Crop Module:  Chinese Cabbage,
Pak Choi, Choi Sum (outdoor)

Effective from 1st June 2016 – 31st May 2018: version 3.2 (Crop Risk Category 2)
This crop specific module for outdoor Chinese cabbage, pak choi and choi sum has been written to complement and avoid duplicating the generic principles of the Red Tractor Farm Assurance Fresh Produce Scheme standards. It is advisable to read the Red Tractor Farm Assurance Fresh Produce standards before reading this crop specific module. This module is designed to stimulate thought in the mind of the reader. It contains crop specific guidance and standards, where applicable, in addition to the requirements stated in the generic Fresh Produce standards.

Within this module the important requirements outlined in the crop specific standards section will be verified during the Red Tractor Farm Assurance assessment and compliance will form a part of the certification/approval decision.

Disclaimer and trade mark acknowledgement

Although every effort has been made to ensure accuracy, Assured Food Standards does not accept any responsibility for errors and omissions. Trade names are only used in this module where use of that specific product is essential. All such products are annotated® and all trademark rights are hereby acknowledged.

Notes: Pesticide Information

The Red Tractor Fresh Produce team has been working with Fera to provide tailored access to the LIAISON database for all Red Tractor Fresh Produce members. This system allows individual growers access to all information for plant protection products approved for use under the Red Tractor Fresh Produce Scheme.

LIAISON can be accessed under the Produce tab via the “Checkers and Services” page where you will also find a user manual. Searches will be filtered specifically for the crops for which you are registered. Once you have logged onto the site and clicked on the LIAISON hyperlink you will be directed to the LIAISON home screen.

You will need a username and password and these will be sent once you have registered:

http://checkers.redtractor.org.uk/rtassurance/services.eb.

General Introduction

Following a systematic approach will help growers identify and manage the risks involved in crop production. This module is based on a typical crop production process and food safety, health & safety, environmental and quality hazards are identified. Appropriate controls may then be established to minimise risk. Food safety and health & safety issues always take precedent over quality and environmental controls. The layout of this module follows the same structure as that used in the Red Tractor Farm Assurance Fresh Produce Standards. The content of the module is reviewed prior to the issue of updated editions. The review process considers both new developments and all relevant technology which has emerged since the last review was completed and which have been found to be both workable by the grower and beneficial to the environment. The aim is to transfer such information and technologies to growers.

Acknowledgements

Red Tractor Fresh Produce gratefully acknowledges the contribution of all consultees in the preparation of this module, members of the Specialist Produce Growers Association, particularly Robert Meakin.
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ADDITIONAL REQUIREMENTS AGAINST CURRENT STANDARDS

None for this crop module
## CROP SPECIFIC STANDARDS

### CHINESE CABBAGE (OUTDOOR)

<table>
<thead>
<tr>
<th>STANDARDS</th>
<th>HOW YOU WILL BE MEASURED</th>
<th>RECORDS (to be kept for 2 years)</th>
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</table>
| CQ.86.a   | Growers must test the crop for methyl inorganic bromide residues where there is a known history of residues | ■ Historic methyl inorganic bromide residue tests  
■ Current residue tests |
| CQ.86.b   | Records must be kept of the introduction of biological control agents | ■ Records of introduction of biological control agents |
| CQ.86.c   | Historical microbial analysis of the water supply must be assessed for trends in conjunction with results obtained from microbial analysis of the resultant crop | ■ Microbial analysis of irrigation water and trend analysis  
■ Microbial analysis of crop |
| CQ.86.d   | Growers must monitor copper content in untreated crops | ■ Copper analysis |
| CQ.86.e   | Growers propagating their own transplants must record pesticide application (NEW) | Crop protection records  
■ Pesticide records to be kept. Personnel records must be kept for 40 years (in practice this is most likely to apply where anticholinesterase organophosphate or carbamate based compounds are used)  
■ Crop protection record organophosphate or carbamate based compounds are used)  
■ Crop protection records |
| CQ.86.f   | Barrier materials, especially temporary crop covers must be disposed of in accordance with waste disposal regulations. Consideration must be given to disposal of pesticide contaminated temporary crop covers/ barrier materials (NEW) | Waste transfer notices may be applicable  
■ Records of disposal |

### PAK Choi (OUTDOOR)

<table>
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<th>HOW YOU WILL BE MEASURED</th>
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| CQ.85.a   | Growers must test the crop for methyl inorganic bromide residues where there is a known history of residues | ■ Historic methyl inorganic bromide residue tests  
■ Current residue tests |
| CQ.85.b   | Records must be kept of the introduction of biological control agents | ■ Records of introduction of biological control agents |
| CQ.85.c   | Historical microbial analysis of the water supply must be assessed for trends in conjunction with results obtained from microbial analysis of the resultant crop | ■ Microbial analysis of irrigation water and trend analysis  
■ Microbial analysis of crop |
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| CQ.84.a   | Growers must test the crop for methyl inorganic bromide residues where there is a known history of residues | Historic methyl inorganic bromide residue tests  
Current residue tests |
| CQ.84.b   | Records must be kept of the introduction of biological control agents | Records of introduction of biological control agents |
| CQ.84.c   | Historical microbial analysis of the water supply must be assessed for trends in conjunction with results obtained from microbial analysis of the resultant crop | Microbial analysis of irrigation water and trend analysis  
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GUIDANCE

CHOICE OF VARIETY AND PLANT HEALTH CERTIFICATION

CHOICE OF VARIETY

None of the current commercially important varieties have resistance to all the five major diseases, (ringspot, Alternaria, light leaf spot, white blister and club root). Varieties differ in their susceptibility to powdery mildew.

Provided they have good commercial qualities, future disease resistant varieties should be included in any integrated crop management system.

Many varieties in current commercial use are hybrids.

Growers should visit their propagator and inspect plants prior to despatch.

PROPAGATION

ICM principles should start with propagation for it is essential the plants leave the propagation house free of pests and disease. Plants should always receive an aphid spray before they leave the propagation area. Growers should liaise with their propagators to ensure the correct pesticides are used and obtain written records of such use. Likewise, growers who raise their own plants must have a written record of their pesticide programme in propagation. Plant raisers should be registered with DEFRA Plant Health and Seeds Inspectorate under the EU Marketing Scheme. Plants should be produced to GLOBAL G.A.P V4.0 through members of the "The UK Plant Propagators Ltd". Growers should be able to produce evidence that any propagated material has been produced from a verifiable production system.

SITE AND SOIL MANAGEMENT

SITE SELECTION

When selecting a site for growing a pak choi crop it is important to consider the following requirements:

CLIMATE

The crop can be grown throughout the UK, although wetter areas in the West can increase the risk of ringspot. In drier areas of the South and East, irrigation may be required during periods of drought to maintain continuity. Wind can be a problem on light land where soil particle contaminate the head.

WEED STATUS

Perennial weeds such as couch, docks and thistles should be controlled prior to planting/drilling a crop of Mature Oriental Brassicas. The presence of potato groundkeepers can also be a problem to control in the growing crop.

TOPOGRAPHY

Fields should be suitable for use of harvest machinery and safe for the use of spraying machinery avoiding the risk of toppling over. Use of fields sloping to the South and West should be made for early production.

PEST HAVENS

Avoid heavily wooded field margins and wasteland, where pests such as rabbits, hares and pigeons can devastate crops. Also any rodent colonies should be identified and controlled.
OBSTACLES

Pylons, telegraph poles, walls and fences make it difficult to operate spraying and harvesting machinery without crop damage.

MICROBIAL SAFETY

Growers must:

- consider the microbial contamination risk from the proximity of local municipal waste sites
- consider the microbial contamination risk from local animal sanctuaries and/or SSSI
- consider the microbial contamination risk associated with the use of environmental headlands / bird cover
- consider the microbial contamination risk associated with the location of septic tanks and their capacity
- consider the microbial contamination risk associated with other farm livestock enterprises
- consider the microbial contamination risk associated with the use of organic manures and composted organic waste and appropriate field access points

ROTATION

Crop rotation can be used to assist with crop health in conjunction with other practices.

Club root can be a problem. Production in these areas should be based on a wider rotation of four to five years between brassica crops together with a well-planned liming policy.

Brassicas thrive best on moisture retentive high alkaline situations and often continuous production can be sustained without detriment to crop quality or to the environment. In such cases growers should be able to justify their rotation with consideration to the following:

- Crop health.
- Avoidance of disease carry-over by incorporating post-harvest residues quickly and efficiently.
- Satisfactory record of pH levels and liming policy.

SOIL MANAGEMENT

Soils

Good drainage is essential. A pH level of 7.0 to 7.3 is required, particularly where club root may be a problem. Over liming is wasteful and can cause temporary ‘lock-up’ of some nutrients such as manganese and boron. Lime should be applied well before planting/drilling if possible. As lime takes many months to balance soil acidity it is not advisable to grow any brassicas where liming has recently been carried out in very low pH situations. Mature Oriental Brassicas can be grown on a wide range of soil types, but lighter sandier soil types will require irrigation.

Direct-drilled crops are sensitive to soil surface capping which can reduce and delay germination and disrupt uniformity of emergence, causing uneven maturity at harvest. Drill press wheels, rolling and irrigating after sowing can contribute to this problem, especially on soils of weak structure or low organic matter.

Cultivations

Whether the crop is drilled to a stand or transplanted, firm soil with a good tilth is required. Timely cultivations are important, particularly on fine, sandy, or silty soils that have a weak structure and low organic matter content. On the lighter soils late ploughing, with the minimum of cultivation, will help to maintain soil structure. Roots will not penetrate a compacted or smeared soil layer and high yields will not be produced unless the plants can root deeply.

Loss of soil structure in the surface layers, due to excessive soil or inappropriate cultivations, can lead to soil capping and reduced emergence.

Wheelings from pre-sowing or planting cultivations may cause compaction; therefore the bed system is to be commended. In large-scale production the tramline system, where two crop rows are left out for the passage of a tractor with wide tyres, facilitates easy fertiliser applications, spraying, irrigation and harvesting machinery access, in addition to confining wheelings to a designated area.

DRILLING AND TRANSPLANTING

Plant populations

Plant population has important effects on:

- Total yield.
- Market for which the crop is grown.
- Costs of production.
- Disease control.

Increasing plant population results in reduced plant size and delayed maturity.
Seedbed

Seed can be drilled under glass from mid-February, for subsequent transplanting to satisfy the earliest markets. Early varieties may tend to bolt under some conditions.

Drilling without protection, for subsequent transplanting, can take place from early April (if the soil conditions are suitable) to end of August for most Mature Oriental Brassicas types. Under poor conditions and low temperature deferred sowing dates are preferable.

The seed should be set at a constant depth of 18-20mm, to ensure even emergence. If chemical control of cabbage root fly control is required choose a product from an approved data base.

Direct drilling

This system is generally used where crops are grown at close spacing. The method requires greater precision to establish the crop than transplanting.

With direct drilling:

i. glasshouse space is occupied for a longer period
ii. expensive hybrid seed requirements are higher
iii. less labour is involved than with transplanting
iv. specialised transplanting equipment is not required
v. unlike transplanting, there is less pressure to establish the crop in mid-summer, possibly in dry conditions.

Vacuum or belt drills cause less damage to the seed than cell wheel drills. Ground wheel drive is superior to unit wheel drive allowing drilling to continue when the soil surface is wet. Adjustable land wheel drive may be required on some bed systems.

Minimum pressure should be applied over the rear wheels of the drill. Also certain drill accessories should be considered, such as:

a. Anti-capping wheels: Twin rear wheels which run on each side of the row with a 25mm gap between, so that the soil is not compressed directly over the seed.
b. Cage wheels: They have expanded metal surfaces instead of the standard steel band.
c. Small rakes: Fitted behind each rear wheel to loosen the consolidated topsoil without disturbing the seed.

Shallow drilling, together with pre-drilling irrigation if necessary, is preferable to drilling deeper to reach moist soil. Avoid deep drilling on soils liable to cap.

Chemicals for the control of Cabbage root fly may be applied simultaneously at drilling

Propagating

The majority of the transplanted crop is grown from glasshouse raised modular transplants or small peat blocks. Transplanting is a major aid in crop scheduling. The modular trays, the most common size having cells of 14ml volume containing peat compost, enable the propagator to have complete control over plant growth.

To ensure the best chances of good establishment, growers should ensure that transplants are:

- Strong and well rooted in the module
- Transplanted when plants are ready and not left too long in module
- Are free from pest and disease
- Are fully soaked and primed with nitrogen immediately prior to planting

Plants should be given a high nitrogen feed prior to dispatch. Growers should ensure that the modules are at maximum water holding capacity at planting. Water should be applied immediately post planting.

Under EC Plant Health Regulations, propagators must be registered with the Plant Health and Seeds Inspectorate (PHSI) of DEFRA. Plant passport details may be incorporated on the delivery note or invoice.

Propagators must comply with the requirement for due diligence throughout the food distribution chain, details of all pesticides need to be agreed and recorded by the propagator and passed to the grower. Applications of liquid feeds should be treated similarly.

EARLY PROTECTION UNDER CROP COVERS

Wide sheets, 10-14 meter wide, of fleece type materials are the most common form of covering.

The activity of herbicides under covers can be erratic. This may be due to high light intensities and warmth causing accelerated breakdown of the herbicide or possibly by the drying out of the soil surface. It is important that individual herbicides are applied to a very moist soil, or on soil moistened before the crop is covered with film, in order to improve the performance of the herbicide.

Physiological problems soon arise if covers are left on too long. Covers should be removed on a dull day or in the late afternoon period.

Disposal of crop cover

To comply with legislation, and protect the environment, plastic must not be burnt. Old polythene be dispatched to a recycling company or disposed of in a registered landfill site.
**ROTATION**

Land rotation is a key determinant in pest and disease control.

Clubroot (*Plasmodiophora brassicae*) may be prevalent especially on acidic land. Maintenance of a pH >7.0 is beneficial. Rotation should aim at a minimum of 4 years.

Many leaf and stem miners have larval stages which pupate in the soil which can lead to the build-up of resident pest populations.

More recent pesticide approvals may have restrictions which force land rotation.

**ENVIRONMENTAL PROTECTION & CONTAMINATION CONTROL**

**SPRAYING SAFETY**

Non-target Areas Growers / Humans: where possible avoid cropping areas adjacent to schools, housing estates, playing fields etc. where there is a risk of drift from spraying operations. To flora: avoid areas adjacent to wildlife reserves, sites of specific scientific interest. Note the position of any beehives.

Spraying Safety: Watercourses and Buffer zones now apply, where the spraying of certain pesticides, when using ground based vehicle mounted/mounted sprayers is prohibited within 5 meters of the top of the bank of the watercourse. Module operators should be aware of ‘LERAP’ regulations introduced in 1999. Chlorpyrifos: Say No to Drift campaign: From 1st January 2012 it is recommended that growers use UK *** rated low-drift nozzles and a 20 meter no-spray buffer zone to any ponds, streams and ditches when applying chlorpyrifos products using a conventional boom sprayer (a dry water body requires a 1 metre buffer zone). Get Pelletwise Metaldehyde Stewardship scheme:

- Ensure no pellets are applied within 6m of a ditch or a watercourse. This includes seasonally dry ditches.
- Dose - No more than 210g ai/ha between 1 Aug and 31 Dec
- For additional protection of water 160g ai/ha or lower may be recommended by your BASIS registered adviser.
- Maximum total annual dose 700g ai/ha year.
- Maximum individual dose per application 210g ai/ha

**NITRATE VULNERABLE ZONES**

Certain vegetable production areas within the U.K. may be located in designated nitrate vulnerable zones (NVZs). These are areas where growers are asked to observe a programme of measures, designed to reduce nitrate loss from the land and help reduce nitrate levels in water.

Guidelines are set out in the current Code for Good Agricultural Practice Protecting our soil, water and air.

Key action points relevant to brassica growers are:

i. Do not apply inorganic nitrogen fertiliser between 1 September and 1 February unless there is a specific crop requirement during that time

ii. Do not exceed crop requirement for quantity of nitrogen fertiliser on each field every year, taking account of crop uptake and soil supply from soil organic matter, crop residues and organic manures

iii. Application of organic manures should not exceed a field limit of 250 kg/ha of total nitrogen in any 12 month period and a limit of 170 kg/ha averaged over the farm arable area each year.

Farmers located within the existing NVZs (designated in 1996 or 2002, and designated again in 2008) are required to adhere to a lower limit of 170 kg/ha total N per year for spreading manure on arable land and all new rules from 1 January 2009, farmers located in the new NVZs (designated in 2008) will also be required to adhere to the new rules from 1 January 2010.

iv. Do not spread organic manures with a readily available nitrogen (>30% ) on sandy or shallow soils from 1st Aug – 31st Dec and on other soils 1st Oct – 15th Jan

v. Do not apply fertiliser or manures when the soil is waterlogged, flooded, frozen hard or covered in snow

vi. Consider a cover crop to use up excess nitrogen over the winter months, ryegrass, is a good choice as it does not involve a 'green bridge'. Sowing must be completed before September 15th to be of any value

vii. Keep adequate farm records, including cropping, livestock numbers and the use of organic manures and nitrogen fertilisers

viii. NVZ boundaries were revised in May 2010.

Growers must comply with NVZ legislative requirements.

**THE BASIC APPROACH TO CROP PROTECTION**

**Key principles of integrated crop management**

1. Biological, environmental and cultural methods of pest and disease control must be used as the first line of defense.

2. Chemical pesticides are to be used only when biological controls are not available or shown not to be working.
3. The crops should be monitored at least weekly and records made of pest, disease and biological control organism levels.

4. Records must be kept of introduction of biological control agents.

5. Climate control computers should be used to ensure a suitable environment is maintained at all times.

6. Records must be kept of all pesticide applications.

Hygiene and the glasshouse environment

1. Remove post-harvest crop debris immediately and bury trash.

2. Empty skips containing organic material as soon as they are filled and do not allow material to decay in these skips.

3. Maintain the glasshouse margins and land outside weed free at all times.

Adaptation for new pests and diseases

The occurrence of a new disease or pest problem is largely unpredictable. It may arise, for example, when a previously non-indigenous disease or pest becomes established in the UK with a change in variety or cropping practice (e.g. switch from soil to substrate cropping) or when a pathogen/pest previously controlled by a particular pesticide develops resistance. In all these situations it may be necessary to implement additional pesticide treatments.

A proposed schedule for controlling 'new' pest or disease problems, in order of priority, is described below:

The key objective is that the organism is controlled by means of a change in glasshouse environment, crop culture, biological or other non-chemical method. In some situations however, it is possible that additional use of pesticides may be necessary, at least in the short term or until a suitable alternate variety with genetic resistance is available. Such new varieties should be incorporated into the cropping programme, as they become available, providing they meet the end-market specifications.

The 'new' pest or disease situation may be controlled with the biological control measures.

If none of these pesticides provide effective control, advice should be sought on a suitable alternative product, currently approved for use on the appropriate protected crop under Control of Pesticides Regulations (1986).

PEST, DISEASE AND WEED CONTROL

For various reasons the use of some approved pesticides may not be acceptable to processors. In order to conform to such requirements, proposed applications should be confirmed with the contracting company.

Pest control

Cabbage root fly (*Delia brassicae*)

Even light attacks by larvae, which feed on the roots, can reduce yield. Severe infestations cause stunting, bluish or red discoloration of the leaves and the plants may wilt and die. There are two or three generations each year, starting from fly emergence and egg laying in late April - early May and extending, with some overlapping into September. Preventive treatments are essential for the peak of the first generation, irrespective of whether the crop is direct drilled or transplanted.

The eggs of cabbage root fly are attacked by several beetle species. These beetles remain in the soil for long periods; their numbers can be reduced by insecticides applied to other crops in the rotation.

Forecasting/monitoring

Present monitoring methods include counting eggs laid at the stem base of brassica to predict the size of the next generation and non-selective water traps to catch adult flies. The HRI computer prediction model gives the timing and duration of populations, based on statistical information and local weather data.

A chemical attractant trap is available that selectively traps adult flies and thus in future a combination of this trap and HRI computer prediction model, will give a more reliable monitoring system.
CONTROL METHODS:

Direct-drilled crops

Treatment should be delayed until late April or the two rough leaf stage, if this is later.

On crops drilled after mid-April an insecticide should be applied before or at drilling. Band spray at seedling emergence.

Plant propagation

a. **Pre-planting drenches**: Chlorpyrifos can be used as a pre-planting drench on block and module raised plants. Chlorpyrifos should not be used to treat blocks/modules which will be planted out before April 1st. When drenching with chlorpyrifos, ensure it does not become washed or leached into glasshouse soils. Where plants are treated outside glasshouses, safe disposal of all run-off liquor is required. Where chlorpyrifos drenches has been used, subsequent applications of pesticides in the glasshouse or in the field should be delayed until adequate wax has formed on plant leaves.

b. **Seed treatment**: Growers should consider the use of this treatment as the levels of active ingredient used are minimal resulting in considerably lower operational exposure and much less active ingredient incorporated into the soil than with other control systems.

Growers should consider the use of seed treatments in preference to module drenches or granule treatments for the control of Cabbage Root Fly.

Transplanted crops

Crops grown from block or module raised plants, which were treated before planting, should not normally need further treatment in the field but there are occasions where subsequent granule treatment is necessary:

a. Where, due to planting delays, copious irrigation has been applied after treatment and considerable time has elapsed before planting which may have led to the leaching of the insecticide.

b. Insufficient insecticide applied by propagator (maintain a check at planting by routine analysis of compost).

c. Early in the season, when the incorporated treatment is not persistent enough to protect the young plants up to the first peak of egg laying.

d. In the absence of irrigation, when upper layers of the soil are dry or soil conditions are cloddy, it is essential to plant deeper in search of moisture for the plants to survive. This necessitates covering the module with soil and this renders the stem at soil surface level open to attack.

**Flea beetles (Phyllotreta spp)**

In direct-drilled crops, small holes are eaten in cotyledons, stems and first and second rough leaves. In warm dry conditions, the damage can be severe and seedlings may be killed.

**Cultural control**: Damage to young plants is common and most crops suffer quickly. Crops should be walked regularly and treated immediately. Avoid double cropping. Avoid using last year’s land for the same crop. Use deterrent sprays and crop covers to minimise reinestation.

**Chemical control**: If damage is severe, or seedlings are growing slowly, use deltamethrin, alpha cypermethrin and spinosad for control. Tefluthrin is an option for pak choi only.

**Cabbage aphids**

Invasion occurs from April to July and, in favourable weather, build-up of aphids is greatest from July to October. Crops should be examined regularly from April onwards and treated when aphids are found.

There are two species of aphid which are of commercial relevance to the crop:

**Peach potato aphid (Myzus persicae)**

Of importance, particularly in warmer, drier seasons, this aphid can be present in fairly high numbers affecting marketable quality. It doesn’t normally form dense colonies but overwinters as adult and in mature stages, on winter brassicae and beet crops together with many herbaceous plants outdoors and under glass. Winged forms migrate to summer hosts in May and June reaching peaks similar to those of the mealy grey aphid. Levels of resistance to many chemical actives are increasing. The pest is an important vector of many plant viruses. Provided good contact can be made with the pest, the use of nicotine is supported.

**Cultural control**: Most aphid infestations develop from colonies that overwinter on old brassica crops and autumn sown oilseed rape. Plough in or otherwise destroy these.

**Aphid population can be reduced by a multitude of insect predators including ladybirds, hoverflies and parasitic wasps. Crops should be walked regularly to determine the balance of predators in relation to plant size etc., to determine whether the crop actually needs spraying, or whether the predators will naturally take care of the...**
aphids. Many factors are involved in this biological ‘integrated’ approach and the risk associated with the various field-walking techniques are being determined by HRI/ADAS currently.

**Mealy grey aphid (Brevicoryne brassicae)**

A widespread pest, which checks the growth of young plants resulting in wilting and possible mortality, particularly in dry conditions. On older plants leaves curl up and marketable quality is spoiled by contamination with the aphid colonies.

All stages, including eggs, occur on stems and leaves of winter hosts (usually other cruciferous species) winged forms migrate to summer hosts from May/June onwards resulting in an early peak during July followed by a population crash. This is followed by a second, often higher peak in September/October. Early identification and treatment is essential as once colonies become established control is much more difficult and spoilage is inevitable.

**Chemical control:** Numerous insecticides are currently approved for use and should be selected from than approved data base. Select insecticides with the least harmful effect on beneficial insects and avoid broad-spectrum insecticides. For these reasons foliar sprays should be chosen for cabbage aphid control. Some synthetic pyrethroids, despite their reputations, often kill a wide range of beneficial predators.

Alternate insecticides from different chemical groups, in order to avoid build-up of aphid resistance. Weather conditions and time of year should be taken into account when selecting the aphicide.

Current work at HRI is focusing on the development of forecasting techniques for aphid populations. Studies of populations show a regular midsummer “crash” where natural mortality is actually greater than by applying aphicides. This normally occurs in late July - early August.

**Caterpillars**

Caterpillars of many species attack brassicae and may appear at almost any time between mid-May and October, although the degree of infestation varies from season to season. The damage caused depends upon the species responsible. Some species larvae, when nearly mature, are difficult to kill with insecticides and cause considerable spoilage. Others, even when numerous, may not justify treatment. The caterpillars of the diamond back moth, feed on the undersides of leaves, leaving the upper surface as a ‘window pane’. Now becoming a common pest, it can have several generations in a season, if control is needed insecticides need to be applied whilst the caterpillars are still young. To help in crop walking and establishing pest thresholds, pheromone traps are available to catch the moths.

**Cultural control:** Frequent crop walking is essential to identify both the caterpillar species and natural predators; some of these numerous predators are capable of destroying every caterpillar in the population. Also some caterpillar species only have one generation per year and thus if the feeding is at low levels on the vegetative parts of the plant chemical control may not be necessary.

**Chemical control:** Check crops regularly and apply insecticides when caterpillars found. Choose a product from an approved data base. Some treatments applied for flea beetle will give incidental control.

**Cutworms**

Cutworms are the caterpillars of several species of noctuid (night-flying) moth; the most important of which is the turnip moth, Agrotis segetum. The young caterpillars hatch in June and July, feed on the foliage for at least a week, before descending to feed on the underground parts of the host plant.

Cutworm attacks are most severe in hot dry summers; routine treatment is not required. Warnings are issued based on trap catches sometimes combined with a weather model to define ‘high risk’ periods, when the caterpillars are small and can be controlled by rainfall/irrigation or chemical treatment. Use pheromone traps to monitor moth numbers. If local information is not available and irrigation is possible, apply at least 20mm of water as advised by the cutworm warning. In absence of rainfall or irrigation, control with a pyrethroid insecticide, timed as indicated by the spray warning.

Some treatments applied for flea beetle will give incidental control.

**Pollen beetle**

Adults, dispersing principally from oilseed rape, can contaminate the crop in summer.

**Cultural control:** A forecasting service is already available to HDC members that will predict the onset of migration of pollen beetles. This should alert growers to start field monitoring. Simple yellow sticky traps set slightly above parts of the plant chemical control may not be necessary. Also some caterpillar species only have one generation per year and thus if the feeding is at low levels on the vegetative parts of the plant chemical control may not be necessary.

**Chemical control:** If beetles are found damaging the crop or are likely to contaminate harvested produce, apply an insecticide with a recommendation for application to leafy brassicae. Pyrethoids should be particularly considered because of their subsequent repellent effect. Re-inspect crops frequently.

Some treatments applied for flea beetle will give incidental control.
**Slugs**

Slugs damage brassica seedlings and established plants on medium to heavy-textured soils in wet conditions.

**Cultural control:** Consolidate soils to inhibit slug movement where necessary. Surface bait to determine need and timing of further control measures.

**Chemical control:** Broadcast affected areas with an approved molluscicide if trap catches pattern indicate a risk. Choose a product from the current list of approved molluscicides.

**Cabbage whitefly (Aleyrodes proletella)**

An occasional pest, damage is caused by the adults and the white scale-like larvae living on the undersides of the leaves and sucking the sap. Where large numbers present plant vigour may be reduced. Up to five generations a year may occur as adults over-winter on the undersides of the leaves. Severe infestations produce a sticky secretion that attracts a black-sooty mould.

Destroy overwintering brassica crops soon after harvest to prevent the movement of whitefly to the new season’s crops. Treatment is rarely necessary, but pyrethroids will provide some control of adults given good coverage.

**Cabbage stem weevil (Ceutorhynchus quadridens)**

A widely distributed but sporadic pest, which attacks all cruciferous crops. The larvae feed in stems and petioles of plants that may subsequently wilt.

Treatments applied for flea beetle will give incidental control.

**Beet cyst nematode (Heterodera schachtii)**

Although rarely damaging the crop is an effective hosts on which the nematode can increase to a level that will affect future Beet crops.

Sample if its presence is suspected and avoid frequent cropping with alternative host crops if the nematode is present.

**Brassica cyst nematode (Heterodera cruciferae)**

This pest is widely distributed; it rarely reduces crop yield. Cysts survive in the soil for several years until stimulated to hatch by the presence of a fresh host crop.

Sample if its presence is suspected and avoid overcropping with brassica crops.

**Cabbage leaf miners (Phytomyza rufipes and Scaptomyza aplicalis)**

Both species are widely distributed, occasionally damaging. As large populations can develop in oilseed rape crops. Control measures are only required if damage levels are high; sprays applied for diamond back moth will keep leaf minor under control.

**Cabbage seed weevil**

In recent years large numbers of adult cabbage seed weevils have arrived on brassica crops in some localities in mid-summer. Weevils can damage the mature crop by feeding on the outer leaves and contaminate the head prior to harvest. They have occasionally checked the growth of young crops.

Vulnerable crops, particularly those on the point of harvest, should be examined frequently from mid-July to mid-August. Applications of a synthetic pyrethroid as for control of caterpillars should kill some weevils and deter others from entering the crop.

**Cabbage stem flea beetle (Psylliodes chrysocephala)**

A widespread and locally serious pest that attacks most overwintering brassica crops, especially seed crops. The build up of this pest on oilseed rape may lead to more serious attacks on vegetable brassicas. Even comparatively light attacks can reduce yield. Rare on Chinese brassicas.

**Leatherjackets (Tipula spp.)**

Leatherjackets are only likely to be of importance in fields previously in grass, or weedy stubble. Most damage occurs in the spring. A low risk for protected crops.

**Turnip gall weevil (Ceutorhynchus pleurostigma)**

This localised and sporadic pest frequently found in Southwest England. It attacks late-sown or late-planted brassicas. The legless grubs feed on the roots within hollow marble-sized galls. Yields are rarely affected.

Good soil and growing conditions help plants withstand attack.

**Wireworms (Agriotes spp.)**

Wireworms are only likely to be of consequence in fields cropped soon after long-term grass.

A low risk for protected crops.
**Swede midge (Contarinia nasturtii)**

Midge occasionally causes severe localised damage in the growing points of young plants, resulting in premature death of the plant or blindness that may be followed by a stem rot. The first generation of larvae appears during the second half of May/beginning of June. There are two or three generations in a season. High humidity favours their build-up, whereas drought slows or stops emergence. The larvae hatch from eggs laid in groups of 15-25 and feed on the young tissue in the growing point. Attacks are very rare in the UK.

At present no chemical has approval for the control of Swede midge. However, when pyrethroid sprays have been used for caterpillar control, midge larvae control has been observed.

**Beneficial organisms**

Beneficial organisms include predators, parasitoids and myco-pathogens. Although a great deal of research has been undertaken regarding the biology and behaviour of natural enemy species, relatively little is known about the numerical impact that they have on pest populations in commercial brassica crops. Natural enemies of pests can themselves be attacked by predators, parasitoids and disease; which may limit their effectiveness. They can also be affected by the use of agrochemicals, which may cause mortality, have sub-lethal effects on development or behaviour, or suppress disease outbreaks.

Finally, with cases of direct pest damage, natural enemies are often effective only after the crop damage has been done. The presence of some natural enemies in produce may also at times cause problems for growers.

**Parasitoids**

Parasitoids spend their larval stages as parasites, feeding on host tissue and killing the host in the process. They tend to be fairly specific, although some species will, for example attack several species of aphid.

The cabbage root fly is attacked by two main parasitoids, a wasp and a rove beetle. The adult rove beetle is also a predator. Rates of parasitism vary from crop to crop and are reduced usually when non-specific insecticides are used.

Cabbage aphids have only one parasitoid, the small wasp, *Diaeretiella rapae* which also attacks the peach potato aphid. The life-cycles of aphids and their parasitoids are closely linked. Again, levels of parasitism vary between crops and may be affected by insecticide use.

Caterpillar pests are also attacked by a range of parasitoids, mainly wasps and flies. These may cause significant mortality in species such as the diamond-back moth.

**Myco-pathogens**

Insect pests may be attacked by a number of bacterial, fungal and viral diseases. Aphids and adult cabbage root flies appear to be particularly susceptible to fungal diseases, whilst caterpillars are more susceptible to bacteria and viruses. Fungal diseases can be particularly devastating, but may be triggered only when environmental conditions are favourable.

**Predators**

**Specific predators** - such as ladybird larvae and adults and hoverfly larvae consume only aphids. They are able to consume large numbers of aphids but may be present in crops only at certain times of the year.

**Generalist predators** - many predators consume a wide range of pest and non-pest species. Generalist predators include species of beetles, spiders, mites, harvestmen, lacewings, flies, earwigs, ants, bugs, wasps and vertebrates such as birds and small mammals. It is estimated that, in cereal fields, there may be about 400 species of generalist predator. Laboratory studies have shown that some predators are able to consume large numbers of pests. However, predation rates in the field will depend upon how often particular pests are encountered and whether there are alternative sources of food. Some species, such as ground beetles, eat both live and dead material.
**BIOLOGICAL CONTROL AGENTS**

<table>
<thead>
<tr>
<th>Pest</th>
<th>Control</th>
<th>Notes</th>
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| Club root  
(Plasmodiophora brassicae) | a) Gliocladium catenulatum  
b) Bacillus subtilis | Commercially available but evaluation continuing |
| Aphis  
- Peach-potato  
- Melon-cotton (Aphis gossypii) | a) Aphidius colemani  
b) Aphidius ervi  
c) Aphidoletes aphidimyza  
d) Verticillium lecanii (Vertalec®) | c) only the indigenous species  
d) for corrective action  
[Regular introduction required - see HDC trial results] |
| Caterpillar | a) Bacillusthuringiensis  
b) Trichogramma evanescens | a) best results are obtained on young caterpillar,  
so monitoring and early application essential  
b) use not permitted in Guernsey. An egg parasite  
so effective monitoring of adult moths is vital |
| Glasshouse whitefly  
(Trialeurodes vaporariorum) | a) Encarsia formosa  
b) Verticillium lecanii (Mycotal®)  
c) Yellow sticky traps | b) and c) for corrective action  
Not usually a problem in peppers |
| Spider mites (Tetranychus urticae) | a) Phytoseiulus persimilis  
b) Feltiella acarisuga | b) commercially available but evaluation continuing |
| Tobacco whitefly (Bemisia tabaci) | Statutory control in UK (inform DEFRA's Plant Health and Seeds Inspectorate)  
Treatments as for glasshouse whitefly may be permitted by PHSI | |
| Western flower thrips or onion thrips (Frankliniella occidentalis or Thrips tabaci) | a) Amblyseius cucumeris  
b) Amblyseiusdegenerans  
c) Orius spp.  
d) Verticillium lecanii (Vertalec®) | a) standard treatment  
b) difficult to establish  
c) for corrective action  
d) only the indigenous species |
| Botryis spp | Trichoderma harzianum | For soil borne problems |
| Molluscs | Phasmarhabditis hermaphrodita | |
| Sclerotinia sclerotiorum and Sclerotinia minor | a) Coniothyrium mintans (Contans®)  
b) Trichoderma harzianum | Contans treatments should be several months on advance of cropping |
| Fusarium spp, Rhizoctonia spp, Pythium spp | Bacillus subtilis | Some commercial products also effective on leaf borne powdery mildews |

**Deterrents and barrier methods**

As part of an integrated pest control policy it is desirable that growers fully exploit barrier methods to prevent re-infestation of crops. Such practices minimise the number of pesticide re-treatments and reduce the pesticide residue risk.

Chemical deterrents are a new area for research which growers should adopt.

Barrier materials, especially temporary crop covers must be disposed of in accordance with waste disposal regulations. Consideration must be given to disposal of pesticide contaminated temporary crop covers/ barrier materials.

**DISEASE CONTROL**

**Introduction**

Oriental brassicas are subject to many of the diseases that attack brassicas. In modular plant propagation under glass, seedling diseases are common and consistently damaging, thus requiring routine treatment. Regular monitoring during propagation and cropping, coupled with correct identifications of disease, are an important element in minimising fungicide use.

Where possible, the guiding principle is that pesticide inputs should be minimised through prevention rather than cure. Where possible an integrated approach is needed, involving the following management steps:

**Good management and planning**

a. Careful site selection. Where possible avoid known potential or previous problems, thereby enhancing plant health. If possible site away other brassica.

b. It is good agronomic practice to rotate crops to prevent the build-up of soil borne diseases. Where this is not possible, therefore agronomy and disease monitoring should be good.

c. Use resistant varieties (when they become available).
Cultural control techniques:

a. Plant propagation under glass goes a long way to reducing the incidence and severity of seedling diseases, especially downy mildew. Irrigate plants in the morning, or soon enough to allow leaves to dry off before the night. Avoid over-watering, as this both washes nutrients and crop protection chemicals out of compost, and creates favourable conditions for damping-off pathogens. The amount of time seedlings are allowed to sit wet in the glasshouse should be kept to a minimum.

b. Maintain adequate ventilation to prevent the creation of a still, humid environment around seedlings. Control feeding to prevent over-soft growth. Adequately sterilise trays to prevent carry-over of diseases such as club root, Pseudomonas, damping-off etc.

c. When cropping apply nutrients according to soil analysis.

d. Encourage steady growth by ensuring regular supply of water where possible.

e. Through good agronomy, provide good growing conditions; i.e. avoid poor drainage or pans.

Chemical control:

a. Regularly crop walk and monitor the crop for diseases, in conjunction with monitoring pests, to establish the need to take corrective action and refer to thresholds (where established). Regular monitoring, both during propagation and cropping, coupled with correct identification of diseases, are an important element in minimising fungicide use. The decision whether it is worthwhile to apply fungicides should consider the disease, time of year, degree of infection and nearness to harvest. The effect of prevailing weather conditions should also be considered.

b. Where fungicidal control is needed, the following points should be considered, whilst ensuring effective control is achieved:

   Use the least toxic and persistent product.

   Use the minimum effective dose rate.

d. Carefully consider anticipated harvest date and ensure the selected chemical has an appropriate harvest interval.

e. Be aware of expiring approvals.

Club root (*Plasmodiophora brassica*)
This effects all vegetables of the brassica family and a number of ornamental cruciferous plants and weeds, including charlock and shepherds purse. It causes swelling of the roots which subsequently rot; the leaves turn blue and wilt whilst the plant may be stunted or even die. This disease is of considerable significance in some production areas, particularly where soil pH is naturally marginal. The resting spores of the fungus remain viable in soil for at least twenty years.

Cultural control:

i. Wide rotation as possible in vulnerable areas.

ii. Soil tests can give a guide to potential infection. Sample at least 3 - 4 months before anticipated planting date, to allow change of cropping.

iii. Liming to maintain a soil pH 7.0-7.3 gives good control, but there is no cure once plants are affected. In susceptible areas, patches, (usually of lower pH) of club root can occur. These small areas should be limed separately.

iv. High pH levels (>7.5) can give rise to minor nutrient problems.

v. In dry times, plants suffering from a small infestation can be brought to marketable yield by copious irrigation.

vi. It is essential to use disease-free modules.

vii. Liming will not work immediately. It should be part of rotational planning.

Chemical control: None available.

Biological control: Trial work shows some benefit from *Gliocladium cantenulatum*, *Trichoderma* and *Bacillus subtilis*.

Damping off and wirestem (*Pythium spp.* and *Rhizoctonia solani*)
These fungi attack the roots and stems of young seedlings and can cause serious losses during glasshouse propagation and affect drilled crops.

With *Rhizoctonia* the stem base becomes hard, brown and shrunken and the plants usually break off later in the season. *Pythium* is best controlled at propagation in the glasshouse with fungicides used pre-sowing or pre-planting as preventative treatments.
**Cultural control:**

i. Good glasshouse hygiene is essential  
ii. Good management as outlined previously  
iii. Use plastic modular trays rather than polystyrene because when the surface coating wears off polystyrene trays, roots and fungi can penetrate the polystyrene and become a “reservoir” of disease. Plastic trays can be sterilised more easily and effectively.

**Chemical control:** For fungicides currently approved for use in propagation both as pre-sowing drenches or pre-planting treatments see Notes.

**Biological control:** Trial work shows some benefit from Gliocladium cantenulatum, Trichoderma and Bacillus subtilis.

**Downy mildew (Peronospora parasitica)**

This disease is endemic in propagation under glass but in the field infections only become significant when mild wet weather conditions prevail in late autumn. This fungus is both air- and soil-borne and may affect young plants via the roots. Spores are produced on infected plants and are distributed by air currents or rain splash, re-infecting plants via the leaves. Yellow brown areas develop between the veins on the upper surface of the leaves, corresponding with white/grey fungal growth on the under surface. Severely attacked leaves turn yellow and die.

**Cultural control:**

i. Good glasshouse hygiene is essential  
ii. Good management as outlined is essential  
iii. Varieties vary in susceptibility - therefore choose the more resistant varieties, provided they give the other agronomic features required  
iv. Increase rotation.

**Chemical control:**

In propagation, routine treatment, both on a preventative and eradical basis, is essential.

Choose a product from an approved data base.

Preferably alternate fungicides from differing chemical groups to avoid development of resistant strains.

**Biological control:** Trial work shows some benefit from Bacillus subtilis.

**Dark leaf spot (Alternaria brassicae and Alternaria brassicicola)**

Usually seed and air-borne, these fungi are also soil-borne following the incorporation of infected crop residues. All brassica crops including oilseed rape and cruciferous weeds are potential sources of the disease.

Symptoms range from small discrete black spots (which can be confused with those of powdery mildew and ringspot) to circular zonate spots, up to 12mm in diameter. The latter have greish, brown or almost black centres, which the case of A. brassicicola may be covered with sooty spores. In the field, spots caused by the two species are indistinguishable. The spots may be surrounded by chlorotic haloes and severely affected leaves may show extensive yellowing. With age the centre of the spot appears thin, dry and papery and may fall out giving a ‘shot-hole’ appearance. Elongated dark brown lesions are found on stems and leaves. The influx of Alternaria normally coincides with the harvest of the oilseed rape crop in July.

Alternaria can be controlled by seed treatments on young plants in propagation. These treatments use very small amounts of fungicide compared to overall applications.

**Cultural control:**

i. Good glasshouse hygiene is essential.  
ii. Good management as outlined is essential.  
iii. Remove crop residues as soon as possible.  
iv. If possible, isolate brassica crops from each other.

**Chemical control:**

i. Use currently approved seed treatments.  
ii. Use currently approved fungicides.

**Ring spot (Mycosphaerella brassicicola)**

This disease is both seed-borne and soil-borne through plant debris in the soil. Infection and disease development is dependent on high humidity and temperatures of 10-20°C. Traditionally troublesome in the wetter southwest but now endemic in all main production areas. Periods of frequent rainfall appear to be critical for epidemic development.

The disease first appears on lower leaves as small circular necrotic, brown or purplish-black spots that gradually enlarge to 1.5cm in diameter. As the ringspots develop, concentric rings of dead tissue are formed, surrounded by a narrow water-soaked area or yellow halo. With age, the ringspots appear grey with the distinctive fruiting bodies of the fungus arranged in concentric rings mainly on the upper leaf surface. Severely affected leaves quickly become yellow and prematurely wither.
The ringspot lesions are grey when dry, but are black and have a water-soaked appearance when wet. Yield may not be affected but quality is drastically reduced.

**Cultural control:**

i. Isolate out-door plant beds.

ii. If possible, have a wide brassica rotation.

iii. If possible, isolate Mature Oriental Brassicas crops from other brassica.

**Chemical control:** Use currently approved fungicides.

The use of tebuconazole will enable growers to achieve much better prophylactic control and if used strategically will reduce the number of preventative sprays quite markedly.

**Canker (Phoma lingam)**

This disease is both seed-borne and soil-borne from infected debris. The fungus produces well-defined spots, with ashen-grey centres, on the upper side of the leaf. On the brassica stems, near the base and on the tap root, brown or purplish areas develop, which turn black.

**Cultural control:** A minimum of four years rotation on infected fields. Do not grow outdoor plant beds adjacent to infected sites.

**Chemical control:** Use currently approved fungicides.

**Root rot (Phytophthora porri)**

This soil-borne fungus disease is occasionally seen on heavier or poorly drained soils. It attacks the stalk or butt and progresses into the head. Rotted tissue is brown to grey with a distinctive pungent odour. Cavities form in the stalk tissue. Bacterial soft rot often follows.

**Cultural control:** Avoid wet heavy, poorly structured soils.

**Chemical control:** None available.

**Grey mould (Botrytis cinerea)**

A fungal disease that appears on the leaves as a grey growth or soft brown rot, it is usually associated with damage or the retention of dead and decaying lower leaves. The disease is spread by wet weather and high humidity. Botrytis can be difficult to control.

**Cultural control:** Avoid lush soft growth from excess nitrogen.

**Chemical control:** Use currently approved fungicides.

**White blister (Albugo candida)**

All the aerial parts of the plant may be affected. The fungus survives in the soil or on plant debris. Initially, small green blisters are produced which later form white patches, at first small and glossy but later turning powdery.

Late in the season the white patches may turn brown. They first appear on the lower surfaces of the leaves and on stems, and marketable quality is reduced.

The strains that attack cruciferous weeds such as shepherd’s purse are distinct and will not transfer to Mature Oriental Brassicas.

**Cultural control:** Plant beds should be kept dry.

**Chemical control:** Use currently approved fungicides.

**Powdery mildew (Erysiphe cruciferarum)**

Powdery mildew is spread by wind-borne spores from affected brassica crops. Disease appears as small patches of thin white fungal growth on either leaf surface and on the stem. In severe attacks, the whole leaf surface is colonised. After frost, the disease may also show discrete black spotting which could be confused with Alternaria symptoms. Disease is favoured by warm (15-20°C) conditions with periods of high humidity.

**Cultural control:** If suitable, apply nitrogen as dictated by soil. (Heavy applications of nitrogen favours disease development). Plants under water stress appear to be more susceptible, particularly shallow-rooted varieties, therefore, if available, irrigate accordingly.

**Chemical control:** Fungicides only warranted on the more susceptible varieties in high-risk years. Use currently approved fungicides.

**Light leaf spot (Pyrenopeziza brassicae)**

This soil-borne fungus comes from infected debris and is also spread by rain splash and wind from neighbouring infected brassica crops, particularly oilseed rape.

Lesions are initially superficial, developing mainly on the upper surface of the older leaves and producing a diffuse silvery appearance. Young lesions show little discoloration but become paler in the centre and bleach with age. Individual spots may merge to produce large bleached patches, particularly on the lower leaves. Around the edge of the lesion, black speckling and concentric rings of white spore droplets can be found. Spread and development are favoured by cold wet conditions.

**Cultural control:** Infected crop residues should be carefully and quickly ploughed in. Adopt a minimum 4 year rotation if possible to reduce the risk of carry-over on debris.

**Chemical control:** Use currently approved fungicides.
Rhizoctonia (*Rhizoctonia solani*)
A bottom rot with black sunken lesions in the midribs. Small irregular lesion scan occur on the head finally coalescing to result in a head rot.

A soil borne disease which persists by sclerotia and is spread by wind/rain splash. Optimum disease development is at 25-30°C.

Cultural control: Soil fumigation and crop rotation will minimise attacks.

*Sclerotinia* (**Sclerotinia minor**, *Sclerotinia sclerotiorum**
Initially watersoaked, pinkish-brown lesions develop. A white fungal mycelium develops and black sclerotia develop within the tissue.

The fungus survives as a resting body (the sclerotia) in soil debris. Optimum disease development occurs at 20°C but it can continue at 0°C and therefore is important in stored Chinese Cabbage.

Cultural control: Use clean seed. Control weeds, particularly crucifers.

*Cercosporella* (**Pseudocercosporella capsellae**
Small dark lesions appear on outer leaves, and coalesce to give a finely branched appearance. Finally lesions become rounded brown spots with well-defined darker margins.

Cultural control: Use crop rotation. Note that turnip, rape and radish harbour the disease. Weeds should be controlled. Use clean seed. Disease development is reduced by refrigeration but development will continue down to 4°C.

*Erwinia* (**Erwinia caratovora caratovora**, *E caratovora atroseptica**
A soft water soaked rot develops becoming slimy. Secondary infection results in a disagreeable odour.

Soil born bacteria invade outer tissues during warm wet weather. Infection can occur after harvest through cut surfaces.

Cultural control: Glasshouse and harvest hygiene are important. Copper sprays can give some protection.

*Pseudomonas* (**P marginalis marginalis**, *P cichorii**
P cichorii produces a slightly sunken brown lesion. Infected tissue remains firm, disease development is quickest at 26°C and can continue at 5°C.

P marginalis marginalis produces a slimy soft rot similar to Erwina. Decay will continue at 0°C. It causes losses in the field and in store after cool moist weather.

Black rot (**Xanthomonas campestris**
This is a bacterial disease, sometimes found in wet cool summer months.

Infections are nearly always seed-borne or spread during propagation but then become endemic by surviving on incorporated residues. The symptoms are V-shaped chlorotic lesions on the leaf margins. Within the lesions the veins become blackened and a characteristic ring of vascular tissue can be seen when the stalks of affected plants are cut crosswise. The disease can develop very rapidly in warm damp conditions.

Control: Plant debris is a source of infection together with cruciferous weeds (e.g. shepherd’s purse). Quick removal or soil incorporation of crop residue is advised. Where the disease is identified a rotational break of at least two years should be practised.

Seed testing: Major seed lots are batch tested. A negative result does not guarantee complete freedom from the disease but more usually subsequent disease expression is economically not significant.

If batches of seed are infected, hot water treatment is the only approved method of control but the can affect seed vigour.

Virus diseases

a. Turnip Mosaic virus is probably the most severe virus that attacks brassicas. Dark necrotic rings and spots on the older leaves of plants associated with severe stunting are the typical symptoms.

b. Cauliflower Mosaic virus is much more common. The symptoms are vein clearing etc. followed by vein banding with stunted growth and distorted leaves. Affected plants are usually very susceptible to frost injury. Cauliflower and turnip mosaics often infect the same plant. The mealy cabbage aphid and the peach cabbage aphid spread both viruses. Aphicides will not prevent introduction of virus but will restrict subsequent spread.

Cultural control: If possible, grow apart from other brassica crops. Isolate outdoor beds from other growing brassica. Remove crop debris as quickly as possible.

Chemical control: Control aphids, especially in plant beds or early in the life of direct-drilled crop. Use currently approved aphicides.
PHYSIOLOGICAL DISORDERS

Tip burn

Tip burn can be a serious problem to Chinese Cabbage when it affects the internal leaves. Margins become brown and papery. There is no post-harvest development, however the tissue is vulnerable to bacterial secondary infections. The disorder is due to a poor distribution of calcium within the plant even when the total calcium uptake is satisfactory.

Cultural control: Calcium sprays can prevent tip burn in outer tissues. Reduced nitrogen supply and slower growth help reduce the problem. Windbreaks and transpiration control can also help.

Black speck/pepper spot

This is a result of the collapse of tissues surrounding the stomata of inner and outer leaves. Lesions can develop further during storage. There is varietal variation.

Cultural control: Manganese sprays are beneficial. Controlled atmosphere stores are beneficial.

Weed control

The use of herbicides can be reduced considerably by attention to the following:

a. Use of stale seedbed technique.

b. Avoiding use of covers where resistant weeds e.g. Pennycress is a problem.

c. Identifying those weeds present and targeting with the use of more selective active ingredients.

d. Use of mechanical weeding machines frequently through the crop.

The range of soil acting residual herbicides is limited. Use currently approved herbicides and select a herbicide that controls the weed spectrum present.

For residual herbicides to work effectively a fine, firm, moist tilth is required. Cloddy soil conditions greatly reduce the effectiveness of herbicides.

Soil fumigation is an option. See the Appendix for Basamid best use guidelines.

NUTRITION

NUTRIENT REQUIREMENT

Macro-nutrients

Excessive use of macro-nutrients is not only wasteful, but can be costly and have a detrimental effect on groundwater quality.

It is important to monitor the crops nutritional status throughout its life. This can be readily done by the use of leaf tissue analysis.

Heavy dressings of organic material are not suitable for protected crop production. Ensure materials are well composted.

Growers must undertake regular soil nutrient status testing.

Soil testing for S supply is not reliable. Growers should consider historical evidence nutrient shortage. Selection of sulphur containing nutrient sources may be necessary. Nutrient P, K, Mg and S supply must be tailored to soil nutrient supply and crop demand. Growers must utilize the services of a FACTS qualified advisor for crop fertilizer plans.

Nitrogen in particular must be tailored accurately to the precise needs of the crop. Note that soil sterilisation causes an elevation in available soil nitrogen (less so with basamid treated soil). Excess nitrogen should be avoided because:

a. The crop does not need it - even in dry conditions there is no advantage in applying extra nitrogen.

b. Maturity can be delayed.

c. Soft unbalanced growth results in increased damage when handling, poor shelf life and increased susceptibility to disease.

APPROVED USES NOT INCLUDED ON THE PRODUCT LABEL

In many circumstances, particularly for minor crops, product labels do not include all of the approved uses and growers wishing to check the approval notice of a particular product should note that this information is available using the LIAISON® search accessible via their Red Tractor Farm Assurance home page after logging in. A search on the ‘Extensions of Authorisation for Minor Use’ page of LIAISON® by crop or product name should yield a results page. A click on the product name should link to a summary of the approval information. Near the bottom of the summary is the specific off-label number (e.g. 0246/09) and this link will open up a pdf of the current EAMU document giving details of the extension of use. For various reasons the use of some approved pesticides may not be acceptable to processors. In order to conform to such requirements, proposed applications should be confirmed with the contracting company.
When planning fertiliser applications nutrients should be applied according to soil analysis. Soil sample for analyses at least 7 days after sterilisation. Typical fertiliser recommendations are given in the Appendix.

Establishment of both drilled and transplanted crops can be adversely affected by excessive levels of fertiliser salts, especially nitrogenous fertiliser in the seedbed. The risk of poor results from high salt levels is less for transplants than for seed.

**Nitrogen top dressing**

Often applied as ammonium nitrate, calcium nitrate, calcium ammonium nitrate but sulphate of ammonia is sometimes used.

Where nitrogen top dressings are broadcast over the crop there is a risk of scorch and subsequent Botrytis infection. To minimise this risk, application should be made when the crop is dry or very wet so that as little as possible sticks to the foliage. Top dressing is normally undertaken at cotyledon stage on the drilled crop. Nutrient feeding by irrigation is a common method of nitrogen application.

Nitrate levels should be minimised in applied nutrient solutions.

**Trace elements**

These should only be applied when deficiencies are evident according to analysis, with crop growth and development appearing to be reduced. In the absence of adverse symptoms, a healthy looking crop may not need foliar application of trace elements. On most soils trace element problems are unlikely.

**Magnesium**

Magnesium deficiency will soon become evident as an interveinal chlorosis. In the case of soils deficient in magnesium, a quick release form of magnesium such as kieserite should be incorporated into the seedbed at least three weeks before planting. Foliar sprays of magnesium sulphate are also effective in correcting a slight deficiency. Care should be taken when applying magnesium sulphate solutions during periods of very hot weather.

**pH**

In common with all horticultural brassica crops the soil pH should be maintained at pH 7.0 to 7.5, although this can cause problems where potatoes are grown in rotation.

**IRRIGATION**

The greatest response is likely to be obtained by achieving rapid establishment by irrigating immediately pre-sowing of direct-drilled crops and (after planting out) with transplanted crops.

Mature Oriental Brassicas prefer growing in warm, moist conditions so the ability to irrigate the crop is essential. Bruising and rain splash detract from the market value of the produce and encourage disease spread. Sprinkler irrigators, either as static lines or mounted on a boom which moves within the crop, are preferred and will generally give better results.

If irrigation waters are not recirculated, steps should be taken to minimise nutrient run off into soil and watercourses. The volume of run off should be measured and samples analysed.

The oriental brassica should be considered a high risk from the point of view of pathogen contamination from irrigation water. It is important that growers follow the appropriate irrigation guidelines in the Generic Standards.

a. consider bulk water treatment to reduce microbial contamination where historical results indicate a threat

b. Historical microbial analysis of the water supply must be assessed for trends in conjunction with results obtained from microbial analysis of the resultant crop

c. All irrigation systems must be drained to remove stagnant water over winter

d. Irrigation of crop should be withdrawn 24 hours before harvest.
HARVEST AND STORAGE

Harvest Hygiene

Staff handling the final crop are subject to Food Hygiene Regulations. Important considerations are personal hygiene, defined facilities for eating, drinking and smoking away from the crop. Illness monitoring and associated return to work procedure.

Storage Disorders

Poor handling and inadequate control of storage conditions can all lead to the rapid spread of fungal and bacterial disorders.

a. Grey mould (*Botrytis cinerea*): This most common spoilage organism causes a brown soft rot. It is easily recognised by the surface growth of grey mycelium and spores. Damage at harvest increases the incidence of this disease.

b. Dark leaf spot (*Alternaria brassicicola*): This air-borne fungus causes grey or black lesions that become dry and leathery in store. At low levels of infection it is unlikely lesions will be seen on the trimmed head when they are put into store, but spores, which germinate during storage, may be present on the heads.

c. Ringspot (*Mycosphaerella brassicicola*): This fungi should be controlled in the field, so that heads taken into store are free from any fungal lesions, which may lead to secondary Botrytis infection.

d. Phytophthora rot (*Phytophthora porri*): This soil-borne pathogen becomes active during wet weather. In store the disease spreads rapidly, therefore, heads should be harvested when dry and without contact with the soil. Ensure cut heads are not windrowed, soil is not collected in bins, or that infection is spread by sticking knives into the soil.

e. Bacterial soft rot (*Pseudomonas marginalis*): This very soft watery rot. Infection generally begins at sites of mechanical damage. In store these rots spread very quickly. As free water on the surface of the head encourages the development of bacterial rots, thoroughly dry off any surface moisture at the beginning of storage and maintain an adequate airflow within the store during storage.

f. Leaf necrosis: These symptoms frequently cannot be removed by trimming and their extent is only evident when the head is cut open during processing. The use of colloquial names and the often vague descriptions, make identification and comparisons of the various disorders difficult. However, four clearly distinguishable necrosis symptoms occur.

g. Pepper spot (*Black speck or spotted necrosis*): The most serious and widespread of these disorders is characterised by the development of very small superficial black spots less than 1 mm in diameter which appear randomly distributed over the leaf surfaces. The spots typically, but not invariably, appear first on the outer leaves of the heads and progress inwards during storage. The symptoms are rarely seen in growing crops. In each spot necrosis starts in the stomatal guard cells and spreads to a few surrounding epidermal cells. Pepper spot is a physiological disorder, not associated with any fungus, bacteria or virus. Incidence and severity varies considerably between growing sites and from season to season.

h. Large necrotic leaf spot (*Black Spot*): After pepper spot, this is the most common necrosis problem of stored brassicas. The large brown or black lesions may be 5 to 10 mm in diameter and frequently coalesce to form irregular discoloured areas. Tissue in the centre of the spots becomes sunken and eventually collapses to leave a brown, papery membrane.

   This disorder is the result of infection, usually early in the growing season, by aphid borne turnip mosaic virus. Therefore, prompt control of aphids with a systemic insecticide, whilst not preventing, may help to slow down spread of the disease (see Appendix).

i. Vein streak: Similar to pepper spot and appears as superficial brown or black markings on the epidermis along the leaf midrib and petiole, occasionally spreading out along the larger veins. This infrequent physiological disorder rarely causes a serious problem.

j. Internal tipburn: The margins of the inner heartleaves, especially round the vein endings, become papery and a discoloured grey or brown. Varieties vary in susceptibility, although some evidence suggests that damage correlates with high levels of nitrogen fertilisers and large head size.

k. Oedema: This condition is rare on pak choi and Choi Sum.

POST-HARVEST WASHING

Water supply

Water can be drawn from the public mains or other satisfactory sources under the Water (Water Quality) Regulations, 1989. Routine microbiological samples of non-mains water should be undertaken.

The final rinse water should always be with water of a potable standard.
Disposal

Waste washing water should be disposed of in a manner that avoids pollution of water courses.

There are statutory powers to prevent the pollution of underground water by discharge of effluent. Underground pollution can be traced to land used for disposal of solid or liquid waste. Pollution of streams and water supplies derived from wells, springs and boreholes can lead to action by the Environment Agency or local water company.

Both screening and sedimentation are recommended as methods of separating solids from water.

RESIDUES AND CONTAMINANTS

Sulphur is now listed in Annex IV of Regulation 459/2010 deleting previous MRLs.

Copper is listed in Annex III of Regulation 396/2005 with a temporary MRLs of 20mg/kg for chinese cabbages. Residues near these levels exist naturally in crops of chinese cabbage, pak choi and choi sum.

Growers must monitor copper content in untreated crops and retain that information.

If copper products are used as a pesticide:

1. Label rates/ number of applications must not be exceeded
2. Harvest intervals must be adhered to. Growers should ensure GAP is followed to ensure sulphur and copper residues are minimised.

Quaternary Ammonium Compounds (QAM) may be used for water treatment, as a surface biocide and as a plant protection product. In October 2012 the EU Standing Committee on Food Chain and Animal health revised its guidelines for QAM compounds. In accordance with EU 396/2005 an MRL of 0.01 exists. Currently there is a temporary MRL of 0.5ppm. Member states are required to:

1. Sample products treated with QAM (both benzalkonium chloride and dimethyl ammonium chloride) and safely dispose of produce with residues > 0.5ppm
2. Incorporate QAM testing in a full range of products into the existing residue monitoring programs
3. Monitor conventional and organic products

Specifically monitor products from premises which use QAM as a biocide.

The temporary level should cover residues arising from most disinfectant uses, although businesses involved with the placing on the market, distribution and sale of foods and feeds should employ appropriate quality control measures to ensure that marketed produce does not exceed 0.5mg/kg.

Red Tractor Farm Assurance is aware that a key area in the production of fresh produce which requires continued attention by growers and their advisors is that of keeping pesticide residues to a minimum. This issue is not just one of meeting the MRL trading standard but ensuring that any individual or multi-residues are kept as low as possible below this level.

The key targets are:

- Optimising late applications of fungicides and insecticides to the edible part of the crop
- Optimising the use of post-harvest treatments
- Ensuring minimum harvest intervals are followed
- Ensuring that application equipment is applying products correctly.
APPENDIX 1: GUIDELINES ON MINIMISING PESTICIDE RESIDUES

These guidelines have been produced after consultation between crop stakeholders and the Fresh Produce crop author. They will be developed over the coming seasons as knowledge on minimising residues develops. Growers should consult with their crop protection adviser to ensure other best practices are not compromised before considering these guidelines. The table below lists the active ingredients that may give rise to crop residues and details potential alternative strategies.

<table>
<thead>
<tr>
<th>Active ingredient</th>
<th>Target: pest, disease, weed</th>
<th>Current position</th>
<th>Suggested guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha-cypermethrin</td>
<td>Flea beetles</td>
<td>7 day harvest interval</td>
<td>Voluntary 21 day harvest interval</td>
</tr>
<tr>
<td>Tebuconazole</td>
<td>Alternaria</td>
<td>21 day harvest interval</td>
<td>Voluntary rate reduction to 0.5-0.7L</td>
</tr>
<tr>
<td>Chlorpyrifos</td>
<td>Cutworm, flea beetles</td>
<td>At transplanting / within 4 days of planting/at cotyledon stage</td>
<td>Adhere to the EAMU latest timing requirement</td>
</tr>
</tbody>
</table>

APPENDIX 2: FERTILISER REQUIREMENTS FOR MATURE ORIENTAL BRASSICAS (KG/HA)

<table>
<thead>
<tr>
<th>Nutrient (kg/ha)</th>
<th>Soil Index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 1 2 3 4 5 6</td>
</tr>
<tr>
<td>Nitrogen (N)</td>
<td>340 300 260 220 -170 -60 -</td>
</tr>
<tr>
<td>Chinese cabbage</td>
<td>250 200 75 22 - - -</td>
</tr>
<tr>
<td>Pak Choi/Choi Sum types</td>
<td>300 150 100 50 0 0 0</td>
</tr>
<tr>
<td>Phosphorus (P₂O₅)</td>
<td>200 (2-) 150M (2+) 60 0 0 0</td>
</tr>
<tr>
<td>Potassium (K₂O)</td>
<td>300 250 200 (2-)</td>
</tr>
<tr>
<td>Magnesium (MgO)</td>
<td>150 100 50 0 0 0 0</td>
</tr>
</tbody>
</table>

Well-rotted farmyard manure at about 25t/ha will provide adequate phosphate and potash at Index 3 for phosphate and potassium without additional fertiliser. All manures should be well incorporated to avoid microbial contact with the crop. At the lower indices the recommended rates shown in the table above should be reduced for each 10t/ha farmyard manure applied by 15kg/ha nitrogen 20kg/ha phosphorus and 45kg/ha for potassium.

Note:
Magnesium should be applied in a readily available form such as keserite.

This table is guide for mineral soils. Varieties vary in their demands.

Modifications to the NVZ regulations come into force 1st January 2009.

It is preferable to have laboratory analysis for organic manures in use as nutrient sources.

Be aware of Fresh Produce Guidance regarding the use of manures and the Safe Sludge Matrix guidance.

Where a history of sulphur shortage is known 50- 80 kg SO₃/ha is a suitable.
Nitrogen index

The reference document is: DEFRA Fertiliser Manual (RB209) 8th Edition, Section 3

There are two methods:

a. The field assessment method
   1. Identify the soil type for the field.
   2. Identify the previous crop.
   3. Select the rainfall range for the field.
   4. Identify the provisional SNS Index using the appropriate table.
   5. Make any necessary adjustments to the SNS Index.

b. The Measurement method
   This method is particularly appropriate where the SNS is likely to be large and uncertain.

The Measurement Method is not recommended for peat soils where net mineralisation can be very large and uncertain.

$$SNS = SMN \ (0-90cm \ or \ maximum \ rooting \ depth \ in \ shallow \ soils \ over \ rock) + \ crop \ N \ (at \ time \ of \ sampling \ for \ SMN) + \ estimate \ of \ available \ N \ - \ from \ mineralisation \ of \ organic \ matter.$$  

The Measurement Method does NOT take account of the available nitrogen supplied from organic manures applied after the date of soil sampling for SMN. The available nitrogen from manures applied after sampling should be calculated separately using the information in Section 2 (N contributions from organic sources), and deducted from the nitrogen rate shown in the appropriate recommendation table. The nitrogen contribution from manures applied before sampling for SMN will be largely taken account of in the measured value and should not be calculated separately.

When using the Measurement Method there are four steps to follow:

1. Measure SMN
2. Estimate nitrogen already in the crop.
3. Make an allowance for net mineralisable nitrogen
4. Identify SNS Index

$$SNS = SMN + N \ in \ crop + net \ mineralisable \ N \ (kg \ N/ha)$$

<table>
<thead>
<tr>
<th>SNS</th>
<th>SNS Index</th>
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<tr>
<td>Less than 60</td>
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<tr>
<td>61 – 80</td>
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<td>81 – 100</td>
<td>2</td>
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<td>121 – 160</td>
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<td>161 – 240</td>
<td>5</td>
</tr>
<tr>
<td>More than 240</td>
<td>6</td>
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</tbody>
</table>

References

- CoGAP, from TSO, PO Box 29, Norwich, NR3 1GN (ISBN 9780112432845)
- Nitrate Pollution Prevention Regulations 2008
- http://www.netregs.gov.uk/
- http://www.getpelletwise.co.uk/
- http://www.saynotodrift.co.uk/
Certification Bodies

Your routine point of contact with the Scheme is through your Certification Body. Certification Bodies are licensed by Red Tractor to manage membership applications and to carry out assessment and certification against the Standards. The table below shows which Certification Bodies apply to each enterprise.

<table>
<thead>
<tr>
<th>Certification Body</th>
<th>Beef and Lamb</th>
<th>Dairy</th>
<th>Combinable Crops and Sugar Beet</th>
<th>Fresh Produce</th>
<th>Pigs</th>
<th>Poultry</th>
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</table>

NSF Certification
Hanborough Business Park, Long Hanborough, Oxford  OX29 8SJ
Tel: 01993 885739    Email: agriculture@nsf.org    Web: www.nsf-foodeurope.com

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