Assured Produce

Crop Specific Protocol

GARLIC

(CROP ID: 83)

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Control Document No: 00053/08

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Acknowledgements

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Preface

This crop specific protocol has been written to complement and avoid duplicating the generic principles of the scheme and appendices.

It is advisable to read the Assured Produce Generic Crop Protocol Standards and the Assured Produce Generic Protocol Guidance Notes (referred to in this document as the Generic Standards and Generic Guidance Notes) first before reading this crop specific protocol.

This protocol is designed to stimulate thought in the mind of the reader.

This crop specific protocol contains crop specific parameters and guidance, where applicable, for the requirements stated in the Generic Standards.

All statements in this protocol containing the words **"strongly recommended"** (in bold type) will be verified during the Assured Produce assessment and their compliance will form a part of the certification/approval decision. The score required for these **"strongly recommended"** control points can be found on the final page of this document and in the checklists produced by Assured Produce licensed certification bodies.

Disclaimer and trade mark acknowledgement

Although every effort has been made to ensure accuracy, Assured Produce 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:

Pesticides with ‘Essential Use’ derogations that expired 31 December 2007 can no longer be used or stored.

There may be other withdrawals or revocations. Products containing substances which have been revoked are shown on the PSD website (http://www.pesticides.gov.uk). Growers should check with their advisers, manufacturers, the Assured Produce website 'Newsflashes', the PSD website (www.pesticides.gov.uk)

Growers should comply with the ‘Use up by’ dates for all pesticide products. Growers should also be aware of and comply with changes on new product labels.

There may be changes for the following reasons:

- the deadline for use of NPE formulations has been extended to 31 August 2008, see http://www.pesticides.gov.uk/approvals.asp?id=2122
- Pesticides with NPE formulations must be used up by 31 August 2008. In many cases products will be replaced by new non-NPE formulations.
- At re-registration stage after Annex 1 listing there may be: reductions of dose rates; changes in timings and/or number of applications for some products.

In the following Appendices products and use by dates are only listed for SOLAs, and in some cases new product MAPP

numbers may not be available yet.

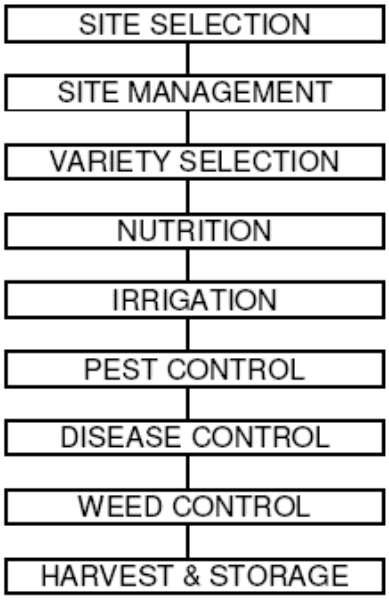
For pesticides on-label, only active substances are shown.

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

1 General introduction

Following a systematic approach will help growers to identify and manage the risks involved in crop production. This protocol is based on a typical crop production process. Using a flowchart approach, 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 precedence over quality and environmental controls.

The flow chart is structured as shown below. Note that the sectional layout of both this protocol and the crop specific protocols follow the same structure.



The contents of each crop specific protocol are reviewed annually by informed farmers and growers, food technologists, scientists, the relevant fresh produce association, processors and agronomic consultants. Updated editions are issued prior to the cropping season.

The review process considers both new developments and all relevant technology which has emerged throughout the course of the previous year and which have been found to be both workable by the grower and beneficial to the environment. As one aim of the Scheme is to transfer such information and technologies to growers, attention is drawn to those features of specific relevance to ICM by using *italic* script. In order that growers may be confident that they are working to a current document, each protocol is dated and numbered. Any changes to the text have been highlighted by marking the document with a line in the margin.

2 Planning and records

See Generic Standards and/or Generic Guidance Notes.

3 Site selection

3.1 Site history

Soil type and latitude have a major influence on the production system that can be used and on the quality of resulting bulbs.

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The most suitable soil types are sandy loam to sandy clay loam, very fine sandy loam (silts), and some peat based soils.

The crop produces a coarse rooting system and whilst requiring a degree of firmness for good root/soil contact, the soil must be free from compaction and well drained. Irrigation is an essential requirement for production on sand-based soils (excluding silts).

3.2 Rotations

3.2.1 Rotation and crop siting

Rotation has a role in minimising disease problems but may not prevent the build up of two major soil-borne diseases over the course of time. It is generally accepted that the minimum rotation should be 1 in 4 years and ideally up to 6 years.

It is recommended that garlic crops should be separated by a minimum distance of 800 m from any commercial onion crop. Isolation reduces the spread of wind-dispersed leaf diseases. However, this may only be possible to a limited extent in commercial practice.

3.3 Choice of production system

Garlic can be produced in a number of different ways:

i. **Over-wintered** , cloves planted in late September/October for harvest the following June/July.
ii. **Spring planted** cloves for harvest in July/August.
iii. **Spring drilled** from bulbils for harvest late August/September. This will produce a single round clove which if planted the following year will develop into a conventional bulb

The choice of cultivar within each section has only a minor influence on disease susceptibility. Leaf diseases are encouraged by increasing population density and by humid conditions. Over-wintering types are the most susceptible to leaf diseases with spring-drilled being the least susceptible. Soil type as well as requirements for continuity of production will influence choice of production system.. Larger bulb size, from lower plant populations has assisted reduction of foliar disease incidence.

3.4 Latitude

Bulbing is influenced by day length and hence site selection is influenced by latitude. In general terms, spring planting is only recommended in England

4 Site management

See Generic Standards and/or Generic Guidance Notes.

5 Variety selection

5.1 Choice of variety or rootstock

See Generic Standards and/or Generic Guidance Notes.

It is **strongly recommended** that varietal yield, quality and storage characteristics are utilised to optimise the performance of garlic crops.

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5.2 Seed quality

See Generic Standards and/or Generic Guidance Notes.

5.3 Seed treatments and dressings

It is strongly recommended that the need for specific seed applied pesticides is justified and documented.

5.4 Plants and nursery stock

As there are no multipliers of garlic at present growers need to keep a nursery stock for future plantings this should be monitored and any diseased or rogue plants should be removed.

6 Nutrition

Garlic requires a fertile soil with adequate reserves of the major nutrients nitrogen, phosphate, potash and magnesium. Application of fertiliser (see Appendix 1) should be on the basis of regular soil analysis, ideally preceding each crop. Soil pH is important and should be in the range 6.5 - 7.0. Garlic is most responsive to phosphate and less responsive to nitrogen than leafy vegetables.

Nitrogen application should be minimised where possible and ideally based on residual nitrogen samling in conjunction with the 'Well-N' predicition model, developed by HRL. This will ensure adequate nitrogen without excess that could lead to leaching into ground water. Late Application from bulbing onwards should be avoided.

Deficiency Risk

Soil Type	Magnesium	Manganese	Copper	Zinc	Iron	Boron
Sand	High	High	High	Moderate	Moderate	Low
Sandy Loam	High	High	Moderate	Moderate	Moderate	Moderate
Silt	Moderate	High	Moderate	Low	Low	Low
Peat	High	High	Moderate	Low	Low	Moderate

7 Irrigation

There is a marked growth response to irrigation on all light soils during dry periods. It leads to an increase in size, which maximises bulb size and yield.

Late irrigation can produce softer bulbs and increases bacterial incidence, and should be avoided. Where available, an irrigation scheduling system should be used to ensure efficient use of water resources.

8 Crop Protection

8.1 The basic approach to crop protection

Garlic is subject to a number of disease problems and it is a guiding principle that pesticide inputs should be minimised through prevention rather than cure.

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8.1.1 Non-chemical methods

See Generic Standards and/or Generic Guidance Notes.

8.1.2 Integrated crop management

An integrated approach should be adopted using the following steps:

8.1.2.1 Good management and planning

a. *Careful site selection to avoid potential or previous problems.*
b. *Sensible crop rotation to avoid build up of soil-borne problems or disease carry over from one crop to the next.*

Cultural preventative techniques

a. *Good crop and field hygiene to minimise spread of soil borne problems by cultivation equipment etc. This is particularly important with green garlic harvesting. There is therefore a greater risk of transporting disease more widely with machinery.*
b. *Avoiding spread of garlic waste except on farms unlikely to be involved in garlic production.*
c. *Minimise wind blown debris from harvesting and grading operations. Crop residues should be ploughed in as soon as possible. Waste trailers must be sheeted at all times in transit.*

Corrective action

Where control of pests/diseases is still required the following approach should be adopted:

a. Establish the need to take corrective action by regular monitoring and reference to forecasting techniques, when available.
b. Consider effect of prevailing weather conditions.
c. Where action is required, as a principle, the possibility of using biological or natural methods should be considered first.
d. If chemical control is needed the following points should be considered, subject to achieving effective control:

- use the least toxic and persistent product.
- use the most selective product to reduce the impact on naturally occurring beneficial organisms.
- use the minimum effective dose rate.
- use appropriate application methods with properly maintained equipment.
- use the minimum number of chemical applications to achieve good control, for example in controlling downy mildew and *Botrytis* .

N.B. exceeding the dose rate is illegal under COPR.

8.2 Plant protection product choice

See Generic Standards and/or Generic Guidance Notes.

Approved uses not included on the product label

In some circumstances product labels do not include all of the approved uses and growers and advisers wishing to check the approval notice of a particular product should note that this information is available from www.pesticides.gov.uk/psd_databases.asp

A search on the database for a product name should yield a results page. A click on the product name should link to a summary of the approval information. At the bottom of the summary are links to available notices which will give the statutory conditions of use.

In the case of products with older approval an electronic approval may not be available. In these cases growers should contact the PSD Information Services Branch for details of the approved conditions of use. Contact details are: p.s.d.information@psd.defra.gsi.gov.uk tel. 01904 455775.

8.3 Advice on the use of pesticides

See Generic Standards and/or Generic Guidance Notes.

8.4 Application of pesticides

See Generic Standards and/or Generic Guidance Notes.

8.5 Records of application

See Generic Standards and/or Generic Guidance Notes.

8.6 Protective clothing/equipment

See Generic Standards and/or Generic Guidance Notes.

8.7 Pesticide storage

See Generic Standards and/or Generic Guidance Notes.

8.8 Empty pesticide containers

See Generic Standards and/or Generic Guidance Notes.

8.9 Pesticide residues in fresh produce

See Generic Standards and/or Generic Guidance Notes.

See Generic Protocol Guidance Notes 8.9 for further background and generic advice.

Assured produce is aware that a key area in the production of fresh produce which requires continued attention by growers and their advisers 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**

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Currently there are no residue issues associated with this crop but awareness needs to be maintained for any future issues.

8.10 Pest, disease and weed control

8.10.1 Pest control

8.10.1.1 Stem and bulb eelworm *(Ditylenchus dipsaci)*

Eelworm attack is initiated by wet conditions. Control measures are influenced by soil type and local considerations.

Routine control measures are most likely to be necessary on very fine sandy loams and on heavier sandy clay loams, again based on previous knowledge of the area/field.

This pest also affects sugar beet and will survive on certain host weeds. Affected fields will remain so for many years even in the absence of Garlic crops. Avoidance of such fields is, therefore, the first consideration.

The only effective chemical control measure is aldicarb applied in the seed furrow strictly according to manufacturer's recommendation. The lowest rate consistent with effective control should be used, based on local and field experience.

Stem and bulb eelworm can cause serious losses in both field and store. Early field infection will cause foliage distortion followed by death of seedlings and resultant bare patches in fields (only in very serious cases will an entire field be uniformly infected). The margin of such patches invariably contains less infected bulbs with characteristically distorted foliage and soft bulbs when mature. Infected bulbs deteriorate rapidly in the initial drying process; the effects are exacerbated by stage 1 temperatures (25 - 30°C).

It has to be emphasised that infection can still occur after treatment (especially after heavy rain) and avoidance of problems based on local experience is of paramount importance. Good drainage is also essential, as localised 'wet' areas will encourage build up of eelworms. The reduced area drilled on very fine sandy loams (i.e. silts) has resulted in a significant reduction in usage of aldicarb.

8.10.1.2 Thrips *(Thrips tabaci)*

Thrips are a pest of variable incidence. Control measures must be based on regular monitoring when the weather conditions are appropriate for attack. More commonly known as 'thunder bugs'; thrips are most likely to attack garlic from June to August. The need for treatment should be judged on appearance of the orange nymphs as well as the symptoms on the plant.

This pest multiplies in the growing centre of the plant and leaves appear with silvery flecking and leads to distortion in more serious cases.

A certain level of flecking is acceptable before treatment is necessary, noting that control approaching harvest is of importance. Adult thrips can feed for a considerable period under skins of bulbs during storage causing downgrading in quality.

When treatment is considered necessary use deltamethrin (see Appendix 4). A repeat application may be necessary depending on prevailing weather conditions.

8.10.2 Disease control

8.10.2.1 White rot *(Sclerotium cepivorum)*

A persistent soil-borne disease that infects soils for many years, this disease is the most serious threat to garlic growing in many parts of the world where the climate is suitable.

Its long persistence (in order of 100+ years) is reflected in local knowledge and many fields are of known infection status. Incidence is not confined to garlic growing areas and source often relates to cottage gardens where onion or garlic waste has been composted in the past.

The disease initially infects roots and spreads back into the bulb causing destruction of tissue from the base upwards. This destruction is accompanied by a white cotton wool-like fungal growth. Early infection causes bulbs to completely rot in the field and later infections cause the total collapse of bulbs in store. Progress of infection is checked at the initial drying stage (28 - 30°C) but continues when the store is cooled.

There is development of control measures but it is therefore essential to:

Note infection areas on farm maps and not only avoid such areas but also where possible avoid spreading contaminated soil to other parts of the farm, particularly with cultivation equipment.

Monitor crops to ensure that any occurrence of infection is recorded. Premature yellowing of foliage in patches is the most usual indicator.

Make every attempt to avoid harvest of infected bulbs. Field population of resting spores (sclerotia) can be reduced by hand collection of infected bulbs but this is recommended only for small areas where such action is practical.

8.10.2.2 *Fusarium* base rot *(Fusarium culmorum f.sp. cepae)*

Basal rot of garlic is caused by *Fusarium culmorum* . Soilborne inoculum infects garlic through the stem plate rather than through roots or storage leaves (5). Leaves of infected plants may not produce disease symptoms, but can be a source of the disease. Transmission can occur when infested soil or debris is transported on equipment, seed, or runoff water. The fungus can survive indefinitely in the soil. *Fusarium culmorum* can also infect elephant garlic, but not to the same degree as garlic. Onion is not a host. Symptoms include pre-emergence decay of cloves and seedlings. Stem plates and storage leaves may decay in the field during the growing season. Lesions may have a reddish fringe. Disease expression is erratic from year to year and field to field. Post-harvest decay may involve a single clove or the entire bulb.

Cultural Control

Growers commonly rotate garlic with nonhost plants to reduce disease pressure. Cereals are a host of garlic strains of *Fusarium culmorum.* Growers also avoid planting in fields with a history of basal rot problems. The primary cultural control of basal rot is curing bulbs properly before storage and storing the garlic at cool temperatures, as *F. culmorum* is favored by warm conditions. Fields with good drainage and freedom from sub-surface pans (or compaction) will minimise problems. There are no chemical treatments.

8.10.2.3 Downy mildew (Peronospora destructor)

Downy mildew is a serious foliar disease that commonly requires routine treatment. The disease is readily spread by air-borne spores and encouraged by warm humid conditions, closely following the infection criteria of potato blight.

Maintaining 500 m separation between overwinter (most susceptible) and spring crops will minimise cross-infection.

Infected crop debris should be ploughed in as soon as possible after harvest to minimise any carryover.

Use of weather based prediction models is anticipated in the near future .

Treatment should be based on routine monitoring so that infection can be identified at an early stage. Following this, a routine spray programme is necessary to ensure adequate control using currently approved fungicides (see Appendix 4). It is preferable to alternate chemical groups to avoid the risk of resistant strains developing.

8.10.2.4 Leaf Blight *(Botrytis squamosa)*

Leaf spot is a disease that affects the foliage in cool wet conditions. It most seriously affects either seedlings of overwintered varieties in the autumn or the foliage of spring-planted varieties, particularly closer to harvest.

This disease will require treatment in occasional seasons only. The risk of infection increases with increasing crop density.

Development work is in progress to predict infection conditions (as with downy mildew).

Treatment is usually combined with downy mildew control in overall fungicide programmes and should be based on routine monitoring. Disease incidence is more tolerable than downy mildew since the disease is less progressive and less likely to cause serious crop loss.

Currently approved fungicides are listed in Appendix 4, and the choice is judged on prevailing weather conditions. Garlic foliage becomes more susceptible to infection as harvest approaches and as the density of the crop canopy increases. Early infection of the outer leaves can affect skin retention in store.

8.10.2.5 Leaf blotch *(Cladosporium allii-cepae)*

Leaf blotch is a disease that occurs when the combination of temperature and long periods of leaf wetness allows germination and penetration of the fungus. In such years infection can result in complete defoliation. Symptoms are bleached elliptical eyespots on the leaves that spread parallel to the leaf veins and can destroy entire leaves.

Routine control measures for this disease are not normally necessary.

Treatment should be based on routine monitoring so that infection can be identified at an early stage. Once identified use of propiconazole (see appendix 4) should give control.

8.10.2.6 Neck rot *(Botrytis allii,porri, aclada)*

The fungus organisms that cause neck rot, including Botrytis porri and B. aclada, survive the winter as sclerotia on dead plant parts in the soil and on infected bulbs. Infection occurs through neck tissue or through wounds. In garlic, neck rot is generally a more serious problem than is leaf blight. Symptoms may first appear on the neck of the plant near the soil line in the spring. The fungus moves rapidly into the neck region of the bulbs causing a water-soaked appearance. A gray mold develops on the surface, later producing black sclerotia. Before bulbing, plants may die or recover depending on weather conditions. Bulbs infected late in the season break down and are often infected by other disease organisms.

Cultural Control

Growers avoid excessive nitrogen and irrigation, especially late in the season. They practice good weed control to aid air movement through field and to keep relative humidity low. When harvesting, growers allow tops to mature, then lift or undercut plants to avoid bruising and mechanical injury. Finally, they make sure that the garlic is properly cured before storing.

Chemical Control

Fungicides are not generally used by growers against neck rot, as cultural methods control the disease at this time.

8.10.2.7 Blue mould *(Penicillium spp)*

Penicillium spp. cause blue moulds to develop on bulbs in store, between the skin and scale tissue. These blue moulds are mostly of a secondary nature but can be associated with a physiological disorder known commonly as watery skin. In such cases scale tissue and inner skins become brown and 'watery'. This favours *Penicillium* which then sporulates freely.

Penicillium is common on stored bulbs but mostly at low levels that do not cause marketing or storage problems.

Potential problems can be minimised by adherence to storage procedures in Section 9. High humidities in store, irrespective of temperature, will increase incidence and level of *Penicillium* infections.

8.10.2.8 Other bacterial pathogens

A number of bacteria species will cause either foliar dieback in the field or deterioration during storage. Field and store symptoms can be linked but the absence of visual effects in the field may still result in storage problems.

Bacterial diseases are initiated in the field and spread principally by water splash. Wet seasons, are therefore more likely to result in storage losses.

The main pathogens are detailed as follows:

Pseudomonas allicola

This disease can cause serious problems in store since the bulb's scale tissue 'soft' rots completely but the outer skins retain the rotten tissue. Once the crop is moved, the bulbs split and cause loss of quality by down grading of adjacent bulbs. Up to 40% infection has been recorded.

The disease is temperature sensitive and where problems are anticipated, can be minimised by reduced drying temperatures.

Recent work at HRI has resulted in a prediction system based on serological agglutination techniques. It is therefore possible to test bulbs at harvest. This technique is now available as a specific test kit.

Erwinia spp

Erwinia infects over a wide temperature range and tends to affect single scales within a bulb. When cut these bulbs reveal one scale of firm tissue that has turned brown.

Infection of bulbs is linked to the dieback of single leaves in the mature plant. Infection then spreads back to the scale at the base of the affected leaf. Incidence of this disease varies according to season, and levels rarely exceed 2-3%. Infection is normally more prevalent in late harvest drilled crops.

Lactobaccillus spp

These bacteria cause water soaking and an odour characteristic of vinegar. This bulb disease is very temperature sensitive and becomes increasingly active above 30°C. It has not been a problem since adopting

the now accepted drying and storage procedures detailed in Section 9.

Secondary bacteria

A range of secondary bacteria can follow on damaged or previously infected tissue. In wet seasons root death is often followed by soft rotting bacterial infection. It is not unusual in most seasons to find occasional plants which have died with soft rot symptoms but these are not normally associated with storage disorders.

9 Harvesting and Storage

9.1 Hygiene

See Generic Standards and/or Generic Guidance Notes.

9.2 Post-harvest treatments

See Generic Standards and/or Generic Guidance Notes.

9.3 Post-harvest washing

See Generic Standards and/or Generic Guidance Notes.

9.4 Maleic hydrazide (MH)

It is accepted, and recently clarified by HDC-funded trials at HRI Kirton, that as an aid to the maintenance of quality, it is necessary to apply maleic hydrazide pre-harvest as a growth suppressant at 10% leaf fallover. It is **strongly recommended** that all sprout suppressant treatments are justified.

The area treated should be related to the projected marketing dates of the bulbs. Application of MH is not necessary on crops to be marketed prior to the 1st December, in so far as can be judged in advance. Crops should be sprayed according to manufacturer's recommendations, lower rates normally prove adequate for crops in ambient storage.

9.5 Scape removal and storage

Some varieties of hardneck garlic will bolt, the flowering shoot (scape) will normally need to be removed in order to allow the bulb to achieve its full potential weight. This operation is normally done by hand.

Scapes are edible and if sold for human consumption all harvest intervals must relate to the harvesting of the scapes.

Storage of the scapes should be at 5-7ºC in cleaned trays or boxes

9.6 Harvest

Topping of the crop is essential to ensure ease of handling into store and minimising restriction to airflow during the initial and most critical drying phase.

It is a case of individual judgement as to the best harvesting system, depending on soil type, local circumstances and prevailing weather conditions.

Top lifting harvesters are recommended to minimise damage and soil contamination.

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It is **strongly recommended** that trailers or boxes are cleaned before they are used to transport loose garlic from the field and the cleaning is recorded.

The maximum loading height accepted in practice is up to 4 m. The maximum quantity that can be loaded at any one time will depend on the airflow specification of the store.

It is **strongly recommended** that stores are cleaned before garlic is stored in bulk and this cleaning is recorded.

9.7 Storage

It is an essential prerequisite of garlic production that adequate store loading and storage facilities are available. The use of expert management, correct airflow and temperature in properly designed and constructed stores cannot be overemphasised in minimising storage disorders and maximising quality.

It is **strongly recommended** that controlled storage facilities are capable of achieving temperature and humidity targets set out in the following sections.

9.7.1 Drying (stage 1)

Initial drying (stage 1) to be achieved by a minimum 25°C and a maximum of 32°C. 28°C will be the norm but special circumstances may require a slightly lower temperature

(e.g. the incidence of bacterial diseases).

In practice, initial drying requires a minimum airflow of 425 m^3 /hr tonne with suitable fans and ducting system.

Crop drying can be undertaken in boxes but such systems are generally less efficient due to air leakage and greater difficulty in obtaining uniform airflow. The store design must allow recirculation of air to minimise fuel usage and to maintain humidity. Specification of the humidity regime during initial drying will vary according to condition of crop. A target duct range 50-65% relative humidity (RH) is normally accepted.

An important point in minimising storage problems and achieving quality is that these specifications are combined with a maximum Stage I drying time of 7 days from initial loading of the store. The specifications become more important with later harvests. Some relaxation is acceptable, however, for early crops harvested in ideal conditions and not scheduled for long term storage.

9.7.2 Curing (stage 2)

After initial drying to a 'rustle dry' condition, it is necessary to maintain temperature and control humidity to cure skins and complete the drying in the air spaces between cloves (stage 2).

Stage 2 is accomplished using intermittent ventilation at 25°C with humidity control by sensors amongst the garlic. It is necessary to ventilate when humidity exceeds 75% RH at the top of the stack and continue until humidity is reduced to 65% RH. Airflow specification is 170 m^3 /hr tonne. Curing normally takes 1-2 weeks. Once all moisture has been removed from the bulb neck and between the cloves, it is possible to begin temperature reduction.

9.7.3 Cooling (stage 3)

Cooling is accomplished gradually, ensuring that the stored crop does not fall below average ambient temperature (unless refrigeration facilities are available). Automatic control is advised, using a differential setting such that ventilation is initiated when outside temperature is 3°C or more below crop temperature. An override prevents overcooling and more sophisticated stores incorporate automatic vents to mix internal/external air.

These also control the duct temperature for cooling and humidity in the earlier stages.

Stores should be insulated such that, when outside conditions are unfavourable, it is possible to close up with the minimum heat loss. Minimum temperature in ambient stores should be 5-8°C dependent on location and average ambient conditions.

Refrigerated storage is ideal since crop temperature is independent of outside conditions. It is possible to cool crops more rapidly after completion of curing and normally switch over to refrigeration at 10-12°C crop temperature.

Refrigeration at -2.5 to -3.5°C is essential for bulbs scheduled to be marketed from February to end of May/Early June. Controlled Atmosphere is necessary for storage beyond this period. Actual change over date will vary accordingly to season.

9.8 Storage disorders

Where attributable to a specific pest or disease, storage disorders are reviewed in the appropriate Sections 8.10.1 and 8.10.2 previously. This section covers those factors where specific diseases or pests are not implicated.

9.8.1 Compression damage

This results in deformation of bulbs and hence a more irregular shape.

It is a factor of season, bulb maturity, and sometimes variety rather than height of storage. Compression can occur in box storage as well as bulk storage although generally less so. In either case, affected bulbs can be found from 30 cm and below.

Compression damage will be worse if the bulbs are harvested very early and in association with wetter seasons and late maturity. Some bulb deformation can result in the field where bulbs are growing in close proximity to each other. Compression damage is self-correcting to a degree when the pressure is released, whether caused in field or store.

9.8.2 Skin retention

A number of factors affect skin retention and it is essential that 'lots' or batches are handled at the correct temperature and humidity relative to ambient conditions. No firm specification can be given but guidelines to minimise skin loss are as follows:

- correct variety choice.
- control of foliar diseases.
- correct timing of harvest.
- correct drying and storage procedure.
- avoiding high temperatures and low humidities prior to grading.

10 Pollution control and waste management

See Generic Standards and/or Generic Guidance Notes.

It is **strongly recommended** that for Green Garlic only, the water used for washing the harvested crop is used with conservation as a priority.

11 Energy efficiency

See Generic Standards and/or Generic Guidance Notes.

12 Health and Safety

See Generic Standards and/or Generic Guidance Notes.

13 Conservation issues

See Generic Standards and/or Generic Guidance Notes.

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Appendix 1 Typical application rates for nutrients (kg/ha)

Nutrient (kg/ha)	Soil Index					
	0	**1**	**2**	**3**	**4**	**4+**
Nitrogen - mineral soils						
Spring established	175	125	100	25	0	0
Overwintered*	50	0	0	0	0	0
Phosphate						
All soils	200	150	100	50M	0	0
Potash			150 (2-)			
All soils	250	200	100 (2+)	0	0	0
Magnesium	150	100	0	0	0	0

Notes:

* Seedbed N is only required on mineral soils. Spring topdressing of up to 100kg/ha nitrogen may be required.

Nitrogen index is defined by:

a. previous cropping, or
b. residual mineral nitrogen sampling, which is the preferred option

Appendix 2 Nitrogen index as defined by previous crop

Index 0	Index 1	Index 2
Cereals, Sugar Beet, Maize	Beans or beans, potatoes, oilseed rape	Any crop in field receiving large and frequent dressings of FYM or slurry.
Vegetables receiving less than 200 kg/ha	Vegetables receiving more than 200 kg/ha	
Forage crops removed	Forage crops grazed	Lucerne
Leys (1-2 year), grazed or cut and grazed, low nitrogen (1)	Leys (1-2 year), grazed or cut and grazed, high nitrogen (2)	Long leys, grazed or cut and grazed, high nitrogen (2)
Leys (1-2 year), cut only	Long leys, cut only	Permanent pasture, cut only, grazed or cut and grazed
Permanent pasture, poor quality, matted	Long leys, grazed or cut and grazed, low nitrogen (1)	

Notes:

(1) less than 250 kg/ha nitrogen per year and low clover content

(2) more than 250 kg/ha nitrogen per year or high clover content

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Appendix 3 Pesticides with On label Approval for Garlic

Active Ingredient	Product Features	Approval Type	Harvest Interval [1]	LERAP Category	Hazard Rating	MRL (mg/kg)
nicotine	non-persistent alkaloid insecticide.	Full	2 days	None stated	Toxic	
ioxynil	a selective post-emergence contact herbicide	Full	2 weeks	None stated	HarmfulIrritant	0.1
azoxystrobin and chlorothalonil	A broad spectrum fungicide	Full	2 weeks	B	Harmful	0.05 0.5

Notes:

[1] or latest time of application

Not all products containing these active ingredients may be currently approved for use on garlic. As label recommendations are revised regularly, read a current label before use.

The Long Term Arrangements for Extension of Use (2000) allow for pesticides with a label or specific off-label approval for use on Bulb Onions to be extrapolated to Garlic. Note: these extensions of use are at all times done at the user's choosing and the commercial risk is entirely theirs.

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Appendix 4 Specific off-label approvals (SOLA) for Garlic

Number	Product name	Active Ingredient	Expiry
11665	Afalon ®	linuron	31/12/13
10784	Agrichem Flowable Thiram	Thiram	31/12/13
12201	Agriguard Chlorothalonil®	chlorothalonil	28/12/13
10864	Agriguard Pendimethalin®	pendimethalin	31/08/08
1748/02	Alpha Linuron 50SC ®	linuron	31/12/08
12214	Alpha Pendimetalin 330EC®	pendimethalin	31/12/08
04873	Alpha Propachlor 50 SC®	propachlor	31/01/09
12893	Alpha Tebuconazole 20EW®	tebuconazole	31/12/13
10443	Amistar®	azoxystrobin	31/12/11
10280	Aramo®	tepraloxydim	31/05/15
06481	Ashlade CP®	chloridazon and propachlor	31/12/13
10994	Bandu®	deltamethrin	01/11/08
11357	Barclay Karaoke®	clopyralid	30/04/09
11648	Barclay Rebel®	propaquizafop	31/12/13
08360	Basagran SG®	bentazone	31/07/11
12412	Bayer UK226®	tebuconazole	31/12/13
06250	Better DF®	Chloridazon	31/12/13
11217	Blazer ®	pendimethalin	31/12/08
07910	Bombardier FL®	chlorothalonil	31/12/13
10560	Brasson®	Propachlor	31/12/13
10518	Bravo 500®	chlorothalonil	31/12/13
10519	Bravo 720®	chlorothalonil	29/02/08
11723	Bulldog®	propaquizafop	30/11/09
012142	Bumper 250 EC ®	propiconazole	31/12/13
12864	Bunker®	pendimethalin	31/12/08
11779	Claymore®	pendimethalin	31/12/08
12942	Clayton Lanark®	lambda-cyhalothrin	13/11/09
12834	Cleancrop Decathlon®	deltamethrin	01/11/08
10646	CleanCrop GYR®	propaquizafop	31/12/13
11066	Cleancrop Malahide®	maleic hydrazide	31/12/11
10500	Cleancrop Rio®	chlorothalonil	31/12/11
13351	Cleancrop Silo	Lambda cyhalothrin	13/11/09
11778	Cleancrop Stomp®	pendimethalin	31/12/13

Notes:

Specific off-label approvals (SOLAs) provide for the use of the product named in respect of crops, situations or pests other than those included on the product label. Such use is undertaken at the user's choosing and the risk is entirely theirs and /or their advisers.

Specific off-label uses may only take place if all the conditions given in the "Notice of Approval" document, the product label and/or leaflet and any additional guidance on off-label approvals have first been read and understood. The conditions of approval given in the "Notice of Approval" are statutory and supersede any on the label which would otherwise apply.

All SOLAs are conditional on the continued approval of the specific product.

Appendix 4 Specific off-label approvals (SOLA) for Garlic (Cont'd)

Number	Product name	Active Ingredient	Expiry
10181	Comrade®	chlorpropham	31/08/08
11835	Cropguard®	chlorothalonil	31/12/13
00604	Cuprokylt®	copper oxychloride	31/12/13
11323	Dacthal W75®	chlorthal-dimethyl	31/12/13
12208	Danadim Progress®	dimethoate	31/12/13
11008	Decimate®	chlorthal-dimethyl and propachlor	30/09/08
07172	Decis®	deltamethrin	11/11/08
11502	Decis Protech®	deltamethrin	01/11/08
11184	DiPel DF	Bacillus thuringiensis kurstak	31/12/13
12585	Dithane 945 ®	mancozeb	31/12/13
12565	DithaneNT Dry Flowable ®	mancozeb	31/12/13
10988	Dow Shield®	clopyralid	31/12/13
12034	Emrald Eyetort®	propaquizafop	31/03/09
11501	Ethosat 500®	ethofumesate	29/02/08
10585	Falcon®	propaquizafop	31/12/13
05558	Fazor®	maleic hydrazide	31/12/08
05461	Fazor®	maleic hydrazide	31/12/13
11033	Fernpath Torate®	clopyralid	30/04/09
11278	Folicur ® (field application)	tebuconazole	31/12/13
10525	Fusilade 250 EW®	fluazifop-P-butyl	31/12/08
11519	Fusilade Max®	fluazifop-P-butyl	31/12/13
08410	Gesagard®	prometryn	31/12/07
10979	Glopyr 200 SL®	clopyralid	31/12/13
11755	Greencrop Champion®	clopyralid	31/12/13
12095	Greencrop Estuary®	pendimethalin	31/12/08
11769	Greencrop Pomeroy®	cycloxydim	31/08/08
10748	Greencrop Satchmo®	propaquizafop	31/12/13
10197	Greencrop Valentia®	cycloxydim	31/08/08

Notes:

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All SOLAs are conditional on the continued approval of the specific product.

Appendix 4 Specific off-label approvals (SOLA) for Garlic (Cont'd)

Number	Product name	Active Ingredient	Expiry
12629	Hallmark with Zeon Technology®	lambda-cyhalothrin	13/11/09
11978	Invader ®	dimethomorph + mancozeb	30/09/12
10528	Jupital®	chlorothalonil	31/12/13
12527	Jupiter 40EC®	chlorpropham	31/12/13
11167	Kubist Flo®	ethofumesate	31/12/13
10847	Lidazone 65 WG®	chloridazon	31/12/13
10832	Loncid®	clopyralid	30/04/09
11558	Lontrel 200®	clopyralid	31/12/13
11460	Marnoch Clodim®	cycloxydim	31/08/08
13529	Markmate 50®	Lambda-cyhalothrin	28/06/11
12901	Mitre®	tebuconazole	31/12/13
08154	Nortron Flo ®	ethofumesate	31/12/13
12105	Orius®	tebuconazole	31/12/13
12311	Orius 20 EW	tebuconazole	31/12/13
08620	Pearl Micro ®	deltamethrin	01/11/08
12156	Penncozeb WDG ®	mancozeb	30/06/11
11946	Pirlid®	clopyralid	31/12/13
10313	Ramrod 20 Granular®	propachlor	31/12/13
10314	Ramrod Flowable®	propachlor	31/12/13
11092	Raptor®	propaquizafop	31/12/13
11295	Raxil ®	tebuconazole	31/12/13
11328	Repulse®	chlorothalonil	31/12/13
12696	Riza®	tebuconazole	31/12/13
11090	Rouge®	maleic hydrazide	31/12/08
11702	Rovral Flo®	iprodione	31/12/08
11062	Royal MH 180®	maleic hydrazide	31/08/08

Notes:

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All SOLAs are conditional on the continued approval of the specific product.

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Appendix 4 Specific off-label approvals (SOLA) for Garlic (Cont'd)

Number	Product name	Active Ingredient	Expiry
05140	Sentinel 2®	propachlor	31/12/13
10584	Shogun®	propaquizafop	31/12/13
13083	Sonar®	chlorothalonil	31/12/13
08314	Source 11®	maleic hydrazide	31/12/08
13618	Source 11®	maleic hydrazide	22/07/11
08830	Standon Cycloxydim®	Cycloxydim	31/08/08
11536	Standon Propaquizafop®	propaquizafop	31/12/13
10729	Standon Pendimethalin 400SC®	pendimethalin	31/12/08
12018	Starane 2®	fluroxypyr	30/12/11
11777	Stomp 400 SC®	pendimethalin	31/12/08
13405	Stomp 400 SC®	pendimethalin	31/12/13
06874	Thyram Plus®	thiram	31/12/13
12438	Tracer®	Spinosad	30/04/13
03250	Tripart Sentinel®	propachlor	31/12/13
02322	Vydate ®	oxamyl	31/12/13

Notes:

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All SOLAs are conditional on the continued approval of the specific product.

Appendix 5 Guidelines on minimising pesticide residues

These guidelines have been produced after consultation between crop stakeholders and the Assured 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.

Active Ingedient	Target: pest, weed, disease	Current position	Suggested guidelines
maleic hydrazide	Plant growth regulator	Residues found regularly between the limit of determination and MRL	Growers should not apply maleic hydrazide to garlic bulbs which are destined for marketing prior to 1 st December, asinternal sprouting is rarely significant prior to this date. Use reduced product rates for crops held in ambient storage.

Appendix 6 Control Points: Garlic

CS.83 GARLIC

CS.83.1 You should utilise varietal yield, quality and storage characteristics to optimise the performance of your garlic crop -

Protocol reference: Section 5.1

CS.83.2 You should be able to produce evidence to show that you have adequately controlled storage conditions, capable of achieving temperature and humidity targets, as set out in the crop protocol -

Protocol reference: Section 9.6

CS.83.3 You should be able to justify the use of sprout suppressant treatments in your crop -

Protocol reference: Section 9.4

CS.83.4 Where loose garlic is transported from the field to store trailers must be cleaned before use and the cleaning recorded -

Protocol reference: Section 9.5

CS.83.5 Where garlic is stored in bulk stores must be cleaned before use and this cleaning recorded -

Protocol reference: Section 9.5

CS.83.6 (Green Garlic only) You should be able to show that water used for washing the harvested crop is used with conservation as a priority

Protocol reference: Section 10

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