brought in to start a new crop to ensure that they are free of mealybugs and other pests. If necessary, treat infested plants. Regularly inspect plants for signs of honeydew (i.e., glistening, sticky leaves) and ant activity. Well-established infestations containing females with ovisacs are much more difficult to control with either systemic or contact insecticides than new infestations because reproducing adults usually stop feeding and the females' body or the wax secretions help protect eggs or crawlers.

Cryptolaemus montrouzieri, the mealybug destroyer lady beetle, is an effective predator of citrus and Mexican mealybugs and other ovisac-forming sucking insects (such as green shield scale). Larval mealybug destroyers themselves look like large, faster-moving mealybugs, but are readily distinguished by their chewing mouthparts. Leptomastix dactylopii, a parasite of citrus mealybugs, is also commercially available. Effective predators or parasites of long-tailed mealybugs are not yet commercially available.

Nematode

The nematodes or roundworms are one of the most common phyla of animals, with over 80,000 different described species (over 15,000 are parasitic). They are ubiquitous in freshwater, marine, and terrestrial environments, where they often outnumber other animals in both individual and species counts, and are found in locations as diverse as Antarctica and oceanic trenches. Further, there are a great many parasitic forms, including pathogens in most plants, animals, and in humans.

Nematode

Photo by Josh Grosse

Root-knot nematodes attack a wide variety of plants. They are microscopic roundworms that live in the soil and on plant roots. They injure plants by feeding on root cells with their needle-like mouthparts (stylets). The root system can become damaged to the point where the plant cannot properly absorb water and nutrients. All species of Meloidogyne are called 'root knot' nematode, but each species has a different host range, causing confusion over which crops or cultivars are resistant or tolerant to which species of root knot nematode. Once a nematode problem is confirmed, affected areas and plants should be isolated because transplants, machinery, and irrigation water can all spread nematode infections.

A root-knot nematode problem can be confirmed only by physically examining the roots for knots or by a laboratory test. Symptoms on affected plants may be evident on parts of the plant both above and below the ground. Above the ground, plants may appear stunted and discoloured and may die. Plants may wilt easily in hot, dry weather and appear to have nutrient deficiencies. Beneath the ground, the roots may have knots or galls (swollen areas) on them. Both large and small roots will have round swellings on them. The entire root system may be shallow with areas that are dead or branched excessively.

Higher soil organic matter content protects plants against nematodes by increasing soil water-holding capacity and enhancing the activity of naturally-occurring biological organisms that compete with nematodes in the soil. Low soil moisture puts even more stress on plants with nematode-damaged root systems. Crab meal compost is potentially nematode-suppressive. Crab meal, like other nematode control practices, must be applied before planting because these materials need to penetrate as much of the rooting zone as possible to be effective. This is only possible if they can be incorporated before planting.

Powdery mildew

There are many kinds of powdery mildew fungi, and some are highly specialised. For example, the powdery mildew that infects squash plants will infect other plants in the cucurbit family but will not infect roses, and the powdery mildew from roses will not attack zinnias and vice versa, although the fungus that infects zinnias also infects many other members of the composite family. Powdery mildew fungi are obligate parasites; that is, they can grow only on living plant tissue. When the mildew-infected plant part dies, so does the mildew unless cleistothecia (resting stages of the fungus) are formed.

Powdery mildew

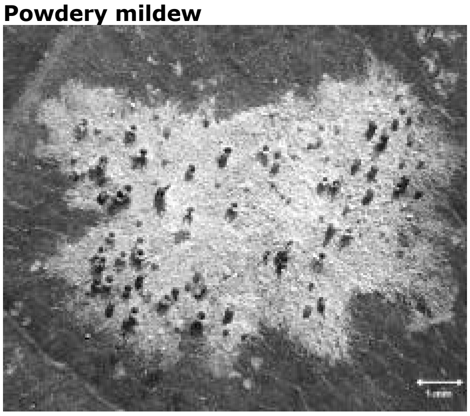


Photo by Heizer

Most powdery mildew fungi grow over the surface of the leaf, sending short food-absorbing projections (haustoria) into the epidermal cells. The fungi produce masses of spores (conidia), which become airborne and spread to other plants. Powdery mildew spores are unique in that they require no external moisture for germination; most other fungi require free water in the form of dew, guttation, rain, or water from overhead irrigation for germination and infection or growth whereas the conidia of powdery mildew (except those that infect grasses) die in water. Spores may be dispersed, however, by splashing water.

The fungus survives in the absence of susceptible host tissues by forming a sexual stage (cleistothecium) resistant to drying and other adverse environmental conditions. With many perennial plants, such as rose, the fungus survives as mycelium in dormant buds or actively on plant tissues. Powdery mildews are favoured by warm days and cool nights and moderate temperatures (20-30°C). At leaf temperatures above 32°C, some mildew spores and colonies (infections) are killed. Shade or low light intensities also favour powdery mildew fungi. Greenhouse conditions are often ideal for development of the disease.

The best control is using resistant cultivars. However little attention has been paid to development of resistant cultivars of flower crops. Because high relative humidity (greater than 95%) favours some powdery mildew fungi, increased air movement around the plants in the greenhouse tends to reduce infection potential in these mildews.

To control powdery mildew organically, finely ground sulphur is effective, but it can burn plant tissue when used with copper and oils.

Root rot

The excess water makes it very difficult for the roots to get air that they need, making them rot. To avoid root rot, it is best to only water plants when the soil becomes dry, and to put the plant in a well-drained soil or hydroponics.

Root rot

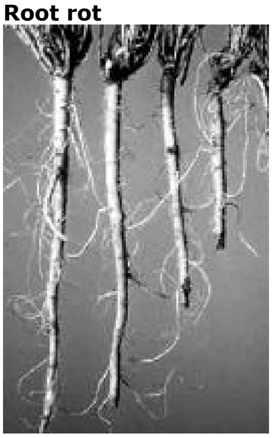


Photo by Tim Woodward

Pythium root rot is a common crop disease caused by a genus of organisms called "Pythium". These are commonly called water moulds. Pythium damping off is a very common problem in fields and greenhouses, where the organism kills newly emerged seedlings (Jarvis, 1992). This disease complex usually involves other fungi as Phytophthora and Rhizoctonia. Many Pythium species, along with their close relatives Phytophthora species, are plant pathogens of economic importance in agriculture. Pythium spp. tend to be very generalistic and unspecific in their host range. They infect a large range of hosts (Owen-Going, 2002), while Phytophthora spp. are generally more host-specific. For this reason, Pythium spp. are more devastating in the root rot they cause in crops, because crop rotation alone will often not eradicate the pathogen.
Pythium attacks juvenile tissues such as the root tip. After gaining entrance to the root, the fungus may cause a rapid, black rot of the entire primary root and may even move up into the stem tissue. As the soil dries, new roots may be produced and the plant may recover or never show symptoms of disease. Under wet conditions brought about by poor soil drainage or excess irrigation, more and more roots are killed and the plant may wilt, stop growing, or even collapse and die. Bulbs of susceptible plants turn black, gradually desiccate, and form a hard mummy.

In the control of Pythium diseases, emphasis is placed on providing good drainage and water management. Steam (at 60°C for 30 minutes) growing medium. Sanitation is important because Pythium spp. can survive in dust, planting medium, or soil particles on greenhouse floors and in flats and pots. Remove and discard diseased plants. Use of properly composted pine bark at 20% in potting mixed is reported to provide some control of Pythium and Phytophthora root rots; also the mycoparasite, Gliocladium virens, is used as a Pythium bio-control agent.

Many, if not most, Phytophthora species can infect roots in the same manner as Pythium species. In addition, Phytophthora species infect larger roots and stems, particularly in woody plants. Infection of the bases of stems or root crowns is very common under wet conditions. Aerial parts, including branches and shoots, also can be infected under wet conditions if soil water is splashed on these aboveground parts. Plants become stunted, low in vigour, and appear as if they were water stressed. Foliage yellows and the plant may wilt and die. Roots rot and stem is girdled by the fungi at or below the soil line, resulting in a dark brown rot.

Emphasis in control of Phytophthora diseases is placed on providing good drainage and water management. Whenever possible, the use plant resistant varieties is preferably. In addition, because aerial parts often are infected, propagative material can be a source of infection. Deep planting where soil covers the base of the stem encourages infection by Phytophthora.

Rust

Rust pustules appear as powdery masses of yellow, orange, purple, black, or brown spores on leaves and sometimes on stems. Pustules are usually found on the undersides of leaves.

Rust diseases are favoured by moderate temperatures that favour the growth of the host. Rust spores can be killed by high temperatures. Some rust infections, such as geranium rust (Puccinia pelargoni-zonalis), can be eradicated by hot water treatment of cuttings, but some damage to the host can occur. Because water is necessary for infection, overhead irrigation should be avoided when rust is a problem. If possible, eliminate alternate hosts if they occur and prune off infected stalks.

Rust fungus on a leaf, under low magnification

Photo by Pengo

Integrated Pest Management

Many insect and mite pests in floricultural crops have natural enemies that can sometimes keep their populations below economically damaging levels. Using pesticides that do not disrupt natural enemy activity is a key component of integrated pest management programmes. When natural enemy populations are not present or are not high enough to reduce pests, they can sometimes be augmented with releases of commercially reared natural enemies. There are two types of augmentative releases:

1. *Inoculative releases* are made when pest populations are low and relatively few natural enemies are released, usually just once or twice a season. The introduced predators or parasites reproduce, and it is their progeny, not the released individuals, that are expected to provide biological control. Releasing the mealybug destroyer lady beetle (Cryptolaemus montrouzieri) in the spring to control mealybugs is an example of inoculative release. The mealybug destroyer is effective in killing mealybug species that feed openly on foliage or stems, but it over-winters poorly outdoors in California and needs to be reintroduced to target areas in spring;
2. *Inundative releases* involve releasing large numbers of natural enemies often several times over a growing season. The released natural enemies are expected to provide biological control. Although they may reproduce, progeny of release individuals generally are not relied on for control. Periodically releasing Trichogramma species (parasitic wasps) to destroy moth eggs is an example of inundative biological control.

A good place to start with augmentation is in situations similar to those where researchers or other pest managers have previously demonstrated success. Desperate situations where pests are already abundant or damage is common are not a good opportunity for augmentation. Because pest presence is necessary to sustain natural enemies, choose crops where some levels of the target pests and their damage can be tolerated. Begin making releases early in the production cycle. Consider what other pests may occur in the crop and how they can be managed in ways that are compatible with biological control. Make other necessary changes in production practices, for example, by avoiding use of pesticides that harm natural enemies.

Increase the likelihood that natural enemy releases will be effective by accurately identifying the pest and its life stages. Parasites and many predators attack only certain pest stages; release the beneficial species when the pest is in its vulnerable life stage or stages. The pest life stage that can be effectively controlled with natural enemies may be different from the pest stage that damages plants. For example, Trichogramma species kill only eggs of moths and butterflies; they are not effective against caterpillars. Trichogramma must be released when moths are laying eggs, before the caterpillars become abundant.

The quality of commercially available natural enemies is not regulated and may sometimes be poor because of production practices, inadequate packaging, or unsuitable conditions during shipping. Evaluate the quantity and quality of each shipment of natural enemies. If beneficials arrive in parasitized hosts, count parasite exit holes in a small sample immediately after parasites arrive. Keep the sample in a suitable place and recount & compare the number of emergence holes about 10 days after deploying the parasite. If natural enemies (typically predators) arrive in a shaker-type container, estimate their numbers and calibrate your application rate by making one shake over a sheet of white paper and counting the number of apparently alive or active natural enemies. Repeat this several times to estimate the average number of predators per shake. If predators or parasitized hosts arrive on leaves, use a hand lens or dissecting binocular microscope to examine the underside of several leaves and estimate the natural enemies per leaf. Contact the supplier immediately if natural enemy quality is unsatisfactory.

Remember that natural enemies are living organisms that require water, food, shelter, and suitable growing conditions. Natural enemies may be adversely affected by extreme conditions such as hot temperatures. Residues of certain pesticides can persist for weeks or months, harming natural enemies long after losing their effectiveness against pest species. Overhead irrigation may drown natural enemies. Many beneficial species stop reproducing under short day length or prolonged cool conditions. Supplemental light may be necessary for some predators and parasites to be effective year-round. Environmental conditions required by natural enemies (such as long days) may not be compatible with production needs of certain crops.

Some Commercially Available Natural Enemies of Floriculture and Nursery Pests (Source: http://www.ipm.ucdavis.edu/PMG/r280390111.html)

Target pest	Natural enemy	
	Common name	*Scientific name*
Aphids	Aphid midge Convergent lady beetle Lacewings Microbial insecticide Minute pirate bugs Parasitic wasps	*Aphidoletes aphidimyza* *Hippodamia convergens* *Chrysoperla* spp. *Beauveria bassiana*[1] *Orius insidiosus, O. tristicolor* *Aphelinus, Aphidius* spp., *Diaeretiella rapae,* others
Broad mites	Predaceous mites	*Neoseiulus* spp.
Caterpillars	Egg parasites Entomopathogenic nematodes Larval parasites Microbial insecticides	*Trichogramma* spp. *Steinernema carpocapsae, Heterorhabditis bacteriophora* several host-specific ssp. *Bacillus thuringiensis* ssp. *kurstaki,* Bt ssp. *aizawai, Beauveria bassiana*[1]
Fungus gnats	entomopathogenic nematodes microbial insecticide predaceous mite	*Steinernema carpocapsae, S. feltiae* *Bacillus thuringiensis* ssp. *israelensis*[1] *Hypoaspis miles*
Mealybugs	citrus mealybug parasite lacewings mealybug destroyer microbial insecticides	*Leptomastix dactylopii* *Chrysoperla* spp. *Cryptolaemus montrouzieri* *Beauveria bassiana*[1]
Scale insects	predaceous lady beetle red scale parasite soft scale parasites	*Rhyzobius (=Lindorus) lophanthae* *Aphytis melinus* *Metaphycus helvolus, Microterys flavus*
Serpentine leaf miner	parasitic nematode parasitic wasps	*Steinernema carpocapsae* *Dacnusa, Diglyphus* spp.
Spider mites	lacewings predatory cecidomyiid predatory mites	*Chrysoperla* spp. *Feltiella* sp. *Amblyseius, Metaseiulus, Neoseiulus, Phytoseiulus* spp.
Thrips	greenhouse thrips parasite lacewings microbial insecticide minute pirate bug predatory mites	*Thripobius semiluteus* *Chrysoperla* spp. *Beauveria bassiana*[1] *Orius insidiosus, O. tristicolor* *Amblyseius, Euseius, Iphiseius, Neoseiulus* spp., *Hypoaspis miles*
Weevils	entomopathogenic nematodes	*Steinernema carpocapsae, Heterorhabditis bacteriophora*
Whiteflies	lacewings microbial insecticide parasitic wasps predaceous lady beetle	*Chrysoperla* spp. *Beauveria bassiana*[1] *Encarsia, Eretmocerus* spp. and others *Delphastus pusillus*
White grubs	parasitic nematodes	*Steinernema carpocapsae, Heterorhabditis bacteriophora*
[1]:These microbial products are registered insecticides.		

Further reading

Pesticide Action Network (PAN) is a network of over 600 participating nongovernmental organizations, institutions and individuals in over 90 countries working to replace the use of hazardous pesticides with ecologically sound alternatives. Its projects and campaigns are coordinated by five autonomous Regional Centres.
A valuable source is PAN Pesticides Database, which is a compilation of multiple regulatory databases into a web-accessible form.
www.pan.uk.org

How to Manage Pests - About Pest Management Guidelines and Other Identification Databases: the UC State-wide IPM Program developed the Pest Management Guidelines, Pest Notes, Natural Enemies Gallery, and Weed Photo Gallery to provide practical information on pest management techniques and identification for a broad range of California pests. Management suggestions apply to California, but also may be useful in other areas. This information is frequently modified and expanded to reflect recent changes in pest management techniques, pesticide registrations, and pest status. The primary sources of information for all three databases are scientists at the University of California's Division of Agriculture and Natural Resources (ANR). These databases are maintained by the State-wide IPM Program.
http://www.ipm.ucdavis.edu/PMG/selectnewpest.floriculture.html

Programme on Breast Cancer and Environmental Risk Factors (BCERF), has a special fact sheet about pesticides & breast cancer:
http://envirocancer.cornell.edu/factsheet/cPESTICIDES.cfm

The **Pesticide Management Education Programme (PMEP**) web site promotes the safe use of pesticides for the applicator, the consumer, and the environment, and also serves as a pesticide information/education centre for those interested in pesticide chemicals: http://pmep.cce.cornell.edu/

Beyond Pesticides, founded in 1981 as the National Coalition Against the Misuse of Pesticides - Source of information on pesticide hazards, least-toxic practices and products, and on pesticide issues. Website has Daily News Blog relating to pesticides.

Compendium of Pesticide Common Names: Classified Lists of Pesticides Lists of pesticide names by type.

Links

- The PAN Pesticides Database is your one-stop location for current toxicity and regulatory information for pesticides: www.pesticideinfo.org
- The list of lists: http://www.pan-uk.org/Publications/publist.htm
- FAO Pesticide Management: http://www.fao.org/waicent/FaoInfo/Agricult/AGP/AGPP/Pesticid/Default.htm
- LEISA Dossier Ecological Pest Management: www.leisa.info
- The International Federation of Organic Agriculture Movements (IFOAM) is an international agricultural umbrella association: www.ifoam.org
- Koppert – organic control: www.koppert.com