Crop-specific Protocol
Chinese Cabbage, Pak Choi, Choi Sum - protected

Effective 1st April 2014
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Preface

This crop specific protocol has been written to complement and avoid duplicating the generic principles of the Red Tractor Farm Assurance Fresh Produce Scheme and Appendices.

It is advisable to read the Red Tractor Farm Assurance Fresh Produce Standards and Appendices before reading this crop specific protocol.

This protocol is designed to stimulate thought in the mind of the reader and it contains crop specific parameters and guidance, where applicable, for the requirements stated in the Fresh Produce Standards.

Within this protocol the important requirements containing the words "must" (in bold type) will be verified during the Red Tractor Farm Assurance assessment and compliance will form a part of the certification/approval decision. Best practice requirements highlighted by the statement ‘it is recommended that’ will also be verified during the assessment but compliance will not be part of certification.

Any new standards have been prefixed in the text with (NEW)

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 protocol 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 Sector has been investigating ways of improving the service to members. Up to date information on plant protection products approved for use on the crops you grow is essential for your business. 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 on the crops for which they are registered under the Red Tractor Fresh Produce Scheme. This information can be accessed directly via the Red Tractor Fresh Produce “Member services” page once you have logged in on the Red Tractor website at http://assurance.redtractor.org.uk/rtassurance/services.eb?goto=%2ftrassurance%2fservices%2fpr_services.eb

A user manual has been produced for growers who are unfamiliar with the LIAISON system. This guide can be found when you log in to the Member Services page of the website. Searches will be filtered specifically for those crops for which members are registered and once a member has logged on to the site and clicked on the LIAISON hyperlink they will be directed to the LIAISON home screen.

This new service replaces the series of appendices which outlined all the registered pesticides available and cleared for use on that crop. The main disadvantage with the previous system was that as new approvals were granted or existing approvals revoked at any time, the lists in the appendices were effectively out of date as soon as the crop protocols had been published.

Members who do not have access to the internet and are therefore unable to access the LIAISON system can purchase paper copies of the most recent approvals for their crops at a cost of £25 per crop. Only credit card payment is acceptable. Members should contact Yvonne Powell-Wainwright on 01904 462613, stating their membership number, credit card details, name and address and the crop they are registered to grow to obtain the information they require, which will be posted to them the same day in paper form.

General Introduction

Following a systematic approach will help growers identify and manage the risks involved in crop production. This protocol 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 protocol follows the same structure as that used in the Red Tractor Farm Assurance Fresh Produce Standards.

The content of the protocol is reviewed annually 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 Assurance Fresh Produce gratefully acknowledges the contribution of all consultees in the preparation of this protocol, members of the Specialist Produce Growers Association, particularly Robert Meakin.
CHOICE OF VARIETY OR ROOTSTOCK AND PLANT HEALTH CERTIFICATION (CV)

CV.1 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.

CV.2 Propagation

ICM principles must start with propagation for it is essential the plants leave the propagation house free of pests and disease. Plants must 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 should have a written record of their pesticide programme in propagation. Plant raisers must be registered with DEFRA Plant Health and Seeds Inspectorate under the EU Marketing Scheme. Plants should be produced to GLOBAL G.A.P V2.0 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 (SM)

SM.1 Site Selection

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

SM.1.1 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 must be able to justify their rotation with consideration to the following:

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

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 rotation restrictions which will require adherence.

SM.1.2 Structure

Microbial safety

Avian/mammalian transmission of disease can occur via open doors or unprotected house vents. Growers must:

a) consider the microbial contamination risk from the proximity of local municipal waste sites
b) consider the microbial contamination risk from local animal sanctuaries and/or SSSI

c) consider the microbial contamination risk associated with the use of environmental headlands/bird cover

d) consider the microbial contamination risk associated with the location of septic tanks and their capacity

e) consider the microbial risks associated with the use of organic manures and composted waste materials and have appropriate access controls put in place.

SM.1.3 Hygiene measures

Previous cropping

A high volume insecticide spray should be applied to the remnants of the previous crop at the last practical opportunity using a short persistence synthetic pyrethroid insecticide.

At the end of cropping, fog or fumigate the crop with a suitable disinfectant. Remove the crop, weeds and all debris within 2 days of treatment, and dispose of them by removing off site (ensure the load is covered). The plastic sheeting should be recycled where possible, but the risk of carry-over of disease organisms should be carefully considered in relation to its re-use on site.

Wash down the glass and the structure inside the glasshouse and then treat with a suitable disinfectant.

In the cases of previous leaf miner or leafhopper problems, a high volume spray of a synthetic pyrethroid insecticide should be applied to bare ground, walls and structure when all equipment has been removed. Persistent pyrethroid insecticides should not be used because of their possible effects on biological control agents.

In the case of previous whitefly problems, fumigate the empty glasshouse with nicotine. Warm climatic conditions are necessary for successful fumigation.

Maintain the empty glasshouse at 17°C, set traps, monitor and retreat until pest free.

Equipment

Thoroughly clean picking boxes, trolleys, tractor tyres, footwear and any associated tools and equipment. Treat them with a disinfectant as listed above. Wash clothing and gloves. Store cleaned boxes and equipment carefully to avoid re-contamination.

After using disinfectants in the glasshouse thoroughly ventilate the house to remove all traces of vapour. Rinse picking trays with water after treating with disinfectant.

Exterior

Destroy all weeds around the glasshouse before the new crop arrives and at regular intervals during the season using non-hormone weed killers of short persistence or mowing.

Prevention:

i. Management and planning: Where geographical and agricultural factors permit choose sites away from existing brassica and rape production to avoid a continuous ‘green bridge’ throughout the year. Plough in crop residues immediately after cutting ceases.

ii. Crop rotation.

iii. Provide good soil structure, correct nutrition and irrigation if possible to ensure conditions to give good strong, healthy growth.

Control:

i. Use available pest forecasts as management tools to aid when to scout for pests.

ii. Regular, systematic crop walking to monitor crop development, pest and disease levels. Increase frequency of crop walking during periods of high pest incidence particularly during hot weather.

iii. In addition to crop walking, use of insect traps e.g. pheromone traps, chemical attractant traps and soil sampling (cabbage root fly eggs) as monitoring tools outside the glass house.

iv. Once validated, the use of tolerance levels may be introduced for cabbage aphids and caterpillars.
v. Identify both pest and naturally occurring predators, to determine whether it is necessary to apply control measures and where possible use selective pesticides to reduce impact on naturally occurring predators and beneficial organisms. However, choice must be weighed up against efficacy and longevity of treatment. Use the least toxic product where possible.

vi. Resistance is building within aphid populations particularly peach potato aphid to many insecticides. It is important to alternate the use of different active ingredients to enable the best chance of control within the existing range of actives.

vii. Use the minimum effective dose rates, normally label rates. Growers **should not** reduce dose rate for peach potato aphid.

viii. Consider use of natural and biological methods of pest control, if available.

ix. Avoid spraying, or allowing drift into grassy banks, dyke sides, hedgerows etc., these can provide a reservoir of insect predators, such as ladybird larvae, hover flies, ground beetles etc. However consider the implication of buffer zone restrictions on certain chemical uses.

x. Carefully consider also the anticipated harvest date when selecting the appropriate product. Ensure you have enough time for the harvest interval to elapse prior to harvesting.

xi. **Product warnings**

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SM.2 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.

SM.3 Soil Fumigation

Soil disinfection

New glasshouse sites are likely to need sterilising before cropping to kill off weeds and weed seeds. Frequency of sterilising thereafter will depend on circumstances and whether other crops are grown in rotation. Crops such as Tomatoes and Cucumbers are likely to suffer more loss from root pathogens than Chinese vegetables.

The use of white polythene mulches, through which the crop is planted, has proved successful in reducing the need for sterilisation by preventing weed growth. They also act as a barrier so reducing the incidence of infection of the lower leaves from the soil and they improve quality through light reflection.

Methyl bromide has been the main sterilant used under glass, but its use is now prohibited. Inorganic bromide residues may still be found both from background and from previous applications. Monitoring of residues needs to continue. Growers must test the crop for methyl inorganic bromide residues where there is a known history of residues.

When sterilisation is necessary the following should be considered:

1. **Steam** - effective but time consuming and needs careful handling from the Health and Safety aspect. New efficient mobile steam boilers are now available. There is a risk of Manganese toxicity after steaming, on low pH soils.
2. **Basamid** - best use guidelines for protected crops are given in the Appendix.

SM.4 Drilling and transplanting

SM.4.1 Plant populations

Plant population has important effects on:
a. Total yield.
b. Market for which the crop is grown.
c. Costs of production.
d. 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.

The seed should be set at a constant depth of 18-20 mm, 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.

Ground wheel drive is superior to unit wheel drive allowing drilling to continue when the soil surface is wet.

**SM.4.2 Transplanting**

**Propagation.**

*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 14 ml 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 despatch. Growers should ensure that the modules are at maximum water holding capacity at planting. Water should be applied immediately post planting.
ENVIRONMENTAL PROTECTION & CONTAMINATION CONTROL (EC)

EC.1 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 defence.
2. Chemical pesticides are to be used only when biological controls are not available or shown not to be working.
3. The crops must 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).

EC.2 Pest, disease, physiological disorders 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.

EC.2.1 Pest control

EC.2.1.1 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 (as above), 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.

EC.2.1.2 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 must be walked regularly and treated immediately. Avoid double cropping. Avoid using last years land for the same crop. Use deterrent sprays and crop covers to minimise reinfestation.

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.
EC.2.1.3 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 focussing 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.

EC.2.1.4 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.

**EC.2.1.5 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.

*Catumworm 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 20 mm 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.

**EC.2.1.6 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 the crop level will adequately indicate the level of this pest. Ensure old crop is destroyed prior to flowering.

**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. Pyrethroids should be particularly considered because of their subsequent repellent effect. Re-inspect crops frequently.

Some treatments applied for flea beetle will give incidental control.

**EC.2.1.7 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.

**EC.2.1.8 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 over wintering 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.*

**EC.2.1.9 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.

**EC.2.1.10 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.*

**EC.2.1.11 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.*

**EC.2.1.12 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.*

**EC.2.1.13 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.*

**EC.2.1.14 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.

**EC.2.1.15 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.*

**EC.2.1.16 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.*

**EC.2.1.17 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.*
EC.2.1.18 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.*

EC.2.1.19 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.

**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.

**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.
## Biological control agents

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<td>a) Gliocladium catenulatum b) Bacillus subtilus</td>
<td>Commercially available but evaluation continuing.</td>
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<tr>
<td>Aphids - Peach-potato - Melon-cotton (Aphis gossypi)</td>
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<td>c) only the indigenous species d) for corrective action [Regular introduction required - see HDC trial results]</td>
</tr>
<tr>
<td>Caterpillar</td>
<td>a) <em>Bacillus thuringiensis</em> b) <em>Trichogramma evanescens</em></td>
<td>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.</td>
</tr>
<tr>
<td>Glasshouse whitefly (Trialeurodes vaporariorum)</td>
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</tr>
<tr>
<td>Spider mites (Tetranychus urticae)</td>
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<td>b) Commercially available but evaluation continuing.</td>
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<tr>
<td>Tobacco whitefly (Bemisia tabaci)</td>
<td>Statutory control in UK (inform DEFRA’s Plant Health and Seeds Inspectorate)</td>
<td>Treatments as for glasshouse whitefly may be permitted by PHSI</td>
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<td>Western flower thrips or onion thrips (Frankliniella occidentalis or Thrips tabaci)</td>
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<tr>
<td>Botryis spp</td>
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<td>Sclerotinia sclerotiorum and Sclerotinia minor</td>
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<td>Contans treatments must be several months on</td>
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**EC.2.1.20 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.

**EC.2.2 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 must 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.

   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.

b. When cropping apply nutrients according to soil analysis.

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

d. 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 must consider the disease, time of year, degree of infection and nearness to harvest. The effect of prevailing weather conditions should also be considered.

Computer prediction models are being developed at HRI for Alternaria and Ringspot.

b. When cropping, fungicides **should not** be applied on a routine protective prophylactic basis.

c. 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. Expiring approvals

**EC.2.2.1 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.

**EC.2.2.2 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 in EC.2.2.
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.

**EC.2.2.3 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:**

i. In propagation, routine treatment, both on a preventative and eradicant basis, is essential.  
ii. Choose a product from an approved data base.  
iii. Preferably alternate fungicides from differing chemical groups to avoid development of resistant strains.

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

**EC.2.2.4 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 12 mm in diameter. The latter have greyish, 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 ageing 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 in EC.2.2 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.

**EC.2.2.5 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 1.5 cm 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.

**EC.2.2.6 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.

**EC.2.2.7 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.

**EC.2.2.8 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.

**EC.2.2.9 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.

EC.2.2.10 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.

EC.2.2.11 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.

EC.2.2.12 Rhizoctonia (*Rhizoctonia solanii*)

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.

EC.2.2.13 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.

**EC.2.2.14 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 must be controlled. Use clean seed. Disease development is reduced by refrigeration but development will continue down to 4°C.

**EC.2.2.15 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.

**EC.2.2.16 Pseudomonas (P marginalis marginalis, P cichorii)**

P cichorii produces a slightly sunken brown lesion. Infected tissue remains firm. Disease development is quickest at 28°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.

**EC.2.2.9 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.*

**EC.2.2.10 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 mosics 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.

EC.2.3 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.

EC.2.4 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.

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.

EC. 3 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 glasshouse production. Ensure materials are well composted.

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 must 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.

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 must 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 (IG)**

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 must 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 must be considered a high risk from the point of view of pathogen contamination from irrigation water. It is important that growers follow the appropriate guidelines in the Generic Protocol (IG).

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 (HS)

HS.1 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.

HS.2 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 must 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.

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**HS.3 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 (RC)**

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 20 mg/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

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 0.5 mg/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 - CHINESE CABBAGE, PAK CHOI, CHOI SUM (PROTECTED)

BASAMID – Best use on protected crops

Introduction

Soil sterilisation using BASAMID in intensive protected cropping is justified based on the intensity of the cropping, and the potential presence of disease and weeds in the crop cycle. Testing for the presence of root pathogens such as Rhizoctonia, Pythium, Sclerotinia and Viruses such as big vein is becoming a practicality. A record of the reason for treatment should be recorded.

Soil preparation

Good soil preparation is vital to achieve satisfactory soil disinfection. The aim is to achieve a fine tilth free from clods down to approximately 25cm or 10 inches. It is essential to cultivate between the posts and around the posts as well as down the bay, to ensure the fumigant can penetrate the soil easily. The soil should be irrigated at least 10 days prior to sterilisation to wet the soil profile to the treatment depth. This is especially important if the greenhouse or polythene house has been free from cropping for an extended period.

If large weeds or deep rooted perennial weeds are present in the greenhouse, prior to preparation they should be dug out prior to application of BASAMID.

All soil improvements such as sub-soiling and leveling should be carried out before treatment. If organic matter is to be added this should be done before sterilisation. Use only peat or compost which must be thoroughly broken up before or during incorporation. If large amounts of organic matter are added or present in the soil then the higher rates of BASAMID should be applied for the best results.

Soil preparation is best achieved by sub-soiling and rotavating or using spading machines. Basamid can be incorporated with a spading machine or if shallow incorporation is required use an L-tined rotavator.

Soil temperature and moisture levels

The soil temperature should be measured using a conventional soil thermometer. The temperature should be between 7°C and 24°C and likely to not fall below the lower temperature during 14 days following treatment. The soil temperature should be taken to a depth of approximately 10cm at both the external edges of the structure and in the centre. The optimum temperature range for treatment is between 10°C and 20°C.

The moisture level should be brought up to field capacity and kept around 60-70% of field capacity prior to and during the time of treatment. After cultivation the soil should be considered as suitable for treatment if the soil 'balls' and then crumbles when dropped. If it is not up to this level then the effectiveness of control will be greatly reduced.

Special attention must be made to the soil surface whilst treating. If a large area is being sterilised irrigation should be applied to replace evaporative loss in the areas awaiting treatment. This means checking the moisture level during the day of treatment and lightly irrigating if necessary up to one hour ahead of application of Basamid. Evaporative loss can occur rapidly under high temperatures.

Rates of use and soil type - Protected crops

Sands, very light soils and soils less than 5% organic matter apply BASAMID at 500 kg/Hectare.

All soil types including those with more than 5% organic matter and where intensively cropped apply BASAMID at 760 kg/HA.
Treatment

Basamid should be applied at the recommended label rate. The product should be applied evenly to the soil surface and incorporated as soon as possible following spreading. Ideally spreading and incorporation should be in one pass. If not possible the granules should be incorporated as quickly as possible before generating gas, within a maximum of 1 hour.

Incorporation is best achieved using a spading machine or L tined rotavator.

The treated soil should be sealed using fumigation grade polythene sheeting (a minimum of 30 micron polythene) as soon as practical after incorporation. Ideally treat and cover bay by bay. The edges should be tucked in or sealed and the treated area should be irrigated after sealing to improve contact between the polythene sheet and the soil. Before sealing the polythene make sure all granules are brushed off the walls and supports onto the soil surface.

The edge near the greenhouse wall should be taped to the wall or tucked under treated soil being careful not to leave soil exposed on the surface.

The minimum time for sheeting down is 7 days after which the polythene sheet can be removed. Longer periods must be left during low temperature conditions in order to maximise the effects of the sterilisation.

After the sheet has been removed ventilate the structure and shallow cultivate the soil to release any remaining gas.

The table below gives guidelines of treatment and aeration time for different soil temperatures.

<table>
<thead>
<tr>
<th>Soil temperature degrees</th>
<th>Days</th>
<th>Treatment time</th>
<th>Aeration time</th>
<th>Germination test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Celsius</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>12</td>
<td>10</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>25</td>
<td>20</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

Fertiliser requirements for Mature oriental brassicas (kg/ha)

<table>
<thead>
<tr>
<th>Nutrient (g/m²)</th>
<th>Soil Index</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonium nitrate</td>
<td></td>
<td>70</td>
<td>50</td>
<td>20</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Triple super phosphate</td>
<td></td>
<td>150</td>
<td>140</td>
<td>130</td>
<td>110</td>
<td>90</td>
<td>45</td>
<td>0</td>
</tr>
<tr>
<td>Potassium sulphate</td>
<td></td>
<td>270</td>
<td>225</td>
<td>180 (2-)</td>
<td>60</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Keserite</td>
<td></td>
<td>180</td>
<td>150</td>
<td>110</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

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.
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 evolves. 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>Deltamethrin</td>
<td>Flea beetles &amp; caterpillars</td>
<td>0 day harvest interval, no max dose</td>
<td>Do not use more than 2 application per week</td>
</tr>
<tr>
<td>Tebuconazole</td>
<td>Alternaria</td>
<td>21d 250g ai/ha</td>
<td>Voluntary reduction to 175g ai/ha</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 Control Points: Chinese Cabbage, Pak Choi, Choi Sum - protected

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<tr>
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<th>Chinese Cabbage (protected)</th>
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<td>CQ.105.11</td>
<td>Producers must be able to demonstrate that chlorpyrifos is not applied later than transplanting /cotyledon stage.</td>
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<td>CQ.105.12</td>
<td>The introduction and monitoring of biological control agents must be recorded.</td>
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</table>