WWW.INDUSTRY.NSW.GOV.AU

primefacts

FOR PROFITABLE, ADAPTIVE AND SUSTAINABLE PRIMARY INDUSTRIES

SEPTEMBER 2010 PRIMEFACT 1052 (REPLACES PRIMEFACT 804)

Organic vegetable production - managing weeds, insect pests and diseases

Robyn Neeson

Organic Farming Liaison Officer, Farming Systems Research, Yanco

Organic weed management

Many organic producers say that effective weed management is one of the greatest impediments to successful organic vegetable production. The use of synthetic herbicides is prohibited under organic standards so the development of an effective weed management program is critical to success.

Planning a weed management program

The following principles should be considered when planning a weed management program:

- Learn to identify weeds. Learn about weed lifecycles and growth habits—including the time of emergence, growth rates, the method of dispersion, and the time of seed set—and why the weeds are filling that ecological niche.
- Maintain a longer term outlook, rather than focusing only on the current or coming season. It is necessary to determine how weeds can be managed throughout the rotation. Seed bank reduction can take a number of years.
- Take an integrated approach to weed management. Avoid relying on a limited number of methods. Be innovative with equipment, tillage and rotations.
- Planning should aim to prevent weed outbreaks. Once there, weed problems are much harder to manage.
- Observe and record changes to weed populations in each field.
- Introduce changes to the lowest risk crops in the rotation.
- Identify the soil characteristics or management practices that favour specific weeds. The presence of a particular weed species might be an indication of a soil fertility or soil structural problem. A slight change in pH or improvements to irrigation management or drainage can change the conditions that were prompting growth and the spread of the weed.
- Build weed management strategies into whole-farm planning. For example, design a fence layout and paddock size that allow for strategic grazing (for example, with goats), grow less competitive crops in paddocks where weeds are not a problem, leave uncultivated areas to host potential biological control agents (for example, Patterson's curse weevil) and choose crops that are able to compete effectively with weeds.

It is important to also remember that weeds can be beneficial. Among the possible benefits to the farming system is erosion control, habitats for insects, capturing soil nutrients and moisture at depth, and food or medicinal value for livestock (provided of course they are not toxic).

Organic management practices

Surveys of organic growers reveal that the most frequently used weed management tactics are manual and mechanical tillage, rotations including vigorous cover crops, slashing, and numerous cultural practices (Kristiansen et al. 2001). An integrated approach to weed management relies on planning long-term remediation strategies—such as soil improvements or the use of biological controls—backed up by short-term management practices.

Reducing the bank of weed seed

Preventing weeds going to seed can greatly reduce weed pressure. Most soils contain a significant weed seed population, and each time soil is disturbed some of the seeds will germinate. It is possible, however, to gradually reduce this population by preventing weeds going to seed during the season and following up with off-season control measures.

Planting short-season crops such as lettuce provides more opportunities for weed suppression; competitive cover crops can smother weeds. Cultivation plus grazing and mowing weeds can prevent weed seed set. If the weeds do manage to set seed, baling the weeds into hay and removing them from the paddock before seed dispersal is an option. The hay could then be used in compost production. Proper composting makes seeds non-viable.

Hand weeding

Perhaps the single most valuable tool in organic weed management is hand weeding, which can involve chipping or digging using a hand-held implement or pulling out weeds by hand. One weed allowed to seed could become an outbreak in a few seasons. Successful organic farmers never walk past a 'potential' weed problem. Hand weeding is often useful in inaccessible areas or for a final clean-up after relying on other methods.

Mulching

Organic farmers use mulches to help reduce weed competition, conserve soil moisture, lower soil temperatures, and prevent erosion. Among the organic materials used are hay, paper and cardboard, compost and sawdust. Organic standards prohibit the use of solid non-woven plastic or synthetic material sheets as mulches. Sometimes, woven plastic or synthetic materials are approved, provided they are completely removed from the paddock following harvest. To be effective, organic mulches should be applied and regularly maintained to a depth of 100 millimetres.

A green-manuring technique that uses the residues of crops (such as vetch) grown in the preceding season can also provide a mulch against weeds. The main crop is then planted into the residual surface mulch of the cover crop. The cover crop is also referred to as 'living mulch' or 'smother crop', and the technique relies on the senescence of growth in that crop, which is then broken down to form a surface mulch. Cowpeas and cold-sensitive clovers have been used with success.

Tillage

For tillage, Steel in the Field: a farmer's guide to weed management tools (Bowman 1997) is essential reading.

Primary cultivation practices such as deep ripping can improve drainage and alter the weed species composition in a field. Primary cultivations, in combination with other control measures such as green manuring, should aim to reduce the weed burden before planting the crop. The final primary cultivation before planting should be carried out after optimum weed germination.

Secondary cultivations—those performed during seed-bed preparation or after planting—should be shallow and should aim to remove weed seedlings while minimising soil inversion or soil mixing, to prevent a 'new' weed seed bank from establishing at the soil surface.

In row-cropping situations, good weed control is facilitated by creating and maintaining evenly spaced, straight hills or beds. Mechanical weed control between crop rows, using implements such as rotary tillers (for example, the WeedFix®), should be carried out when the weeds are small and the crop is at the two- to three-leaf stage and, if necessary, again at the five-leaf stage or while it is still feasible without damaging the crop. Once the crop canopy has closed, competition from weeds should be minimal.

The most difficult place to manage weeds is within the crop row, and hand weeding is probably the most common method here. Having crop guards around tillage implements will allow weeding to be done as close as possible without damaging the crop.

To ensure a good weed kill, cultivations should be avoided if rain is imminent and should be timed for the earlier part of the day during hot, dry and windy conditions. Avoid cultivating wet soil: it will become compacted and drainage will be impeded. Any form of prolonged tillage will affect the soil structure and increase compaction, as well as predisposing the paddock to erosion and fertility loss.

Water management

Effective water management is a central ingredient of weed management in organic production.

Pre-planting irrigation or rainfall stimulates weed emergence, after which weeds should be killed by shallow cultivation or by flaming. Planting of the main crop should occur shortly afterwards to avoid further weed germination as a result of rainfall.

Burying drip irrigation lines below the bed surface provides water to the crop but restricts the water's availability to weeds closer to the soil surface, particularly if rainfall does not occur. Post-planting operations are also be greatly facilitated if the drip line is buried.

Crop physiology

Vigorous crops often out-compete weeds. Fast-growing crops can quickly cover beds and fill gaps in the crop stand that weeds might otherwise occupy. Species with large leaves can shade out competing weeds.

Biological weed control

Various biological agents are available to facilitate weed management. Among them are insects (for example, crown root weevil for control of Patterson's curse), fungi and bacteria (for example, rusts formulated into biological herbicides known as myco-herbicides) and plant derivatives (for example, corn gluten meal, some vegetable oils and plant root exudates such as those from oilseed rape). Some of these agents have been formulated into commercial products known as bio-herbicides. The certifier's approval should be obtained before any treatment is used.

Some biological agents are effective over a longer period and rely on establishing and maintaining a colony of organisms. The organisms' persistence—and hence long-term weed control—is dependent on the presence of a sustainable food source as well as suitable habitat, so it is desirable to set aside an area where there is a low level of the host weed or there is an alternative food source. These areas are usually uncultivated borders—for example, in windbreaks—adjacent to cropping areas. Genetically modified organisms are not permitted as biological controls in organic systems.

Flame weeding

Flame weeding can be used to control weeds before and after germination of the crop. Effective pre-emergent flaming calls for good timing. The operation must be done after a flush of young weeds appears but ahead of significant crop emergence. The most effective time to kill weeds is before the three- to four-leaf stage. 'Indicator' seeds can be sown with the crop: they can be timed to emerge just before the crop in order to determine when it is safe to flame.

Ideally, beds should be smooth, with minimal clods: protruding clods or uneven terrain can shield small weeds or deflect the flame into the plant canopy.

For energy-efficient flaming it is desirable to travel as fast as possible, using the lowest gas pressure and thus the least fuel. Although there will be little immediate effect visible, the weeds will droop and wilt within a few hours. A quick way of testing whether the flaming has been effective is to firmly squeeze a plant leaf between thumb and forefinger, then let go. If there is a fingerprint where the leaf was squeezed, the heat has burst the cell walls and the leaf will wither.

For flaming to be successful, operations need to be carefully timed. When weed pressure and planting schedules allow, delay the final flaming until just before planting. This gives the crop the least weed competition during its most vulnerable stage. Flaming is best done in the heat of the day, when it is hot and dry with little or no wind.

Flaming has differing impacts on pests and their predators, so it is important to carefully monitor populations to see how they are being affected.

Two types of flaming equipment are generally available. One is a hand-held propane flamer connected to a backpack-supported fuel tank and is generally used in inaccessible areas or for small weed outbreaks. The other type of equipment involves propane burners that can be either individually mounted or attached to a two-row, rear-mounted tractor-drawn cultivator. These can be four- or six-row flamers, depending on the size of the operation.

Sanitation

Good sanitation can help to prevent new infestations and the spread of weeds. It involves the use of well-graded seed, removal of crop refuse, thoroughly composting manures and green waste, as well as cleaning down machinery between operations and before moving from one field to another. Livestock can act as weed carriers if they have been grazing on weed seed in infested pastures or have been hand fed on grain. Mulch applied to crops should be free of weed seeds. As noted, proper composting of crop refuse destroys weed seeds.

Solarisation

Solarisation, a technique used to kill weeds (as well as some pathogens and nematodes), involves placing clear plastic film over moist soil. The plastic is applied during the hottest part of the year for four to six weeks. The soil temperature should reach 60°C at a depth of 5.08 centimetres and 39°C at a depth of 45.7 centimetres. The main difficulty with soil solarisation is finding a time between crops when temperatures under the plastic are high enough for long enough to be effective. Once solarisation is completed, the plastic film used can be recycled for future use or disposed of in an environmentally acceptable manner.

Organic sprays

A number of organic sprays are approved for weed control under organic Standards. Among them are essential oil sprays, homeopathic products and biodynamic peppering. The efficacy of these substances is yet to be scientifically evaluated. A pine oil derivative is approved for use by some certifiers.

Grazing animals and birds

Goats, pigs, sheep, and other animals will eat weeds but will also root out or graze any crop plants present in the field. Pigs are sometimes useful to root out tubers of nut grass and Johnson grass before a crop is planted. Sheep can be used to 'crash' graze paddocks to prevent seed set. Goats and some breeds of sheep (for example, Dorpers) are foragers and often eat plants that are less palatable to other species. Whilst grazing can be s a very useful weed control strategy owners need to be aware of potential toxicity risks.

Managing problematic weeds

Weeds that organic growers commonly report as problematic—examples are couch, dock, kikuyu and sorrel—tend to have underground parts that are less vulnerable to the usual forms of non-chemical weed control such as tillage and mulch or are heavily seeding annuals (Kristiansen et al. 2001). Some annual weeds have very long-lived seeds and can survive for more than 40 years before germinating.

The primary approach to controlling perennials with cultivation is to separate the above-ground and underground parts and then exhaust the food reserves in the underground part. Tap-rooted and shallow-creeping perennials are generally easier to control; the deep-creeping and tuber, corm and bulb types are often the most problematic. Difficult-to-manage annuals are controlled by preventing the conditions that encourage seed germination and by stopping further seed set. Merfield (2000) provides some useful management strategies for weeds of this kind.

Noxious weeds

Farming organically does not exclude anyone from adhering to laws imposed by the Commonwealth or the states and territories. Under the New South Wales Noxious Weeds Act 1993, for example, producers are required to control certain weeds. The Act does not specify chemical control, but it does specify that the noxious weed be either fully and continuously suppressed and destroyed (for W1 and W2 category weeds) or be prevented from spreading and its numbers and distribution reduced (W3 category weeds). For a W4 noxious weed, the action specified in the declaration must be taken. The Act can be viewed online at:

www.legislation.nsw.gov.au/viewtop/inforce/act+11+1993+FIRST+0+N

and details of weeds declared in New South Wales can be viewed online at www.dpi.nsw.gov.au/agriculture/pests-weeds/weeds/legislation

Insect pest and disease management

Organic standards prohibit the use of synthetic pesticides and discourage a pest and disease management strategy that substitutes reliance on synthetic pesticides with allowable organic insecticides. Under the standards a more holistic approach needs to be adopted, which essentially comes down to an 'integrated' pest and disease management strategy – without the chemicals.

Planning an organic pest management program

Instead of using synthetic pesticides, organic farmers adopt cultural practices that encourage healthy plant growth and other practices that encourage the presence of pest predators.

Three conditions must pertain if a pest problem is to develop:

- The pest (or disease) must be present.
- The crop must be a suitable and susceptible host.
- The environmental conditions must be favourable.

These conditions are known as the 'pest triangle'.

The first step in an integrated pest management system lies in knowing what pests are likely to, or might possibly attack the crop, the pests' life cycles, what conditions favour their survival, and what conditions or natural enemies might control the populations. The second step is to pre-plan the cropping system to minimise the potential for pests to become a problem. The third step is to monitor the conditions that might favour a pest outbreak. If all the conditions of the pest triangle are favourable to a pest outbreak, the fourth step is to intervene, to modify those conditions in order to reduce the risk or severity of damage.

Step 1: Knowledge

Key pests

Less than 1 per cent of all insects are 'pests'. But agricultural production creates conditions that favour the build-up of a small number of insects to pest levels. 'Key' pests tend to be insects that are likely to cause serious damage if left unmanaged. They can be regular pests, such as *Heliothis* is on tomatoes and many agricultural crops, or they can be irregular but potentially devastating, such as russet mite on tomatoes or pumpkin beetle on cucurbits. Lists of likely or possible pests and a number of crop guides for most agricultural crops are readily available from state departments of agriculture.

Pest biology and life cycles

Knowledge of a pest's biology and life cycle is essential for finding out where it is most vulnerable and how it is most likely to be managed. The more one knows about them the more likely it is one will find ways to thwart their successful development.

Natural enemies

In natural environments most organisms' populations are kept in check by a range of 'natural enemies', among them bacterial, viral and microsporidium diseases, nematode infections, parasites or parasitoids, and predators (for example, bats and birds). These natural enemies are called 'beneficials'. Most insect pests have a range of specific and generalist natural enemies that either kill them or limit their ability to cause damage or reproduce. In most agricultural systems—and particularly those that use few, if any, insecticides—there are a range of generalist predators.

Populations of specific natural enemies can build up in the presence of the pest. If natural enemies are to thrive they need the 'beneficial' equivalent of the 'pest triangle':

- The beneficial must be present.
- There must be suitable hosts and, in some cases, a nectar or pollen source.
- The environmental conditions must be favourable.

Shelter, breeding grounds and year-round food sources encourage predators. Nectar-producing species incorporated in pastures and windbreaks attract parasitic wasps, which parasitise scarab species in pastures. On-farm wetlands encourage predatory waders and, if correctly located and properly designed, provide a filter for nutrients in drainage before it leaves the farm. Ideally, there are also suitable non-pest hosts for the beneficial populations to increase, so that if a pest arrives it finds itself in a hostile environment.

Step 2: Prevention

Within a pest management system, it is wise to prevent or limit the likelihood of pest populations causing serious damage. A variety of cultural control methods can be used to reduce the likelihood of pest outbreaks.

Site selection

Some sites will be more prone to pests than others. For example, growing organic tomatoes next to large plantings of sweet corn or other *Heliothis* host crops will increase problems with *Heliothis.* Choose sites that are isolated from sources of pests.

Choice of crop

Choose a crop that is optimal for the location: a strong, vigorous plant is less susceptible to attack. When growing organically, it is often better not to grow crops that are already grown extensively in the area, unless there are natural barriers that reduce the flow of pests onto the organic land.

Cultivar selection

Some cultivars are resistant to, repel, or are less palatable to pests than other cultivars. In sweet corn, for example, the H5 variety has a tighter 'throat' to the cob, reducing *Heliothis* caterpillars' access.

Crop rotations

To reduce soil-borne pests and diseases, rotate host with non-host crops. Rotations can also break insect pests' life cycles and help control weeds.

Material from off-site

If using transplants or bringing any materials to the site, assess the risk of bringing pests with them. Insects, and particularly diseases, can easily come from off-site contamination.

Timing of planting

If possible, choose planting times when pest pressure is likely to be lowest. Early planted crops of processing tomatoes experience less *Heliothis* pressure than later planted crops.

Crop health

Plants growing with optimum water and nutrition tend to be less susceptible to pest attack and might better compensate for damage. Over- or under-provision of water or nutrients will stress the plant and increase its vulnerability.

Sanitation

Many key pests have many host plants. If those host plants are weeds or old harvested but uncultivated crops, they can contribute to supporting the pest population on the property. Controlling weeds—particularly flowering weeds—is crucial for the successful management of, for example, western flower thrips. Mites are often spread through properties or from crop to crop by machinery or on the clothes of people walking through the paddocks.

Natural habitats

Natural habitats provide a source of beneficials to colonise the farming system.

Trap crops

In some instances other crops might be the preferred habitat for a particular pest, and if some of the preferred crop is grown it might draw the pest away from the main crop. For example, pigeon peas have been used successfully as a trap crop for *Heliothis* in soybean production. In some cases a particular crop stage is preferred by the pests, so a small sacrificial planting can be used as a trap crop.

Insectary crops

Many beneficial insects require nectar or pollen as food sources, and a nearby flowering crop can act as an insectary crop and help increase the number of beneficials working the main crop. Other insectary crops can be crops that host a related non-pest species—for example, a species of aphid that can then support the establishment of aphid parasitoids and predators that might move into the main crop if aphids become established there.

Inter-cropping

Alternating rows of different crops has been used as a means of reducing pest pressure. Of itself, inter-cropping does not reduce pest pressure, but some combinations of crops work well together and result in less pest pressure. Inter-cropping is not widely used in highly mechanised or extensive agricultural systems: it is most typically used in labour intensive systems such as market or home gardens.

Step 3: Observation

Once the basic system for reducing pest incursions and build-ups and maximising the effects of beneficials is in effect, the next step is monitoring. Agricultural environments are complex systems, and changes in weather or the arrival of a key pest can rapidly change a pest situation. Regular observation of the factors in the pest and beneficial triangles can warn of a potential problem while there is still time to respond.

Crop monitoring

Systematically checking crops for the key pest stages (for example, eggs for *Heliothis*) and using available traps (for example, pheromone traps or sticky traps) to help monitoring are fundamental to developing an ability to respond to an emerging problem. Weekly checks are recommended for most crops, with more frequent checking during periods of high vulnerability or high pressure. In some areas commercial scouts monitor crops for a fee.

Pest identification

Whilst in the process of learning about the pests and beneficials that visit crops, it is important to have insects or diseased plants identified by an expert. Most state agricultural departments offer diagnostic services.

Pest prediction models

Insects and diseases tend to respond predictably to temperature and/or moisture levels, so models can be developed. In some cases the models can be developed into prediction models, and for some cropping systems, such as cotton, there is crop management software that can help predict pest problems with the input of a range of data.

Step 4: Intervention

If observations of the crop or cropping situation suggest a need for action to reduce a likely or current pest build-up, the available tools fall into three categories—mechanical, biological and chemical controls.

Mechanical control

Mechanical controls are methods that can physically remove pests or physically prevent them moving into the crop.

- Light or bait traps. Moths and some beetles are attracted to black light and so can be caught in a ‘light trap’. These traps are not very selective, which means that a large number of non-pest, and possibly beneficial, insects might also be trapped. In Western Australia some lettuce growers use large light traps to help manage *Heliothis.* Some insects such as fruit fly are attracted to fermenting yeast or other ‘baits’ and can be trapped this way. Pest-specific pheromones can greatly increase a trap’s attractiveness to the target pest.
- Bug vacs or suction devices. In the United States large vacuum cleaner–like machines are used to suck up all the bugs in a crop. Strawberry growers have been the most successful users of this technique. It is not very specific, however, and beneficials are as likely, if not more likely, to be sucked up. In some cases a modified leaf-blower is used to collect beneficials from insectary crops or areas where their numbers are plentiful; they are then released in a crop where their numbers need to be increased.
- Covers and barriers. For high-value crops, row covers or fully enclosed net houses can prevent pests reaching the crop. The size of the holes in

the covers or net determines which insects can be excluded. Smaller holes usually mean less water penetration. The disadvantage is that, once a pest has found a way into the plants, its numbers might increase more rapidly in the absence of predators or it might be more difficult to physically control. Row covers and net houses do, however, offer other potential benefits such as providing a warmer environment and increasing the rate of plant growth; on the other hand, they can also increase humidity and the likelihood of fungal diseases developing.

- Soil solarisation. Soil pests and some soil-borne diseases can be controlled by soil solarisation, which involves using sealed or overlapping clear plastic to heat the soil beneath to high temperatures, thus sterilising the top few centimetres of soil. Proper laying of the plastic and enough sun exposure to raise the soil temperature to a lethal level to the required depth is crucial. This technique has the disadvantage of sterilising the soil (also killing beneficial micro-organisms) and leaves the soil open to colonisation by pests.
- Pupae busting. ‘Pupae busting’ means cultivating the soil to destroy the exit holes for *Heliothis* (*Helicoverpa armigera*) moths after pupation. Normally it is done after harvest and before the over-wintering larvae or pupae are due to emerge as moths. Cultivation to a depth of 10 centimetres is sufficient. Although some pupae can be physically destroyed, the main purpose is to destroy the exit tunnels. Pupae busting is essential to keep the number of spring-emerging *Heliothis* to a minimum.
- Removal of pests. Sometimes only a small number of pests are in the crop and the crop area is relatively small. In this situation hand removal of pests is an option.

Biological control

Biological control uses beneficials, habitat manipulation and/or products derived from natural organisms to control pests. Natural enemies (beneficials) are organisms that feed on or otherwise kill the target pest. They can be predatory insects (including spiders and mites), parasitoids, fungi, bacteria, viruses, nematodes or animals (for example, insect-feeding birds). Biological control is often best used as a preventive method, but some components of biological control are useful as direct intervention.

- Introduced beneficials. Predators or parasitoids of a specific pest can be released into the problem area. Perhaps they are absent because they do not naturally occur in the area, for some reason they have been killed, or their populations are not sufficiently high to adequately control the pest. Some predator and parasitoid species are available from commercial insectaries to release into a crop to control a specific pest outbreak.
- Habitat manipulation. Although this is normally a preventive method, slashing neighbouring insectary crops can encourage beneficials to move across into the target crop and perhaps control the pest.
- Autocidal control. Autocidal control involves using mass-reared pest insects that are released after having been sterilised by radiation or chemosterilants. When the sterilised males mate with ‘wild’ females no progeny is produced. The success of this strategy is dependent on releasing enough sterile males into the natural population to out-compete or outnumber the natural or wild males and prevent the females reproducing. This is a tool being used in fruit fly control.
- Semiochemical control. Semiochemical control uses synthetically produced chemicals that imitate sex or aggregation (grouping) pheromones to disrupt the pest’s behaviour. Both sex and aggregation pheromones can lure pests into a sticky or pesticide trap. Sex pheromones are also used to disrupt or prevent mating and reduce the number of pest offspring. This technique is commonly used in orchards and is more effective as a preventative method.
- Biocidal control. Biocidal control uses natural products or organisms that have a toxic or lethal effect on the target pest. Among such agents are products derived from plants (such as neem and natural pyrethrum), pathogens, bacteria, viruses, protozoa, fungi, nematodes and animals. In general, biocidal control can be used only as a direct control method once pest numbers have reached damaging levels since the kill rate is usually high but the carryover effect is low.

Chemical control

Chemical control is usually associated with synthetically derived poisons, which are not allowed under organic standards. Some chemicals are, however, permitted under organic standards, and these tend to be biologically derived or inorganic products or minerals.

It should be noted that even if the product is acceptable under organic standards it may not be legal to use it. Any insecticide, biologically based or not, is regulated by the Australian Pesticides and Veterinary Medicines Authority (APVMA) and each pest–crop–insecticide combination must be approved. Approved uses are clearly written on the insecticide label and any use contrary to those instructions is illegal.

Disease management

Causes of plant disease

Various members of the four major biological groups—fungi, bacteria, viruses and nematodes—cause plant diseases.

Viruses

Viruses are micro-organisms that can infect plants and animals. Many viruses affect plants, and all of them need external agents, or vectors, for their transmission. Examples of vectors are insects, mites, nematodes and fungi; examples of insect vectors are thrips, aphids and leafhoppers. Some viruses have specific vectors—perhaps a certain type of aphid or fungus. There are no chemical treatments for viruses, which means the vector must be controlled if possible.

Fungi

Fungi are microscopic organisms but have structures that can be seen with the naked eye. They produce hyphae, or strands, that can be seen on plant material. Their fruiting structures are visible with a hand lens or microscope, and their spores can be carried by wind or spread through water. These spores usually require moisture—rain, dew or high humidity—to germinate and infect plants. Some fungi have a narrow host range; others have a wide host range. Many soil-borne fungi are important in breaking down plant material and are an important part of soil biology.

Bacteria

The bacteria that cause diseases in lettuce are single-celled organisms and do not form more complex structures such as those developed by fungi. Bacteria can be secondary invaders of plant tissue when they invade damaged tissue. The initial damage can be caused by insects, other pathogens, frost, herbicide or hail. Other entry points for bacteria are natural openings found on the leaf surface. Bacteria are transported by rain, insects, pruning and cutting implements, machinery, moving soil and water.

Nematodes

Nematodes are very small worm-like animals, too small to be seen with the naked eye. Some types are pathogenic; others are beneficial and consume pathogenic fungi; yet others contribute to soil biological activity. Pathogenic-type nematodes have a mouthpart that pierces plant cells for feeding. As a consequence of this feeding, the plants can become stunted and die. Nematodes are usually associated with plant roots, but some species affect other plant parts. Nematodes tend to be more of a problem in light-textured soils such as sand.

Diagnosis

Control recommendations cannot be made unless the problem has been accurately diagnosed. Publications on plant diseases might help with diagnosis; otherwise, there are plant disease diagnostic services in each state. Disease control will not be successful if the disease has not been correctly identified.

Reducing plant diseases organically

It is important to have a complete picture of what diseases occur in a particular region. The proposed cropping site should not have a history of any serious soil-borne diseases. Ask the district horticulturist what diseases could cause trouble for the proposed crop.

Variety selection

When choosing the correct variety for the area, account should be taken not only of optimising yield but also of maximising disease control. Appropriate variety selection can help disease management:

- varietal resistance and tolerance

- the physical shape or habit of the plant.

A variety can have genetic resistance to a disease; that is, it has been bred to be resistant to the disease. For example, resistance to downy mildew has been bred into some lettuce varieties. Varieties can also show reduced or increased disease levels as a result of their physical characteristics. Plants might not be completely resistant to a disease but can be tolerant.

Pathogen-free seed or vegetative propagation material

Many viruses are seed borne. Potatoes are a good example of vegetative material capable of carrying pathogens. Make sure any planting material is free of diseases. Always keep a small amount of the material for reference in case problems are found after planting.

Climate

Many plant diseases are affected by environmental conditions. High rainfall—or, more specifically, high leaf wetness—can promote infection with many of the fungal diseases, such as downy mildews and rusts. Reducing the plant density can increase the air flow through the crop, but may compromise weed management.

Weed control

Weed control is important for many plant diseases because often the weeds are also the hosts of the diseases. Many weeds and ornamental plants are hosts of tomato spotted wilt, which is a virus affecting tomatoes. The virus is transmitted by thrips.

Crop rotation

Changing the crops grown has long been a way of reducing diseases. It can be important in controlling many soil-borne diseases, but it will not have an effect on soil-borne diseases that produce inoculum that can survive in the soil for many years. Fungi that produce sclerotia (hard-bodied survival structures of some soil-borne fungi) are an example of this. Rotation will be successful if the disease in question survives only on host material and does not survive when all residue of that host is absent.

Roguing

'Roguing' means physical removal of any diseased plants. The practice can reduce both the spread of the disease and the carryover of the disease. It can be labour intensive, though, so might be of benefit only in high-value crops.

Removal of crop residue

Removal of crop residue is very important if overlapping of plantings occurs. In lettuce production, lettuce is planted in overlapping plantings so that a continual supply is available. Once a block is harvested, plant material should be ploughed in. As a last resort, burning the plant material—something not favoured in organic standards—can help reduce the carryover of disease. Grazing livestock such as poultry can help to remove crop residue.

Irrigation management

Over-irrigation can cause serious problems by favouring soil-borne diseases.

Overhead irrigation can contribute to plant foliar diseases. If it is used, make sure that plants dry out as quickly as possible—for example, by avoiding watering in the evening, so that foliage does not remain wet overnight.

Trickle irrigation is the best option for reducing plant disease. Flooding can, however, be used to limit some diseases (such as sclerotia) before planting a susceptible crop.

Soil solarisation

See section on weed management.

Soil management

Improving soil health through increasing biological activity can reduce the chance of soil-borne pathogens being a problem. Addition of compost and incorporation of green manure crops can help reduce soil-borne diseases by increasing the biological activity of beneficial species in the soil. Careful selection of the green manure is important, to ensure that it, too, is not a host to the pathogen.

Ploughing

Ploughing of crop residues can be useful for burying sclerotia and subsequently increasing the biological breakdown of the survival structures.

Biological control

Research into biological control is expanding rapidly, and growing numbers of micro-organisms for biological control of soil-borne diseases are being developed. *Trichoderma* (a common soil-borne genus of fungi) species have been developed to control soil-borne plant diseases.

Fungicides

A number of organically acceptable chemicals are available if disease control is necessary. Among them are copper, lime sulphur, sodium bicarbonate, sulphur and vegetable oils. These products are effective only against foliar plant pathogens. Copper is useful against downy mildews and bacterial diseases; sulphur is effective against powdery mildews. Note that both copper and sulphur are currently under review for use in organic systems, and using alternatives to them might become necessary.

Other organic sprays

Among other possibilities for disease control are products still under evaluation, such as compost teas and milk. Evidence suggests that both these products are efficacious for certain diseases. Milk has shown some effectiveness against powdery mildew.

Many organic farmers believe that, by stimulating the natural defence mechanisms in plants and animals, resistance to disease can be strengthened. Some commercial products are marketed on this principle; examples are seaweed extracts.

ISSN 1832-6668

Replaces Primefact 804

Check for updates of this Primefact at:
www.dpi.nsw.gov.au/primefacts.

Job number 10274 PUB10/134