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SPECIAL ISSUE

Pesticides

Issue 13 April 2009

Editorial

Towards safer and reduced usage of pesticides

Pesticides are a major policy issue at both European and national level. Consumers have shown concern over possible harmful effects to human health and the environment, and policy makers have reacted by revising existing policy and creating new policy. In March of this year the European Commission completed a review of existing pesticides on the market before 1993 and removed more than two thirds of these substances. They were removed either because dossiers were not submitted, incomplete or withdrawn by industry or because substances failed the review[1].

As part of the Commission's strategy to ensure safer use of pesticides[2] a new legislative framework has recently been adopted that includes a regulation specifying stricter criteria for approval of pesticides and a directive on the sustainable use of pesticides[3]. This special issue intends to examine current research that could influence future policy in this important area.

Considering the health risks surrounding pesticide use, the article 'Can herbicides increase pancreatic cancer risk?' associates two herbicides with a risk of developing pancreatic cancer. One of these has been the subject of a recent proposal to withdraw it from EU approved pesticides. Meanwhile, the article 'Greek olive oils contain no harmful levels of pesticides' offers a more positive conclusion.

In terms of environmental impacts, 'Soil microorganisms help prevent non-target effects of pesticides' provides evidence that certain types of soil and microbial activity reduce some of pesticides' harmful effects.

The article 'How much are consumers willing to pay to reduce pesticide use?' provides a direct link to policy. It estimates how much people would be willing to pay for food to reduce the impact of pesticides on health and the environment and calculates the corresponding level of tax.

Another important strategy is the development of biological or non-chemical pesticides as replacements for conventional pesticides. 'Fungi and roundworms as non-chemical substitutes for pesticides' identifies three possible alternatives, to be used on their own or in combination with traditional pesticides. Finally, 'Eucalyptus essential oil as an alternative to chemical pesticides' outlines a number of uses for eucalyptus to help reduce use of conventional pesticides.

Policy makers have clearly acknowledged the public concern over pesticide use. By using the results and recommendations of relevant research they can continue to build on previous policy and successfully manage the production and use of pesticides in the future.

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[1] See http://ec.europa.eu/food/plant/protection/evaluation/rev_prog_exist_pest_en.htm
[2] See http://ec.europa.eu/environment/ppps/home.htm
[3] See http://ec.europa.eu/food/plant/protection/evaluation/new_reg_ppp_en.htm

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Can herbicides increase pancreatic cancer risk?

There is only a small chance of recovering from pancreatic cancer. This type of cancer has been linked to a number of risk factors, including smoking, but a new study suggests that pancreatic cancer may also be associated with exposure to certain herbicides.

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"The risk of developing pancreatic cancer for workers exposed to low doses of pendimethalin increased by almost one and a half times. The risk for those who had had a high exposure to the herbicide was 3 times greater."

Other risk factors, in addition to smoking, that have been associated with a greater chance of developing pancreatic cancer include diabetes, obesity, race (with Afro-Caribbean people more susceptible), chronic inflammation of the pancreas and a family history of pancreatic cancer. Some scientists add exposure to certain pesticides to this list.

In order to understand the relationship between commonly used pesticides and pancreatic cancer, researchers have analysed data from the Agricultural Health Study (AHS)[1]. This is one of the largest long-term health studies with over 89,000 participants from the states of Iowa and North Carolina in the United States. Participants included agricultural workers who apply pesticides and their spouses. Spouses often help their partners on the farm and can therefore be exposed to low levels of pesticides. Participants completed questionnaires about their health, lifestyle and pesticide use. The researchers examined their exposure to 24 different pesticides, including both herbicides and insecticides. Thirteen of them were analysed in greater depth as these pesticides are used more intensively.

The study suggests there is a significant association between the risk of developing pancreatic cancer and exposure to two herbicides, pendimethalin and EPTC. Both herbicides are used to control weed growth, for example, in cultivated crops, such as beans, carrots and onions.

In this study, no association was found between organochlorine insecticides and pancreatic cancer. This is in contrast with results from previous studies. One explanation is that only certain populations with higher exposure might be susceptible.

Associations were found between age, smoking and diabetes and the incidence of pancreatic cancer for workers and their spouses. After adjusting for these risk factors, the researchers calculated that the risk of developing pancreatic cancer for workers exposed to low doses of pendimethalin increased by almost one and a half times. The risk for those who had had a high exposure to the herbicide was 3 times greater. For EPTC, the risk to low users almost doubled and the risk was two and half times greater in high users, compared with non-users of the herbicide.

Pendimethalin is classified as a possible human cancer-causing agent by the United States Environmental Protection Agency and there has been a recent proposal[2] to withdraw pendimethalin from the list of pesticides approved for use in the EU.

EPTC is classified as a herbicide that is unlikely to cause cancer, but in the AHS it was associated with an increased risk of colon and prostate cancer. Both of these herbicides are able to form 'N-nitroso-compounds', which have been implicated as significant causes of cancer, including pancreatic cancer.

Source: Andreotti, G., Beane Freeman, L.E., Hou, L. *et al.* (2009). Agricultural pesticide use and pancreatic cancer risk in the Agricultural Health Study Cohort. *International Journal of Cancer:* 124(10):2495-2500.

[1] See: http://aghealth.nci.nih.gov/
[2] http://www.europarl.europa.eu/meetdocs/2004_2009/documents/pr/740/740972/740972en.pdf

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Greek olive oils contain no harmful levels of pesticides

There are concerns that pesticides which make their way into food products can have harmful effects on health. However, Greek researchers have tested a range of olive oils for pesticide residues and concluded that levels were sufficiently low in these samples and do not pose a health risk.

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"Olive oils should be tested for multiple pesticide residues to monitor the exposure of consumers to both registered and unregistered pesticides. Other sources of pesticide exposure in the diet should also be considered when assessing overall risks."

Olive oil production is a major agricultural activity in Mediterranean countries and a variety of pesticides are used to protect the olive crop from pests and diseases. It is possible a number of different pesticide residues could accumulate in olive oils. Consumption of olive oil is rising as people become aware of the benefits of eating a healthy diet. However, this means that consumers could be at risk from elevated exposure to these residual chemicals.

Researchers, partly funded by the EU programme, Pythagoras1[1], examined 100 olive oil samples from the 10 main olive oil producing regions in Greece. 71 samples were taken from olive mills and 29 samples came from local markets. Ten of these samples were organic; the remainder were from conventionally grown crops. All samples were from crops grown in 2004-2005.

Tests were carried out for 35 pesticides, including endosulfan, which is no longer registered for use in olive cultivations. The researchers calculated the estimated daily intake (EDI) of pesticides in olive oil in adults and children. These figures were compared with the acceptable daily intake (ADI) of pesticides, as advised by the Food and Agricultural Organisation of the United Nations (FAO) and World Health Organisation (WHO)[2]. Overall, results of the study suggest all EDIs were well below the acceptable daily intakes.

For olive oils from conventional cultivations:

- 10 per cent of samples had no residues of the pesticides
- 20 of the 35 pesticides were detected across the remainder of the samples
- the three most commonly detected pesticides were dimethoate, fenthion and endosulfan
- on average, three different pesticide residues were found in the olive oils
- commercially and individually processed extra virgin olive oils contained the highest amounts of the targeted pesticides, possibly as a result of farmers protecting their crops against the olive fruit fly, a pest that has the greatest impact on the quality of the olive oil

For the organic olive oils, six of the ten samples contained no detectable pesticide residues. One of the other samples might have been contaminated from neighbouring conventional farms. But the remaining three samples contained low levels of endosulfan.

The researchers suggest olive oils should be tested for multiple pesticide residues to monitor the exposure of consumers to both registered and unregistered pesticides. Other sources of pesticide exposure in the diet should, however, also be considered when assessing overall risks from pesticides.

Source: Amvrazi, E.G. and Albanis, T.A. (2009). Pesticide residue assessment in different types of olive oil and preliminary exposure assessment of Greek consumers to the pesticide residues detected. *Food Chemistry.* 113:253-261.

[1] See: http://www.epeaek.gr/epeaek/en/home.html
[2] See: http://www.fao.org/agriculture/crops/core-themes/theme/pests/pm/jmpr/en/

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Soil microorganisms help prevent non-target effects of pesticides

A new study has investigated the properties of different types of soils which can cause pesticides to cling on to soil and prevent them from affecting non-target species. It demonstrates that microorganisms can play an important role in binding pesticides to soil. Microbial levels can therefore help indicate how much pesticide is freely available in soil.

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"Pesticides which are strongly bound to soils are thought to be less bioavailable to animals and plants. Furthermore, they leach less from the soil into surface or groundwaters."

Pesticides applied during agricultural use can contaminate soil and damage non-target plants and soil organisms. However, soil particles can bind some of these residues and reduce the amount of pesticide that is 'bioavailable'. Researchers tested 5 different types of commonly used pesticides; simazine, carbendazin, acetochlor, chlorpyrifos and diuron on three different types of soils; sandy, brown forest soil with clay and alluvial soil (soil deposited by rivers).

In addition, the study examined the effect of microorganisms on 3 of the pesticides; acetochlor, diuron and simazine, by comparing sterilised soil (with no microorganisms) with natural soil samples containing the pesticide samples.

Each type of soil interacts differently with each type of pesticide. This means that some soils are better at binding the various pesticides. The level of binding was determined by how much of the pesticides could be extracted from the soil samples, using a variety of different chemicals.

The amount of a pesticide that can be stripped from a soil sample gives an indication of how strongly a pesticide has been adsorbed (bound to the surface). Pesticides which are strongly bound to soils are thought to be less bioavailable to animals and plants. Furthermore, they leach less from the soil into surface or groundwaters.

The ability of soil microorganisms, such as bacteria, to bind pesticides to the soil was examined. The study found that the greater the activity of the microorganisms, the greater the amount of pesticide that could bind to the soil. For example, an average of 39.4 per cent of diuron could be extracted from microbiologically active soil compared with between 65-98 per cent extraction from sterilised soil samples.

The researchers suggest that the microorganisms, together with the large quantities of metabolites (substances produced during the living process) produced by the microorganisms, provide extra surfaces for the pesticides to bind to, thereby reducing their bioavailability.

Overall, an aqueous (humic-acid) solution was the most effective at extracting pesticides. The study produced detailed results of the binding properties of the pesticides in the different soils. Of the five pesticides, diuron was the most mobile, binding least to the different soil types. In addition, alluvial soils and brown forest soils adsorbed pesticides more effectively than sandy soils.

Source: Virág, D. and Kiss, A. (2009). Comparative study of accessibility of distinctive pesticides. *Journal of Environmental Science and Health*, Part B. 44:1, 69-75.

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How much are consumers willing to pay to reduce pesticide use?

Many countries would like to decrease their pesticide use but are concerned about the accompanying cost. A recent study reveals that consumers are willing to pay more for food produced with fewer or no pesticides.

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"Consumers are willing to accept considerably higher prices if they are designed to improve human health than if they seek environmental benefits."

The impact of pesticides continues to be a subject of political debate at both a national and European level. In 2006, the European Commission launched a strategy to improve the use of pesticides across the EU[1] which called for national action plans. Many policies already exist to minimise the negative impact of pesticides. These include pesticide taxes in Denmark and Norway and the Voluntary Initiative[2] in the UK. However, research is needed to inform these policies.

One of the most informative forms of research is estimates of consumers' willingness to pay (WTP) to reduce or avoid the negative impacts of pesticides. This study took a novel approach to this concept by separating WTP to avoid environmental impacts and WTP to avoid risks to human health.

The study questioned UK consumers about two types of food produced from different production systems. These were a loaf of white bread and a weekly basket of fruit and vegetables. The bread was investigated to determine WTP to avoid the impact of pesticide use on the environment as a result of cereal production. The fruit and vegetables were investigated to determine WTP to reduce the impact of pesticide on health due to residues on food.

The respondents were presented with choice cards that consisted of three agricultural production processes:

- Current farming practices
- A green policy employing less pesticides
- No pesticides - a nationwide ban on pesticide use

The decision to buy the product at a certain price was taken as an estimate for WTP for reduced or no pesticide usage. The results demonstrated a preference for both the 'green' and the 'no pesticides' options, despite higher prices. However, the likelihood of choosing the 'green' option drops at the highest of prices (1.03 Euros per loaf and 10.32 Euros per basket of fruit and vegetables). The likelihood of choosing the 'no pesticides' option remains strong at even the highest payment level, indicating that people are willing to pay more for 'no pesticides' than the green option.

The study used the WTP estimates to calculate the levels of tax needed to achieve a certain reduction in pesticide use. The tax is payable by the producer but translates into higher food prices for the consumer. They show that consumers are willing to accept considerably higher prices if they are designed to improve human health than if they seek environmental benefits.

A tax to reduce the environmental impact could only be 14.89 Euros per kg of active ingredient, whereas a tax to reduce the effects on human health could be as high as 137 Euros per kg of active ingredient. Although this difference may seem high, it is interesting to note that in Norway the base rate of the pesticide tax can be multiplied by 150 for pesticides considered to have a large impact on human health and the environment.

Source: Chalak, A., Balcombe, K., Bailey, A. *et al.* (2008). Pesticides, Preference Heterogeneity and Environmental Taxes. *Journal of Agricultural Economics*. 59(3): 537-554.

[1] See: http://ec.europa.eu/environment/ppps/pdf/com_2006_0372.pdf
[2] See: www.voluntaryinitiative.org.uk

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Fungi and roundworms as non-chemical substitutes for pesticides

The use of some pesticides is a recognised concern for health and the environment. A new UK study identifies some naturally occurring alternatives to control wireworm, a widespread pest of potatoes.

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"Most striking were the effects of the *Metarhizium anisopliae* fungus strains, V1002 and LRC181A, which caused 90-100 per cent mortality in wireworms."

The wireworm causes major problems in arable crops, including potatoes, in many parts of the world. Wireworms are the larvae of click beetles and their damage to potatoes can drastically reduce yield. When more than 10-15 per cent of potatoes are damaged, the crop is no longer financially viable for the farmer.

One of the major ways of controlling wireworms is by applying insecticides to the soil, but there are concerns about their health and environmental impact of these chemicals. The study identified three alternative, naturally occurring, pesticides that showed promise for development. These were two types of parasitic fungi and one type of parasitic nematode (or roundworm).

The researchers investigated the pesticidal properties of six fungi and twelve nematodes in all. The wireworms were exposed to the different parasites and the mortality of the wireworms was assessed every week for three weeks. The dead larvae were dissected to confirm the cause of death. Differences in the effects of the fungi and nematodes were analysed statistically.

After three weeks, there were significant differences in the effects of the fungi. Most striking were the effects of the *Metarhizium anisopliae* strains, V1002 and LRC181A, which caused 90-100 per cent mortality. There were also significant differences in the parasitic effects of the different types of nematode. The most aggressive was the UK strain of *Heterorhabditis bacteriophora*, UWS1, that caused 67 per cent mortality.

The authors also refer to previous research which demonstrates that the fungi *M. anisopliae* can work together with chemical pesticides to control wireworm and other pests. This suggests it could be used to reduce the use of conventional pesticides. The same fungi can also be used in conjunction with nematodes, providing a completely organic or chemical-free approach to controlling pests.

In addition to a directive to control which pesticides can be placed on the market[1], the EU has adopted a strategy to improve the way pesticides are used[2]. This includes promoting alternative methods of protecting plants which have fewer negative impacts on health and the environment.

Source: Ansari, M.A., Evans, M. and Butt, T.M. (2009). Identification of pathogenic strains of entomopathogenic nematodes and fungi for wireworm control. *Crop Protection*. 28: 269-272.

[1] See http://ec.europa.eu/environment/ppps/legal.htm

[2] See http://ec.europa.eu/environment/ppps/pdf/com_2006_0372.pdf

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Eucalyptus essential oil as an alternative to chemical pesticides

Controlling pests with natural products can have greater environmental benefits than using chemical pesticides. A recent study reviews the use of eucalyptus essential oil as a natural pesticide and offers recommendations for its future application.

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"Since essential oils are a complex mixture of components (unlike chemical pesticides which are based on a single product), they work together within a plant and it is unlikely that pests will become resistant to them."

Chemical pesticides have played a major role in securing food supplies the world over. However, excessive use has led to increased environmental pollution, harmful effects on human health and resistance among pests to the chemicals used. This has driven the search for less harmful alternatives.

Essential oils derived from natural plant products are easy to extract, biodegradable and do not persist in soil and water. Eucalyptus is particularly useful as it possesses a wide range of desirable properties for pest management and is regarded as non-toxic to humans.

Eucalyptus essential oil can act directly as a natural insect repellent and the study lists numerous pieces of research that demonstrate this property. For example, previous research has found that eucalyptus essential oil can protect plants against rice weevils, pine processionary moths and mushroom flies.

The study also lists examples of research which have found that eucalyptus essential oil is toxic to microbes including bacteria and fungi. Eucalyptus essential oil could therefore have a role to play in the protection of crops against mould, mildew and wood rot fungi. In addition, when applied in a vapour form, eucalyptus essential oil has potential to manage weeds, especially as its toxicity appears to be species-specific.

The study also highlights several benefits of using essential oils over chemical pesticides. Since essential oils are a complex mixture of components (unlike chemical pesticides which are based on a single product), they work together within a plant and it is unlikely that pests will become resistant to them.

Additionally, they can be used for non-agricultural pest management in urban areas, homes and other sensitive areas such as schools, restaurants and hospitals. Since eucalyptus oils are particularly strong when in vapour form, they could also be used commercially as a fumigant (gaseous pesticide) for stored products and impregnated into packaging to prevent insect infestation.

The authors also draw attention to some drawbacks of essential oils. For example, essentials oils do not persist for long in the environment and need to be continually reapplied to achieve the desired results. They also point out that the properties of eucalyptus may change depending on species, season, changing climate and even age. Because eucalyptus oils are insoluble in water, they are not as effective in controlling pests that live in soil or for weeds under field conditions. The authors suggest that this could be overcome by emulsifying the oil.

The study explains that eucalyptus essential oil could have a large role in the control of pests and provide an alternative to chemical pesticides. However, the costs of extraction and application need to be better understood to decide how cost-effective it is.

Source: Batish, D.R., Singh, H.P, Kohli, R.K. *et al.* (2008). Eucalyptus essential oil as a natural pesticide. *Forest Ecology and Management*. 256: 2166-2174.

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A selection of articles on Pesticides from the *Science for Environment Policy* News Alert

New software to standardise risk assessment of pesticide pollution (12/2/09)

Researchers have developed a computer tool to help standardise risk assessment procedures for pesticides across Europe. The software combines climate, soil and crops data specific to each location to help understand the potential impact of each pesticide used.

The impact of pesticides on freshwater creatures (9/2/09)

A recent study has concluded that, although spray drift of pesticides can have short-term effects on individual stream-dwelling invertebrates, there is no evidence to suggest that there is an impact on populations as a whole. However, to reduce the impact of the pesticides on these organisms, a no-spray buffer zone is shown to be a simple and effective measure.

Pest control can happen naturally (15/1/09)

Pesticides commonly used to control root-feeding nematodes are harmful to the environment and reduce soil biodiversity. By studying natural plant populations, researchers have observed that soil microorganisms and other naturally occurring predators can effectively control nematode species. These natural forms of control could be adapted as biocides and potentially play a major role in sustainable agriculture.

Encouraging innovation in biopesticide development (18/12/08)

Biopesticides can control crop pests effectively with minimal environmental impact when used as part of an Integrated Pest Management programme. However, their regulation is governed by a system originally designed for chemical pesticides and this can act as a barrier to investment in biopesticide research and development (R&D). A recent study investigated two innovative biopesticide regulatory schemes in the UK and The Netherlands which could help overcome this barrier.

Increased amphibian mortality due to agri-chemical pollution (27/11/08)

Global decline in frog populations is thought to indicate environmental damage caused by human activity. In particular, the use of agri-chemicals has been linked to an increase in infectious diseases in amphibians. A link has now been found between a parasitic infection and localised interaction between phosphate fertilisers and herbicides.

Is farming becoming more environmentally sustainable? (4/9/08)

The environmental track-record of agriculture has come under scrutiny in a new report which details the environmental performance of farming in OECD (Organisation for Economic Co-operation and Development) member countries since 1990. Its findings demonstrate that progress has been made, but there are still areas for improvement which policy measures could help overcome.

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