Garddwriaeth Cymru
Horticulture Wales

Knowledge exchange, collaboration and supply chain development.

Reducing pesticide use

Introduction

Pesticides have been widely used in agriculture and horticulture for over 75 years and some production systems have become heavily reliant on them. Overuse of pesticide has led to some serious problems:

- Most pesticides to a greater or lesser extent kill non-target species as well as pests. This has contributed to the steep decline in biodiversity over the last 5 decades and reduced populations of beneficial organisms including pest-predators and pest- parasites.
- Many pesticides also pose serious risks to human health, both to the general public mainly through exposure to pesticide residues on food, and to agricultural and horticultural workers who apply them to crops
- Some pesticides are highly persistent and build up in the environment. The most well-known historically is DDT (Dichloro-Diphenyl-Trichloroethane). Recent research has highlighted that 'Neonicotinoid' pesticides are ubiquitous and practically everywhere in soil and water
- Overuse of pesticides has led to the development of resistance in pests and pathogens, reducing their efficacy.

Over the last 30 years or so, pesticides containing almost 375 active ingredients (pesticidal compounds) have either been banned or severely restricted because of environmental or human health risks. Those recently withdrawn, restricted or currently being phased out include:

- Diquat, a widely used herbicide
- Metaldehyde, routinely used by many growers against slugs
- Dodine, a fungicide widely used against apple scab
- Copper-based fungicides for example those used to control late blight in organic potato production.

The 'Pesticide Red List' provides further details of herbicides and pesticides which are currently banned, or will be prohibited in the near future.

Integrated pest, disease and weed management

For all these reasons, there has been a move towards reducing pesticide-use in agriculture and horticulture. Integrated Pest Management (IPM) views using pesticides as a last resort and aims to rely on a combination of non-chemical approaches to managing pests, diseases and weeds.

Organic, and agroecological systems more widely, rely almost entirely on these methods. The following sections set out the key components of IPM approaches.

Cronfa Amaethyddol Ewrop ar gyfer Datblygu Gwledig
Ewrop yn Buddsoddi mewn Ardaloedd Gwledig
European Agricultural Fund for Rural Development:
Europe Investing in Rural Areas
Llywodraeth Cymru
Welsh Government
Prifysgol Glyndŵr Wrecsam
Wrexham Glyndŵr University

General crop husbandry

Healthy vigorous plants are much better at out-competing weeds and tolerating/ resisting pest and disease pressures. Successful crop husbandry includes

- Building and maintaining soil fertility and structure
- Maintaining optimal soil moisture
- Selecting the most appropriate varieties
- Planting at the right time and at the right spacings

Guide No 1 in this series 'Growing for Quality' provides more information.

Pre planting

Variety selection

Varietal pest and disease resistance is a mainstay of integrated pest management. While the market is probably the biggest determinant of variety choice, pest and disease resistance is a close second.

- Unlike cereals there is no comprehensive database of varietal characteristics for vegetable crops. With a reduction in publicly funded breeding programmes, seed company catalogues are now probably the best source of up to date information on varietal resistance. The exception is potatoes; AHDB maintain a Potato Variety Database
- Pest and disease pressures can be very location-specific. New entrants should talk to neighbouring growers about key diseases in their area before selecting varieties.
- Guide No1 in this series 'Growing for quality' has further information

Crop rotation planning

From a pest, disease and weed management point of view, rotation creates a constantly changing environment in which no pest or weed species can adapt and become unmanageable. An example is given in the box below. There is no single rotation that is best for every situation, but 'good' rotations have several things in common:

- They are as long as possible. Populations of pests and weed seed banks decline over time, so the longer the time-interval between crops of the same type the better. Leaving 6 or 7 years between potato crops will reduce the populations of potato cyst nematodes more effectively than a 3-year gap. The same is broadly true of club root in brassicas, for example
- They are as diverse as possible. The more types/ families of crop involved in the rotation, the less likely it is any one pest/ disease/ weed species will be adapted to them all
- They include 'weed smothering' crops with broad leaves that grow quickly and shade out weeds once the leaf canopy closes. These include many brassicas, squash and potatoes. This reduces the burden for following weed-susceptible crops like onions, leeks and other alliums

Year	Crop	Notes
1	Red clover	Cut and mulch
2	Potatoes	Grazing rye winter green manure
3	Brassicas	
4	Mixed vegetables	Winter green manure as appropriate

A 4 year potato / mixed vegetable rotation from 'A farmer's guide to organic vegetable production' (2008) D, Frost & T Little

Cultivation

Cultivations, both primary (e.g. ploughing) or secondary (e.g. harrowing) have an important part to play in managing soil pests and weeds. For example:

- Burying weeds, preventing their emergence (although the reverse can also be true)
- Pulling out roots/ rhizomes of perennial weeds such as couch grass, creeping buttercup and docks and exposing them to the elements. Most effective during periods of dry weather
- Exposing soil pests such as wireworms and leather jackets to predators (such as rooks and other birds) and the elements

Operations that lift the topsoil such as bed forming, ridging and harvesting potatoes, can have some of the same effects.

Optimising establishment

Weeds are a problem because they compete with crops for nutrients, for space and for sunlight and they reduce crops yields. It is therefore very important to give crop plants the best possible start. This can be achieved by:

- Planting into a clean, weed-free seedbed. 'Stale seed beds' involve preparing the seed bed a few days or weeks before planting. This encourages the first flush of weeds to germinate which are then destroyed (e.g. by light harrowing) before the crop is planted or sown
- Raising plants from seed in modules or blocks in a propagating unit (or buying them from a specialist plant propagator) before planting them out. For some plants this is a better approach than direct drilling in the field because they are already growing vigorously with well-developed root systems and gaps in the stand are reduced. They therefore have an advantage over the weeds (especially if they go into a clean weed-free seed bed). However, raising transplants on the holding can require specialist equipment and significant investment of time and money.

Physical barriers

The most common examples are:

- Meshes which prevent insect pests laying eggs on the foliage (e.g. cabbage white butterflies on brassicas). They can also protect seedlings – for example from rabbits
- Nets or cages which prevent bird damage on soft fruit
- Mulches (plastic, plastic alternatives, straw, woodchip) through which the crop is planted to supress weeds

Mechanical weeding

A range of mechanical weeders are widely used including

- Handheld hoes (including wheeled hoes which are pushed along the rows)
- Ridgers which are used in ridge crops such as potatoes
- Tractor mounted steerage hoes
- Brush weeders
- Finger weeders
- Thermal weeders, such as flame weeders or hot foam applicators are sometimes considered mechanical weeding because they directly damage the weed. These methods deliver an intense burst of heat (70oC) for a second or so to rupture the plant cells (it does not require burning or scorching). Flame weeding is becoming increasing common in crops such as carrots, It is usually carried out pre-emergence of the crop. Timing is crucial; it must be carried out just before emergence so that the maximum number of weeds are destroyed while germinating seeding are protected by the soil. Thermal weed can be used for interrow weeds post emergence but targeting must be accurate crops with shallow or sensitive roots not suitable for this approach. Various systems are used to deliver heat including flame weeders, infrared burners and hot foam systems

This guide contains more details.

Undersowing

Undersowing creates a dense layer of vegetation beneath the crop that suppresses weeds and may provide habitat/ food for beneficial insects

- It is important to strike a balance between the benefits of weed suppression against the risk of competition between the understory and the crop
- Low, fast growing legumes such as trefoils are often used because they can also contribute to soil fertility
- Undersowing tends to be most successful in taller-growing crops, such as sweet corn. Brassica's are sometimes undersown with birdsfoot trefoil, but results can be variable.
- In orchards there is a wider range of possibilities for underplanting. Comfrey is sometimes used because it is good at scavenging nutrients (especially phosphorous), and has benefits for the soil. Herbs, such as basil, mint, and chives are used and can generate additional income.

Polyculture

Monoculture is the cultivation of a single crop, particularly on large areas of land. The alternative is polyculture, where several crops are grown together at the same time. There are advantages – and some risks - to growing crops together in a 'polyculture'. These include:

- Higher populations of natural enemies (predators and parasites) of insect pests due to more diverse and continuous food sources
- Slower spread of infestations and infections because the different species make it harder for the pest or pathogen to 'find' its host

However, getting the right combination of crops is vital as some combinations can exacerbate problems. For example, an aphid struggling to find a host will visit more plants and therefore could spread viruses further faster Poly cropping is much more common in small-scale tropical horticulture, but there are a number of examples in the UK, and it is an area of increasing interest.

- Intercropping is where more than one cash crop is grown together. For example carrots and onions are grown in alternate rows to reduce carrot fly and onion thrips. However, this approach is not well established in the UK and more research is needed
- Companion planting is similar to intercropping except that one of the crops is not a cash crop in its own right. Companion plants include marigolds, garlic and birdsfoot trefoil. They have a general repellent effect on insects such as aphids and root flies, and marigolds are known to secrete a chemical which deters nematodes
- Trap crops are 'sacrificial' plants which are highly attractive to a particular pests and lure them away from a commercial crop. For example, turnips can used to detract cabbage root fly from calabrese, or nasturtiums can be used to attract cabbage root fly.

Biological control

Biological control is the use of 'natural enemies' to keep populations of pest, disease and weed species at levels below which they cause economic damage. Biological control systems have been developed primarily for insect pests but there are other examples that target weeds and diseases. Natural enemies include predators, parasites/ parasitoids and pathogens (fungi, bacteria and viruses) that attack insects.

There are 2 approaches to biological control that are relevant to growers:

- 'Conservation' approaches manage the environment/ cropping system to conserve and enhance natural enemy populations already present by:
    - Creating habitats e.g. managing field margins and hedgerows for wildlife, planting strips with seed mixtures favouring natural enemies (e.g. 'beetle banks'), leaving rockpiles as overwintering sites etc, leaving a few selected weeds (e.g. nettles to support aphids and the natural enemies of the aphids)

- Reducing pesticide applications to a minimum to avoid killing natural enemies and using them in such a way as to reduce their impact (see 'using pesticides in IPM systems')
- Polycultural cropping can be seen as an example of this approach inap

- 'Augmentative' approaches directly enhance natural enemies' populations. Several companies now mass-rear these species which growers can purchase and release into their crops. This approach is most effective in protected cropping because the mobile species are more likely to stay within the cropping environment – in the greenhouse or polytunnel. There are many products available as outlined in the table below. Nematodes, fungi and bacteria are sometimes formulated as a 'living pesticides' and applied in the same way as synthetic products. In this form they are known as 'Biopesticides'.

Some of the most common include:

Type	Biological control spp	Main target spp	Crops
Predators	Green Lacewing larvae (Chrysopa spp)	Aphids	Wide range
	Ladybird adults and larvae (e.g. Aphidalia spp)	Aphids	Wide range
	Predatory mites Phytoselius persimilis,	Spider mites	Tomatoes, peppers, cucumbers, other key glasshouse crops
	Predatory mites (Amblysieus spp)	Spidermites, thrips	Tomatoes, peppers, cucumbers, other key glasshouse crops, strawberries
Parasitoids (wasps)	Aphidius colmani	Aphids	Wide Range
	Encarsia formosa	Whitefly	Tomatoes, peppers, cucumbers, other key glass house crops
Nematodes	Steinernema feltiae	Fruit moths; black vine weevil	Top fruit; Strawberries
Fungi	Beauvaria bessiana	Aphids, thrips, whitefly, beetle spp	Wide range
	Metarhizium anosophilae	Aphids, thrips, whitefly, beetle spp	Wide range
Bacteria	Bacillius thrungiensis (usually the toxin rather than live bacteria)	Caterpillar pests	Brassicas

As the biological control industry has developed, systems are constantly being refined and are becoming increasingly effective and pest specific. However, there are a number of challenges which smaller grower in particular face:

- Biopesticides are not always available in quantities for small growers, and this is exacerbated by their limited shelf life compared to chemical pesticides
- The cost can be higher compared to chemical pesticides
- The efficacy is more variable because of the complexity of pest – predator/ parasitoid/ pathogen interactions.

Crop hygiene

A key approach to managing problems is to prevent them being introduced in the first place:

- Seed hygiene: In conventional systems, most seed is 'dressed' with a pesticide. In organic systems a range of seed treatments are used including hot water and steam treatments. For potatoes, always use certified seed – this guarantees a high level of freedom from key diseases
- Transplant hygiene: Make sure all imported seedlings have a phytosanitary certificate and always disinfect module trays after each batch
- Field hygiene. Where possible destroy crop residues after harvest. Clean machinery where there is risk of transmitting diseases and pests from one crop to another (this is particularly important for successional plantings of the same crop). Avoid 'dumps' of infected plants. This is a very common source of infection of late blight on potatoes for example.

Using pesticides in IPM

Where pesticides are used, they should be applied as sparingly as possible, taking into consideration their impact on natural enemies and the wider environment. Key principles are:

Only apply pesticides when they are economically justified

- Monitor your crops closely (daily if possible but at least weekly), noting the prevalence of not only pests and diseases, but also natural enemies
- Predictive tools can help assess the risk of problems developing and therefore whether application is necessary. The most well developed is 'Blight watch' developed by AHDB Potatoes which uses meteorological data to warn growers of when conditions favourable to blight (so called 'Hutton Periods) are forecast. Models are also available for Carrot and Cabbage root fly, but are less 'user friendly'.
- Use the most efficient application systems. There are many factors you need to consider to maximise the efficiency and efficacy of pesticide applications including the formulation of the pesticide, the type of sprayer/ applicator, the nozzles used, and the pressure at which the sprayer operates. For example Dropleg sprayers, which consist of plastic drag hoses with spray nozzles fixed on their tip, spray upwards which covers the underside of leaves better, (where the pests tend to be) and reduces spray drift. Detailed information in general and specific guidance for top fruit growers is available here

Use selective pesticides

- Some pesticides are intrinsically less harmful to natural enemies than others. For example, Abamectin based products are less harmful to the predatory mite Ambleisius cucumeris (used for spider mite and thrips control) than cypermethrin
- Pesticides can be applied at a time, or in a place or way that reduces exposure to beneficial organism, as illustrated in the case study below
- Pesticides can also be made more selective by applying them at a time, or in a place

Case study: IPM in Practice
Nick Bean, Springfields Fresh Produce, Tenby Pembrokeshire

Springfields Fresh produce has historically grown a wide range of fruit, vegetables and ornamentals but in recent years has focused on cherries, blueberries, strawberries and aspargus. Nick has been developing an IPM programme for many years, particularly in strawberries.

His approach includes:

- Buying in clean fruit stocks. “We always by certified stock and check in very carefully for pests and diseases when it arrives on the holding”
- Quarantining new stock, as far as is practically possible for at least one and preferably two weeks
- Using soil free growing systems such as hydroponics to eliminate soil borne pest and disease problems.
- Designing and managing protected cropping structures to maximise air flow to reduce spread of diseases
- Maintaining high crop hygiene, for example removing all debris between crops
- Using synthetic pesticides (insecticides and fungicides) selectively. These are non-persistent products applied at the beginning of the season, before natural enemy populations have built up. This gets the crop off to a ‘clean start’.
- Using insecticidal soaps and Maltodextrin against spidermites which are less harmful to non target species than many synthetic pesticides
- Using ‘plant elicitors’ such as phosphite and phosphonic acid to strengthen and prime plant defence systems,
- Using biological control products on a regular basis (every 2 – 3 weeks) thereafter. These include:
    - Biopesticides based on the entomopathogenic fungi Beauvaria bessiana and Metarhizium anosophilae against thrips, aphids, whitefly and other insect pests
    - Biopesticides based on Bacillus subtilis against Botrytis and Ampelomyces quisqualis against powdery mildew
    - Biopesticdes based on entompathogenic nematodes against vine weevils
    - Predators including: predatory mites Phytoselius persimilis and Amblyseius cucumeris against spidermites; and green lacewing larvae against aphids.

Constant monitoring for pests and diseases underpins all of Nick’s management decisions, He uses a range of methods, including:

- Regular crop inspections
- Pheromone traps for light brown apple moth and blossom weevil
- Stick traps (blue for thrips and yellow for aphids

Taking advice is central to the success of the programme. Nick uses the Fruit Advisory Service regularly and closely monitors advice and research findings published by organisations such as AHDB HorticultureThe reed bed is populated with, in this case, Common reed (Phragmites australis) which helps to oxygenate the waste. This in turn promotes microorganisms in the bed that break organic matter, producing clean water suitable for irrigation. At the same time, the system creates a diverse habitat that will support a wide range of species including insects and wetland birds.

Using pesticides safely

Many pesticides pose serious risks to health, so if you do use them you should:

- Always read the label/ safety data sheet (SDS)
- Take all reasonable precautions to protect human health and the environment
- Hold an officially-designated specified certificate
- Have your sprayer tested by the National Sprayer Testing Scheme (knapsacks and handhelds are exempt)
- Wear personal protective equipment identified in the instructions
- Only spray when weather conditions are suitable
- Try to avoid walking through treated areas
- Not eat, drink or smoke when applying pesticides
- Wash off splashes from the skin and clothing immediately, and wash before eating, drinking, smoking or taking a rest break
- Keep a record of all pesticide use
- Report all suspected cases of environmental damage, poisoning or other adverse reactions

Read the Health and Safety Executive guidelines in full.

Storing and transporting pesticides safely

- Store all pesticides in their original containers with the approved product labels. Never decant pesticides into drinks bottles or other similar containers
- All stores must be constructed in a way as to prevent unwanted releases. They should also be constructed of non-combustible material and secured against unauthorised access
- Never carry pesticides in the cab of a tractor, self-propelled equipment or other vehicle. Use a vehicle with a bulkhead between the cab and the load compartment and store chemicals in a secure, leak-proof chemical container or use a secure cabinet mounted on the outside of the vehicle or on a trailer.
- Make sure you lock the vehicle or cabinet whenever you are not in sight of it

Read the Health and Safety Executive guidelines in full.

Resources

- ***A farmer's guide to organic fruit and vegetable production Organic Centre Wales***
  http://www.organiccentrewales.org.uk/uploads/hortguide_eng.pdf

- ***Blight Watch*** https://blightwatch.co.uk/home/

- ***Biology and management of leatherjackets Organic Centre Wales***
  http://www.organiccentrewales.org.uk/uploads/leatherjackets_factsheet.pdf

- ***Biology and management of wireworms. Organic Centre Wales***
  http://www.organiccentrewales.org.uk/uploads/wireworms_factsheet.pdf

- ***Ecological selectivity of pesticides and pesticide application methods Integrated Protection in Field Vegetables IOBC-WPRS Bulletin Vol. 118, 2016 pp. 94-98. Rosemary Collier, Andrew Jukes, Claudia Daniel, Martin Hommes:*** https://orgprints.org/32313/1/2016_IOBCCollier.pdf

- ***Orchard spraying: Opportunities to reduce rates Horticultural Development Council. Peter Walklate, Jerry Cross*** https://www.hse.gov.uk/pesticides/resources/H/HDC_Factsheet_20-05_Tree_Fruit.pdf

- ***Pest and disease management for organic farmers, growers and small holders: A complete guide. (2010) Garden Organic Gareth Davies, Phil Sumption, and Anton Rosenfeld***

- ***Pesticide Red List, Plantwise,*** https://www.plantwise.org/pesticide-restrictions/

- ***Pesticides: What you need to know. Health and Safety Executive***
  https://www.hse.gov.uk/agriculture/topics/pesticides.htm

- ***Pesticides and the loss of biodiversity, Pesticides Action Network Europe***
  https://www.pan-europe.info/old/Resources/Briefings/Pesticides_and_the_loss_of_biodiversity.pdf

- ***Selective pesticides database***
  http://iobc-wprs.org/ip_ipm/archive/IPM_Future_Jansen_20130320.pdf

- ***Weed management for organic farmers, growers and small holders: A complete guide***.
  (2008) Henry Doubleday Research Association Gareth Davies, Becky Turner, Bill Bond

- ***Warwick University Crop Centre. Pest prediction models***
  https://warwick.ac.uk/fac/sci/lifesci/wcc/resources/morph/models/