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1. Introduction and principles

Pests and diseases can cause serious losses to organic growers both in crop yield and monetary returns. Organic pest and disease management should be designed according to organic principles.

Organic farming and growing provides a sound basis for the control of pests and diseases by creating cropping systems, which are less prone to high levels of pest and disease. A preventative and long term strategy, builds on the lack of stress and integrated control strategies to minimise the need for curative solutions.

Pest and disease management systems in organic systems aim to prevent economically damaging levels of pests and diseases building up on crop plants.

Use of extensive crop rotations provides effective control against a wide range of pathogens and the build up of weed burdens.

Growers should work towards producing well nourished crop plants within a biologically diverse farm environment. Promoting a healthy soil, with good structure, high biological activity and containing sufficient nutrients, will promote the growth of vigorous crop plants that are in turn unattractive to or resistant to pests and diseases by reducing the area of monoculture or suitable habitat available to crop pathogens, by increasing the presence of competitors or natural enemies of the crop pathogens and by decreasing the probability of transfer of pathogens between susceptible crops.

2. Pest and Disease Management

There are two basic types of approach to pest management:

Strategic
- Strategic practices are techniques that are primarily aimed at preventing pest and disease problems arising in the first place and generally take the whole farm system into account.
- These include maintaining and promoting soil fertility, using crop rotations, using crop varieties resistant to pests and diseases, promoting biodiversity and promoting basic sanitary precautions to prevent the spread of pathogens.

Tactical
- Tactical practices can be curative and preventative and are normally aimed as specific pest, disease and crop combinations usually where serious crop loss is anticipated.

Rotations
- Crop rotation is vital to pest and disease management.
- In many cases pests and diseases are unable to survive in the absence of the host crop and so absence of the host will cause their numbers to decline.
- Rotations should allow for the longest possible period between growing crops of the same family.
• Adding cover crops and green manures can also have a beneficial effect e.g. cleaning the soil of susceptible pathogens
• Rotation is most useful against soil borne pests and diseases such as cyst nematodes in potatoes, white rot in alliums and club root in brassicas
• Rotation is not generally effective where pests or diseases are spread by air, such as blight or mildew.
• In some instances rotation can promote problems e.g. wireworm can be a problem in vegetable crops grown immediately after grass-clover leys

**Resistant varieties**

• Plant varieties differ in their susceptibility to pathogens. Resistance mechanisms to disease can include characteristics such as thick waxy layers on leaves or hairs to deter pests from feeding or impair development
• Resistance is usually referred to as specific (vertical) or non specific (horizontal)
  o Specific resistance relies on plant breeders matching specific virulent genes in the pathogen with resistant genes in the plant. This means that the variety is resistant to specific races of the pathogen e.g. downy-mildew-resistant-lettuce which is resistant to a specific race of downy mildew. Specific resistance is highly effective even under high disease pressure but can break down over a number of seasons
  o Non-specific resistance is effective against all strains of a pathogen, but can break down in high disease pressure years or when environmental conditions give an edge to the pathogen it can be expected to be long term. Non-specific resistance is often thought to be better for organic production systems
• There is limited information available on the pest and disease resistance of varieties grown under organic management, however resistance ratings from non-organic trials should provide a useful comparison between varieties
• Information on pest and disease resistance is routinely given in seed catalogues and is also provided through the national variety trials run by the National Institute of Agricultural Botany (NIAB)
• In many cases saving your own seed can be an effective way of breeding a strain that is particularly adapted to your situation and therefore potentially able to deal better with pest and disease attack.

**Promoting biodiversity**

• Ecological studies have shown that systems with higher biodiversity have a higher and more stable productivity
• This is partly because resources are used more efficiently but also because there are no unchecked outbreaks of pests and diseases
• Reduced numbers of pests and diseases are brought about by:
  - increased predator or parasite populations
  - provision of alternative hosts
  - prey for natural enemies
  - decreased colonisation or reproductive rates of pest organisms
  - prevention of movement and emigration of pests and diseases
  - increased synchrony between the life cycles of pests, diseases and their natural enemies
Hygiene and Sanitation

Good hygiene and sanitation can prevent the introduction or spread of pathogens. The extent to which this is possible depends on the pathogen and the costs involved

- When buying in seed or stock ensure that only clean, certified seed is used on the farm and that transplants are free from pests and diseases
- Own saved seed should be checked for pest and disease loading before being sown.
- Cleanliness in on-farm operations can prevent the spread of pathogens between fields on a farm
- Soil-borne diseases are often spread on equipment and these should be routinely cleaned down after operations in any particular field. If working with larger team (particularly of casual labour) educating your workforce about hygiene and infection risks are also crucial.
- Removing crop debris can help prevent spread of some diseases as can the removal of volunteer plants or weeds
- Physical removal and destruction of infested or diseased plants can be useful in some situations
- You can avoid planting at peak periods of susceptibility e.g. plant main season carrots in June in order to avoid the first peak of carrot flies

Cultural practices

- Manipulating the time of sowing and the crop density have traditionally been used to manage diseases
- Generally more open canopies (wider spacing between plants and rows) will reduce the spread of plant diseases as leaves dry more quickly and humidity is reduced
- Manipulating planting depth can also help as shallower planting of potatoes will help reduce the incidence of stem canker in spring as the roots are not in contact with wet and cold soil
- Adequate and careful cultivation of soil prior to sowing or planting will allow crops to establish quickly e.g. brassicas where rapid crop establishment is necessary to outgrow pest damage
- Mulching and raised beds modify soil conditions by warming it up and drying it out although some types can encourage other pests e.g. slugs
- Time of weeding is important as although they have a detrimental effect on crop yield they can provide alternative food or prey for parasites or predators of pathogens
- Polycropping reduces the chance of pests or diseases encountering a suitable host or by confusing pest host-finding behaviour
- Covers and fleeces can be labour intensive as they need to be removed for weeding and other farm operations
- Barriers are normally used to prevent larger mammals such as rabbits, badgers or deer gaining access to and feeding on crops
- Manual removal of pests is only practical in small areas with larger sized pest insects e.g. caterpillars
Biological control

Involves the manipulation or release of natural enemies and pathogens in order to control plant pathogens

- Biological control attempts to shift the balance of competition between the pathogen and the crop in favour of the crop
- Biological control agents are normally a fungus or insect and will either kill the pathogen or reduce its vigour and competitive ability
- *Bacillus thuringiensis* (BT) has been widely used in organic systems against Lepidoptera caterpillar pests
- Conservation biological control or habitat management has been increasingly promoted as a biological control technique
- It works by creating conditions for natural enemies of crop pests and diseases to survive and increase. It creates and supplies resources that biological control agents need either physical or biological.

Chemical Control

This covers a diverse range of products normally in liquid form which are used to modify pest behaviour or kill pathogens

- They are normally based on natural plant extracts, compost teas or inorganic salts
- It is sometimes necessary to reapply such products, if for example there is strong sunlight which may degrade products, or heavy rain which will wash solutions away
- Application of any chemical products must be in compliance with UK law and the registered certifying body regulations

Guidelines

- Get to know what pests and diseases occur on your farm. Time spent noticing what pests or diseases occur and consulting texts available on their behaviour is worthwhile
- Understanding behaviour, life cycles and habits will help give you a realistic assessment of likely losses
- Take notes and use counting methods to estimate populations and so estimate the level of damage
- You should instigate and maintain monitoring programmes for all pests and diseases
- Use forecasting systems where they are available
- Consider and identify the key environmental factors which impinge both favourably and unfavourably upon pest species in the ecosystem
- Identifying sources or causes will help when looking at ways to control the populations
1. Weed Management

The cost of weeds in terms of yield and economic losses are well understood but their beneficial properties must also be taken into consideration; including:
- prevention of leaching
- erosion control
- refuges for insect predators of crop pests

Organic farmers should not aim to completely eradicate weeds from their system but to manage them.

Crop Choice and Sequence

Crop planning has important implications for weed management:
- Length of rotation, choice and sequence of crops will depend on individual farming circumstances and will include factors such as:
  - soil type
  - rainfall
  - topography
  - enterprises
- No one rotation can therefore be recommended, however, in general terms rotations should include:
  - alternation of autumn and spring germinating crops
  - alternation of annual and perennial crops (including grass)
  - alternation of closed, dense crops such as oats which shade out weeds and open crops such as maize which encourage weeds
  - a variety of cultivations and cutting or topping operations that directly affect the weeds
- Consider putting weed sensitive annual crops after perennial leys as it has been shown that in the third cropping year after a grass/clover ley there can be twice as much weed emergence as compared to the first.

Fertility building leys

Length of the fertility building period within the rotation will have an impact on weed population and if well managed the ley period can act as a weed suppressing phase:
- Choice of fertility building crop and ensuring good establishment are both important
- Grassland systems that have temporary leys instead of permanent pasture will provide the opportunity to control perennial weeds during cultivations between ploughing and reseeding
- The seedbed needs to be well prepared and good contact made between seed mix and ideally moist soil to achieve good establishment

Cover or break crops

Break crops are so called because they break the cycle of normal cropping and provide diversity in rotations. This change of cropping can provide benefits not only for pest and disease control but also nutrient use efficiency, higher economic returns and improved weed management:
- Cover crops primary purpose is nutrient management but they are also quick to germinate and dense so can suppress weed emergence.
• Some stockless systems rely on short bursts of green manures rather than leys for fertility and will lose the benefit of a longer weed-suppressing phase
• Some cover crops exhibit allelopathic properties – they exude chemicals that can have an inhibitory effect on surrounding plants

**Intercropping and under-sowing**

Two or more different crop species can be grown together and this is known as intercropping or mixed cropping
• The advantage in terms of weed management is that there is greater ground coverage by the crops leaving less area available for weeds to populate
• Mixed cropping can involve purely cash crops or a mixture of cash crops and fertility building crops
• They can be arranged as under-sown crops, strip crops or row intercrops
• Under-sowing reduces weed emergence as a quick growing dense layer of vegetation covers the ground
• If cash crops are under-sown with fertility building crops then there are other advantages besides weed suppression

**Variety choice and seed quality / grade**

• Some varieties are weed tolerant and others actively suppress them
• Organic systems need varieties that actively suppress weeds if possible
• Quick germination, good early vigour, large leaf area, prostrate growth or height are all desirable traits
• Spatial distribution of the canopy foliage and rooting system will also be important
• Varieties with a larger seed size have been shown to exhibit greater initial vigour of emergence and growth which may provide extra competitive ability
• The most vigorous species should be chosen as they are most likely to out compete weeds
• Crop seeds should be free from contamination by weed seeds
• Organic growers are required to use organically produced seed where available and this should be clean

**Seed rate and crop spacing**

• In drilled or transplanted crops the proximity of plants to one another will determine the competitiveness of the plant stand as a whole
• Seed rates tend to be higher for organic than conventional crops
• The greater amount of space taken up by the crop in rows the less space is available for weeds to invade

**Crop establishment**

• The ability of the crop to get a head start on the weed flora is critical
• This can be aided by use of primed seed or by transplanting an already established plant into a freshly prepared weed-free seedbed
• Bare root transplants can be raised on holdings or modular plants raised or bought in and then planted out into the field these have the benefit of allowing accurate spacing and not relying on germination which can lead to uneven establishment with subsequent yield losses
• It also accentuates the difference in size between crop and weed which helps with mechanical weeding

**Cutting regimes**

In horticultural and stockless arable systems, ley management will include topping at intervals during the summer. Different species of ley require slightly different management regimes but in general the following is a good guide.

• Ideally in fertility-building leys the sward should not be allowed to get higher than 40cm. If the vegetation gets higher than this then topping will create a mat of vegetation that will act like a mulch and create dead spots in the ley where clover may be excluded by more vigorous grasses or which weeds may colonise

• Topping the ley regularly will ensure that tall weeds that may have germinated will not be able to set seed

• In grazed pasture, weeds that are not eaten by livestock will need to be topped to prevent seed shed

• In grassland systems, cutting for hay or silage will have an impact on the weed flora. Silage would be cut early in the season when the sward is young and fresh whilst hay is cut at a later stage

• Cutting late may allow weeds in the pasture to grow to maturity and set seeds. Ripe seeds may contaminate the hay and remain viable when passed through livestock

**Use of manures**

• Placing manures and slurry more accurately on crops can work to benefit the crop rather than the weeds for instance after silage cuts, the application of slurry to stubble may provide optimum conditions for weed seed germination

**Livestock**

• Livestock can make good use of the nutrients in mixed systems using grass/clover leys for fertility building

• They produce a resource which can be used across the farm to fertilise cash crops

• Management of the ley is very important in livestock systems

• The right grazing balance over the year e.g. lighter stocking in the winter and during wet periods to prevent poaching and alternating between sheep and cattle who graze out certain weeds

**Fallowing**

• A fallow period may have to be planned into a rotation if weeds cannot be controlled during cropping or fertility building

• It may not be necessary to stop cropping for a whole year but instead to employ a bastard fallow e.g. no crop for part of the year (often in the summer when cultivations can take place and dry weather assists root desiccation)

• This technique is better used in plough dominated systems rather than grassland management

**Farm hygiene**

• Hygiene prevents the spread of infestations around the farm
• Ensure that any compost, manure or slurry to be spread is weed seed free
• Washing down machinery after using it in a field with flowering weeds or where there is a particularly bad infestation. This should also apply to contractors
• Management of non cropped areas should be undertaken to prevent spread or invasion of weeds
• Livestock water and feeding points must be rotated to ensure that excessive dunging does not occur as perennial weeds thrive in high nutrient areas

Tillage

Tillage is the most effective way to reduce the size of the weed seed bank.
• Ploughing can be particularly useful in terms of managing weeds.
• A “stale seedbed” can be prepared with seeds being encouraged to germinate and then cultivated usually mechanically or by flaming to kill off weed seedlings
• If weed seeds have been allowed to shed on the soil surface then ploughing will bury weed seeds to a depth below which they are able to germinate. Many weed species have seeds that are extremely long lived so this may only be a temporary solution
• Secondary tillage involves the preparation of a fine, flat seedbed into which the crop can be drilled or planted. A tight cropping schedule may not allow for this break or weather conditions may be unsuitable

2. Methods of weed control

Mechanical

Mechanical weed management kills weeds by burying, cutting or uprooting
• Most weeding machines tend to be more effective on small weeds
• Weather and soil conditions will have a major impact on the efficacy of mechanical weed management

Manual

• Manual methods of weed control are still widely used in organic systems
• This will often involve following a mechanical inter-row weeding operation with manual labour to thoroughly remove weeds in the crop row
• This can be by groups of workers hand-weeding crops, hoeing using hand held implements or by workers lying on a flat bed weeder pulled by a tractor
• Hand rogueing or pulling is also a widely used technique for patches of weeds or removal of difficult to control species such as docks

Thermal

There are two main methods, flame and infra-red weeding
• They both involve combustion of liquefied petroleum gas
• Flame weeding targets a flame directly as the soil surface While infra-red burners use the flame to heat a ceramic or metal surface that then radiates heat towards the ground
• In both cases the plant cell contents are effectively boiled causing the cell walls to burst and the plant to desiccate
• This method can be used to help create a stale seed bed, for pre-emergence weed control in slow germinating crops e.g. carrots, for post-emergence broad spectrum weed control in tolerant crops e.g. onions and as selective post-emergence treatment between crop rows or in patches

Mulching

Provides a physical barrier over the soil surface through which light cannot penetrate
• It prevents weed seed germination and suppresses emerged seedlings
• There are 3 main types:
  - sheeted – a layer of material such as plastic, paper or woven fabric which covers the soil surface
  - particle – a layer of material such as straw or green waste compost is spread over the soil surface
  - living – a low growing ground covering crop is sown
• Crops are planted or sown through these mulches