Assured Produce

Crop Specific Protocol

POTATOES

(CROP ID: 47)

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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 specific parameters and guidance, where applicable, for the requirements stated in the Generic Standards. **All statements in this protocol suffixed by CFP (Critical Failure Point) are in bold type and are requirements of the scheme which, if not complied with, will result in the member not achieving Full membership at his annual assessment.**

All statements in this protocol containing the words **"must"** (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 **"must"** control points can be found on the final page of this document and in the checklists produced by Assured Produce licensed certification bodies.

All statements in this protocol containing **"should"** (in bold type) will be verified during the Assured Produce assessment but their compliance **will not** form part of the certification/approval decision (i.e. they carry no score).

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:

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 Products containing substances which have been revoked are shown on the PSD website (http://www.pesticides.gov.uk).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:

- 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)**

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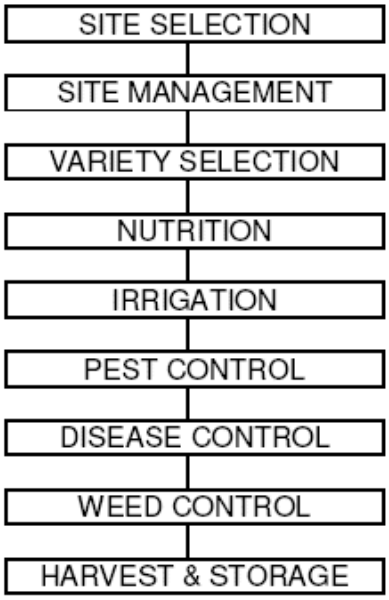
1 General introduction

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.

2 Planning and records

See Generic Standards and/or Generic Guidance Notes.

3 Site selection

Perfect potato sites and soils are rare and in practice a wide range of soils are capable of growing good crops of potatoes using appropriate management techniques such as de-stoning and de-clodding.

Field selection should involve an assessment of the risk of hazardous foreign objects in the soil as well as an assessment of previous potato cropping, soil borne pests and diseases and weed

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Free draining soils make management easier, alleviating planting and harvesting problems. Physical or chemical soil pans must be rectified to avoid rooting depth restriction.

Effective drainage systems and high soil organic matter will improve soil structure.

3.1 Site history

3.1.1 Environmental considerations

Sites for potato production should be selected with due consideration to conservation and the local environment. Consideration should be given to the compatibility of potato cropping with the existing conservation interest of the site particularly in the case of unimproved or semi-natural habitats.

Potato crops should not damage sites of archaeological interest.

Landowners have a statutory obligation under the Ancient Monument and Archaeological Areas Act 1979 to protect scheduled Ancient Monuments and Historic Buildings on their property.

3.2 Rotations

3.2.1 Crop rotations

3.2.1.1 Pest and disease considerations

Wide rotations (at least 1 in 5 and preferably wider) are desirable. Close rotations can increase the risk of potato cyst nematode (PCN) and other soil-borne problems such as Rhizoctonia and Black Dot, which reduce yield and tuber quality.

3.2.1.2 Double and continuous cropping

Double cropping in rotations closer than 1 in 5 can cause rapid build up of potato cyst nematodes, *Rhizoctonia* and volunteers. Other soil-borne problems (Black dot, powdery scab and *Verticillium* spp.) may also become a nuisance.

Continuous cropping should only be practiced with short season crops and in conjunction with special pest and disease testing.

Wider rotations, careful site selection, considered use of pesticides, targeted testing for particular pests and diseases and close crop monitoring should avoid over-heavy reliance on chemical control measures.

3.2.1.3 Weed considerations

Most annual weed problems can be dealt within the potato crop. Perennial weeds are difficult to control in potatoes and can have detrimental effects on both yield and efficiency of harvesting. Perennial weeds should be controlled in previous crops.

3.2.1.4 Volunteer considerations

Close potato rotations increase the risk of volunteer problems. Volunteer potatoes can act as carry-over hosts for many potato pests and diseases.

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3.2.1.5 Volunteer potato control strategy

Volunteer potatoes are very difficult to control in any crop but an integrated control strategy will help contain this problem:-

- grow potatoes in as wide a rotation as possible;
- lift potato crop early in kind soil conditions;
- leave as few small or waste potatoes in fields after harvest as possible;
- avoid or delay ploughing after potatoes;
- use glyphosate in cereal crops;
- consider the use of fluroxypyr in cereal and clopyralid in sugar beet.
- maleic hydrazide **should** only be used where market outlets permit **and** only if application conditions are ideal (this product leaves permissible residues in the tuber even when used according to the label);

3.2.2 Specific scientific predictive tests

See - 8.10.1.1 Potato cyst nematode (PCN), Free living nematodes (FLN), 8.10.1.2 Spraing (Tobacco rattle virus) 8.10.2.12 Potato moptop virus and 8.10.1.4 Wireworm. Soil tests are now available for Black dot and Rhizoctonia.

4 Site management

4.1 Soil mapping

See Generic Standards and/or Generic Guidance Notes.

4.2 Soil management at planting

Aim for a tilth as free of large clods as possible. Totally clod-free seed beds may depress yields and slumping of the ridges may occur.

Excessive cultivation will damage soil structure.

4.3 Soil fumigation

See Generic Standards and/or Generic Guidance Notes.

4.4 Substrates

See Generic Standards and/or Generic Guidance Notes.

4.5 Drilling and transplanting

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.

5.2 Seed quality

The use of healthy seed can reduce the level of pesticides applied to the subsequent ware crop.

When selecting seed potatoes, growers should recognise the effect that location, health, management and handling of the seed crop have on the ware crop.

Growers should aim to purchase seed from seed producers within the Safe Haven Certification Scheme.

5.2.1 Planning

Seed should be purchased on its quality rather than price alone. Early ordering will help secure better quality lots.

A good relationship with the seed supplier is essential. A direct dialogue between the seed and ware growers in all matters concerning the seed crop husbandry and treatments is important.

Seed should be supplied to an agreed production and tuber specification to suit to the intended ware market. An example of SERAD's seed tuber export tolerances are given in Appendix 15.

Seed suppliers should provide the following details:

- agent
- growers name and address
- date of tuber initiation
- tuber count
- date crop loaded in store
- details of all post-harvest chemicals and dates of application

Husbandry records of seed crop in field and store should be available to the ware grower on request.

5.2.2 Seed Classification

Statutory seed classification can only be a very general guide to crop health.

5.3 Seed treatments

All treatments should be discussed between seed producer and buyer. Fungicide use should be tailored to variety, seed health status and the intended market outlet for the subsequent ware crop. Judicious choice of fungicides for the seed crop can result in reduced need for chemical treatment of the ware crop. Fungicide treatments are not a substitute for sound husbandry.

5.3.1 Application of fungicides to potato tubers

Most potato fungicides only protect against or suppress the development of disease and have no curative effect. Tubers should be largely free from soil so that the fungicide is applied directly on to the skin and target organism. The entire tuber surface should be covered by fungicide for effective control of silver scurf.

The British Crop Protection Council's (BCPC) leaflet "Guidelines for the effective chemical treatment of potatoes" 1991 and the SAC/BPC's Store hygiene cd 2004 are useful guides.

5.3.2 Disease control in seed stocks

5.3.2.1 Powdery scab *(Spongospora subterranea)*

Cultural control: *The main methods of control are cultural (see Section 8.10).*

Chemical control: No completely effective chemical controls are available. There is a SOLA recommendation for fluazinam in seed crops.

5.3.2.2 Stem canker/black scurf (*Rhizoctonia solani*)

Cultural control: see Section 8.10

Chemical control: There are effective seed and soil treatments. See Appendices 7 & 8.

5.3.2.3 Dry rot *(Fusarium spp.)*

See Section 8.10

Cultural control: *Minimise tuber damage when handling and avoid excessive handling. Unfortunately, early harvesting which assists the control of other diseases can encourage Fusarium. Good skin set and appropriate store management will help prevent infection.*

Chemical control: Seed tuber treatments can give reasonable control when they are applied at harvest.

Some strains of *Fusarium* are resistant to thiabendazole.

5.3.2.4 Gangrene and skin spot *(Phoma exigua* and *Polyscytalum pustulans)*

See Section 8.10

Cultural control: *Like many seed-borne diseases, gangrene and skin spot can be controlled by an integrated seed disease management strategy which involves:-*

- *choosing drier, warmer seed production sites*
- *desiccating early with a fast acting chemical*
- *harvesting early and carefully in dry, warm soil conditions*
- *handling gently*
- *perhaps treating with a fungicide*
- *drying the crop thoroughly and keeping the crop dry*
- *curing properly*
- *storing at 4° C*
- *clean the seed store and containers prior to loading*

Varietal susceptibility varies and this must be considered on certain seed production sites.

Chemical control: Chemical treatment is a small part of an overall control strategy for gangrene and skin spot.

Liquid fungicide sprays at store loading may help.

5.3.2.5 Silver scurf *(Helminthosporium solani)*

See Section 8.10

Cultural control: *Strategies to control gangrene and skin spot will also help control Silver scurf. Cool (<4° C) storage reduces the development of silver scurf. This may conflict with the need to sprout some*

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seed.

Chemical control: If needed fungicides can be applied to seed stocks, either as soon as possible after lifting to prevent infection, or later to suppress sporulation and infection. Some strains of silver scurf are now resistant to thiabendazole.

5.3.2.6 Black dot *(Colletotrichum coccodes)*

See Section 8.10

5.3.2.7 Blackleg *(Erwinia spp.)*

See Section 8.10

Cultural Control: *Current varieties vary in their susceptibility to blackleg. There are no guaranteed control methods for blackleg but seed producers and ware growers can minimise the risk of infection by the adopting the following procedures:-*

- *choose warmer, drier production sites for susceptible varieties*
- *stock seed(of known origin) should be stored cold and dry*
- *avoid poorly structured compacted growing sites*
- *plant in warm kind seed beds*
- *handle seed very gently*
- *fertilise correctly*
- *irrigate correctly*
- *desiccate early and completely*
- *harvest early on dry days and in good soil conditions*
- *positively dry the crop at store loading*
- *keep the crop cold and dry after curing, during transit and in store on the ware farm. Representative seed samples can be tested for blackleg bacterial loading. This test gives an indication of blackleg risk in the growing crop.*

5.3.2.8 Viruses

Virus diseases have to be kept at very low levels in seed crops. Virus control in seed crops involves roguing, aphid protection and early burn off. Aphicides are not effective in controlling non-persistent viruses like Potato virus Y.

Use of certified seed ensures low virus levels in the ware crop.

Home saved seed has no official inspection but the tubers can be tested for important viruses and other diseases.

5.3.3 Grading facilities

Seed growers should have the ability to split the seed and ware fractions into store. At dressing out time it should be possible to split size the seed crop and where necessary spray the various fractions in a single operation.

Careful handling of warm (8-10°C) seed will prevent damage and disease.

5.3.4 Harvesting dates

Early desiccation and harvest will significantly reduce the incidence of bacterial, fungal and viral

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disease.

5.3.5 Inspection procedures

Official inspection of seed crops is mandatory but ware producers are encouraged to look at the growing and or stored seed crop.

5.3.6 Storage of the seed crop

Many potato storage problems are the result of poor store management techniques. Good store management with close store monitoring will reduce the need for post harvest storage chemicals and ensure high storage out turns.

Good potato store managers will:

- *only store potatoes which have adequately set skins, are relatively soil and damage free, have not been rained on and are unaffected by blight or blackleg*
- *monitor the store regularly, and record store temperatures and fan run hours from the date of loading*
- *dry and cure the crop as soon as it is loaded into store*
- *keep the crop at a steady holding temperature*
- *never tolerate condensation*
- *only handle potatoes gently at temperatures of at least 8°C*
- *only store the crop in clean buildings and containers*

5.3.7 Home-saved seed

Saving "seed" from ware crops with appropriate management and storage facilities can produce suitable quality seed.

Many ware potato buyers will not accept the routine use of aphicides to protect ware crops from virus.

Seed can carry and therefore spread nematode cysts. Growers using their own “seed” should consider the need to test their seed for cysts. Certified seed is only produced on potato cyst nematode free land.

5.4 Plants and nursery stock

See Generic Standards and/or Generic Guidance Notes.

5.5 Genetically modified organisms (GMO's)

See Generic Standards and/or Generic Guidance Notes.

6 Nutrition

6.1 Nutrient requirement

Fertiliser application should be based on:

- *soil analysis*
- *anticipated soil nitrogen availability*
- *potato crop response to individual elements*
- *variety*

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- *time and duration of crop growth*
- *organic manure application*
- *market outlet requirements (e.g. dry matter or cooking quality)*
- *crop off-take information*

Fertiliser recommendations and organic manure values are given in DEFRA RB 209 Fertilizer Recommendations 7th ed. 2000.

6.2 Advice on quantity, type and timing of fertiliser

See Generic Standards and/or Generic Guidance Notes.

6.3 Nitrogen

Excessive amounts and ill-timed applications of nitrogen can adversely affect crop performance and may be leached from the soil.

6.4 Application equipment

See Generic Standards and/or Generic Guidance Notes.

6.5 Records of application

See Generic Standards and/or Generic Guidance Notes.

6.6 Fertiliser storage

See Generic Standards and/or Generic Guidance Notes.

6.7 Organic manures

Applications should be made only in accordance with the DEFRA Codes of Good Agricultural Practice for the Prevention of Pollution of Water and Air and the requirements in Nitrate Vulnerable Zones. Application of nitrogen in organic manures should not exceed a total of 250 kg/ha. This figure is lower in nitrate vulnerable zones.

The nutrient content of any organic manure applied must be taken into account in deciding inorganic fertiliser policy for the field.

See "Making the most of organic manures for optimum results and cost savings" BPC 2000.

The use of any domestic or industrial wastes as nutrients or soil conditioners should be discussed with end users of the crop. ADAS and SAC's "Safe Sludge Matrix" provides guidelines on the use of sewage sludge.

7 Irrigation

7.1 Predicting water requirement

Irrigation of potatoes has a great influence on tuber yield and quality. Accurate irrigation scheduling, in conjunction with weather forecasts, is essential to achieve the yield and quality the market demands, conserve water and to avoid disease and soil structure problems.

7.2 Irrigation method

Where appropriate the use of soil moisture measurement devices, beds, tied ridges, booms and trickle systems will conserve water and reduce disease risk.

7.3 Quality and supply

Where there may be a risk of impurities in irrigation water, samples should be analysed for likely contaminants.

7.4 Quality aspects of irrigation

7.4.1 Common scab

Common scab may be controlled by keeping soil around the developing tubers near to field capacity for 4 to 6 weeks after tubers begin to form. Maintaining such low soil moisture deficits (SMDs) requires frequent applications of small amounts of irrigation.

7.4.2 Powdery scab

Irrigation regimes to minimise common scab increase the risk of powdery scab. Fields with a history of powdery scab should be irrigated very carefully and should be planted with a resistant variety (see Section 8.10).

7.4.3 Potato blight

Irrigated crops have to be considered vulnerable to potato blight and fungicide protection programmes should be planned accordingly (see Section 8.10).

7.4.4 Blackleg

Irrigation can create soil conditions favourable for the development of blackleg. Irrigation scheduling systems will help reduce these risks.

7.4.5 Tuber quality parameters

Well-planned irrigation improves skin texture, tuber size and shape by avoiding large fluctuations in soil moisture. Careful irrigation management should reduce growth cracking, secondary growth, hollow heart, enlarged lenticels and jelly end rot.

7.4.6 Irrigation stop dates

Irrigation stop dates will depend on crop cover, tuber size, maturity, soil type and moisture content, disease levels and the weather forecast.

8 Crop protection

8.1 The basic approach to crop protection

8.1.1 Non-chemical methods

See Generic Standards and/or Generic Guidance Notes.

8.1.2 Integrated crop management

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8.1.2.1 Preparation of seed for planting

The use of healthy seed will improve yield and crop quality and reduce the need for pesticide applications to the growing and stored ware crop.

Production systems for healthy seed combine the following good potato husbandry points:-

- *in general select light soils in relatively warm, dry locations*
- *plant high quality stock seed into "kind" seedbeds*
- *destroy haulm early with fast-acting desiccants*
- *harvest gently in good soil conditions*
- *consider fungicide use at store loading and/or after curing*
- *once in store, dry the crop with forced ventilation*
- *cure the crop thoroughly*
- *store at a constant temperature avoiding condensation*
- *store in clean buildings and containers*
- *handle crop gently at temperatures over 8°C*

8.1.2.2 Physiological and chronological age of the planted seed

The optimum physiological and chronological age will depend on variety, planting and harvest dates and intended market.

All seed should have open eyes at planting and should be cooler than the soil temperature. Avoid damage to the eyes (sprouts).

8.1.2.3 Storage of seed on the ware growing farm

To keep seed in good physiological condition and to avoid disease development it is important to:-

- thoroughly clean the seed storage building and containers
- handle seed gently avoiding any sprout damage
- cure the seed if necessary
- store at a constant temperature
- avoid any condensation

8.1.2.4 Lighting

For seed sprouted in trays or crates adequate light is required for sprout growth control.

8.1.2.5 Fungicides

Fungicides to control seed-borne diseases can be applied by the ware grower pre-sprouting as a liquid over a roller table and/or as dusts or liquids on the planter. All seed fungicides can sometimes, for unknown reasons, have phytotoxic effects. Follow label instructions very carefully.

Choice of product, if any, depends on the intended market, previous products applied, the diseases found and likely problems. See SAC technical note T486 Potato tuber diseases: determining the requirement for a fungicide treatment.

Residues of seed fungicides are appearing in routine ware potato residue test programmes. This may be due to “contamination” of potato boxes whilst in use as seed containers. Where possible don’t use seed boxes for ware potatoes and always inspect ware boxes prior to filling. If necessary boxes should be cleaned before ware use.

See Appendix 8 for the chemical control of tuber-borne diseases.

8.1.3 Regular crop inspections

See Generic Standards and/or Generic Guidance Notes and see also 8.10.

8.1.4 Monitoring of pests

See Generic Standards and/or Generic Guidance Notes and see also 8.10.

8.1.5 Monitoring of local weather conditions

See Generic Standards and/or Generic Guidance Notes and see also 8.10.

8.1.6 Thresholds

See Generic Standards and/or Generic Guidance Notes and see also 8.10.

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 advice

Assured Produce is aware that a key area in the production of fresh produce that requires continued attention by growers and advisers is that of keeping tuber residues to a minimum. This issue is not simply meeting the MRL trading standard but ensuring that any individual or multi-residues are kept as low as possible.

The key targets are -

- **Optimising late applications of crop protection products to the tuber.**
- **Optimising the use of all post harvest treatments**
- **Ensuring minimum harvest intervals are followed**
- **Ensuring application equipment is working correctly and that application techniques follow product label guidelines**

The commonest pesticide residues found in potato tubers are: CIPC (chlorpropham), maleic hydrazide, imazalil and thiabendazole. Recently residues of azoxystrobin (Amistar),fozthiazate (Nemathorin), oxamyl (Vydate), pencycuron (Monceren) and propamocarb hydrochloride (found in Consento, Infinito, Merlin, Proxanil and Tattoo) have been discovered. All these residues are virtually always below the MRL.

Reducing the doses and or widening the harvest intervals with these products is unlikely to reduce the residue level.

Tecnazene, which is not approved on potatoes, is occasionally found but this is usually a result of past contamination of storage containers or buildings.

Correctly applied potato blight fungicides, foliar insecticides, desiccants and herbicides very rarely if ever leave tuber residues.

See Appendix 16 for guidelines on minimising pesticide residues in potatoes.

8.10 Pest, disease, physiological disorder and weed control

8.10.1 Pest control

Integrated pest control systems ensure that chemical treatments are only used when absolutely necessary. Pesticide choice should be based on:

- *identification of the pest and estimate of its likely damage*
- *use of non chemical control methods*
- *environmental considerations, including the presence of predators*

- *persistence of the chemical*
- *level of known resistance in the region*
- *prevention of resistance build up*
- *level of control required*
- *harvest date/interval*
- *previous chemical applications*

8.10.1.1 Potato cyst nematode (PCN)

PCN is the most important and most widely distributed pest of potatoes in the UK, affecting both yield and quality of potatoes.

Site selection

If PCN presence is suspected all fields to be cropped with potatoes need to be sampled and when possible the PCN species identified. Decisions about rotations, use of resistant and/or tolerant varieties and the need for chemical treatment can only be made on the basis of soil sampling and previous records.

Interpretation of soil sampling results

Nematicide treatment is usually recommended for "moderate" and higher PCN infestations (ADAS category).

For those in the "low" category, nematicide treatment is not advised unless:-

- potatoes are grown in close rotation, or
- potatoes are grown on very light soils, or
- a variety very susceptible to PCN attack is to be grown, or
- *Globodera pallida* is present.

Integrated control

PCN is most effectively managed by integrating rotational control, chemical control and where appropriate, resistant varieties.

In the absence of potatoes PCN levels decline by 20-30% each year, depending on the species present and the site. This rate of decline may be even less where potato volunteers are present and so control of volunteers is important (see Section 3.2.1.5).

By using resistant varieties and nematicides rotations can be significantly reduced while still keeping PCN levels at acceptable numbers. However production systems based on rotations closer than 1 in 6 have to be planned and monitored very carefully.

Resistant varieties

Many commercial varieties have resistance to Globodera rostochiensis. Where such varieties have been repeatedly grown there has been a build up of G. pallida. This is a far more difficult species to control due to its slower rate of decline and its extended hatching period. Where possible, varieties should be chosen to avoid G. pallida becoming the dominant species.

At present no variety has complete resistance to G. pallida and only a few have partial resistance. These varieties also tend to be intolerant of PCN.

Trap cropping with Solanum sisymbriifolium (Sticky nightshade)

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It is now possible to grow this relative of the potato whose roots stimulate the hatch of potato nematode cysts. S sisymbriifolium is a semi-tropical species and can be quite difficult to establish. There are no published results on its efficacy.

Chemical control: Economic potato production will often require chemical control as part of an integrated control programme. Nematicide use depends on PCN numbers and species present, potato variety chosen, soil type and length of rotation. Accurate incorporation of nematicide granules, especially in stone and clod separation systems, is vital.

Operators applying nematicide granules must hold the appropriate NPTC PA4 qualification. Membership of the nematicide manufacturer's product stewardship programme ensures the best use of nematicides. Currently approved nematicides are given in Appendix 1.

8.10.1.2 Spraing (Tobacco Rattle Virus)

The virus is restricted mainly to light sandy soils in which the free-living nematode vectors (stubby-root nematodes) are common. In some seasons susceptible varieties can be severely affected, with tubers being unacceptable for sale yet impossible to grade out.

Correct identification of "damage" is important. Tobacco Rattle Virus can be confused with Mop Top Virus and Internal Rust Spot. Reliable laboratory tests are now available.

Site selection

Soil sampling for the nematode vectors and previous experience of problems can give a guide to likely problems but laboratory soil tests can now identify the virus and provide a better assessment of risk. Fields with high populations of virus infected stubby-root nematode should only be cropped after careful choice of variety.

Resistant varieties

Research at the Scottish Crop Research Institute has identified "resistant varieties" (rarely infected and show no symptoms) 'Spraing sensitive' varieties (show symptoms) and "Spraing susceptible" varieties (which may not show symptoms but can carry the virus). Resistant varieties can be useful on problem sites.

Cultural control: *As the spraing virus infects many common weeds good weed control between potato crops may be helpful. Growing barley in rotation with potatoes on fields with a history of spraing may also help to reduce virus incidence. Choose seed and seed sources with care especially from sandy soils. A seed test on susceptible varieties could identify the virus and prevent its introduction to "clean" fields.*

Chemical control: In fields with a known history of spraing, where nematode levels are high and the TRV virus has been identified do not crop with a "Spraing sensitive" variety even with chemical treatment. Nematicides only give a reduction in spraing symptoms with "Spraing sensitive" varieties. See Appendix 2.

Poorly managed “in furrow” application of granular nematicides may be a cause of tuber residues of some nematicides. Staff operating this equipment should be appropriately qualified and attend refresher application technique workshops.

8.10.1.3 Slugs

Crops grown on heavy, cloddy soils or fields with a history of previous damage are most at risk from slug damage. Slug damage is often difficult to predict or reduce.

Varietal susceptibility

Select less susceptible varieties on slug prone sites.

Cultural control: *Rotation, rainfall, variety, incorporation of organic matter, soil type and trash carry over from the previous crop all affect slug populations. The production of a fine soil tilth will suppress slug activity. Damage can be limited by lifting the crop as early as possible.*

Parasitic nematodes are now commercially available as biological control but their efficacy on slugs in potatoes is not proven.

Chemical control: Whilst test baiting can give an indication of activity of slugs on the soil surface and may assist in accurate timing of application of slug pellets. Prophylactic treatment in high-risk situations may be appropriate. Currently approved products are listed in Appendix 3.

8.10.1.4 Wireworms

Large wireworm populations occur only in permanent grassland but commercially significant wireworm damage is now not unusual in crops grown on old arable soils.

Site selection: *There is a high risk of wireworm damage to potatoes grown immediately after grass which has been down for 5 or more years; even in the 2nd, 3rd and sometimes 4th year after grass, wireworms can still be a problem. As chemical controls are only partially effective, cropping with potatoes after grass should be avoided. .*

Wireworm attack is also affected by bulk density and sand content of the soil, grass species diversity of the old sward and field aspect. However these relationships are not reliable enough to predict damaging populations.

Cultural control: *The control of wireworms by cultural methods cannot be relied upon to prevent damage to potatoes grown soon after ploughing-in old grassland. However, once in an arable rotation, wireworm populations decline over a period of 3 to 4 years. Early harvesting may avoid some damage as the longer the crop is in the ground the worse the damage becomes. There are no resistant varieties but early bulking varieties may be ready to harvest before wireworm attack, usually in the late summer.*

Buried, fresh carrot traps in the crop prior to potatoes may give an indication of likely wireworm problems in the potato crop.

Pheromone trapping may provide growers with a more accurate prediction of tuber damage. Adult beetles are trapped in the field the year prior to planting potatoes. The numbers of beetles caught can be related to the likely tuber damage in the following potato crop. However reliable catch thresholds are yet to be determined.

Chemical control: Soil sampling for wireworm larvae can be a guide to likely damage but it not reliable. Specially baited traps in the ploughed land may give a more reliable guide to the need for chemical treatment. Local knowledge and chemical control in crops previous to potatoes are important. Products with current approval for use in potatoes are given in Appendix 4. The approved products give a reduction in wireworm damage, not control.

8.10.1.5 Cutworms

Cutworm attacks can be severe, if somewhat sporadic. Serious damage is usually confined to un-irrigated, light land crops in Eastern England in long, hot, dry summers.

Forecasting cutworm attacks

Pheromone traps may be used to catch moths, but moth numbers are not a direct guide to correct spray timing. Spray timings should be based on dynamic models of egg and larval development (see the Horticultural Development Council www.hdc.org.uk). A minimum of 10 mm irrigation or rain, correctly timed, can give effective control of young cutworm larvae, and reduce the need for chemical treatment.

Cultural control: *Backward and weedy crops are more prone to cutworm damage. Early planting, rapid establishment and effective weed control will minimise the risk of damage. Because young cutworms cannot survive in wet soil, frequent irrigation will help to prevent the development of damaging infestations. Irrigation can be timed to coincide with the presence of larvae in their first or second instar.*

Chemical control: If a crop is considered to be at risk and irrigation or rain is not timely an insecticide should be applied according to local spray warnings. Products approved for cutworm control are listed in Appendix 5.

8.10.1.6 Aphids

In most years control of aphids on ware potato crops is unnecessary. However in some years heavy aphid feeding on the haulm can reduce yield and in a few varieties virus spread may be a problem.

Cultural control: *Planting healthy, virus free seed from either classified seed crops or crops on which a virus test has been conducted will reduce the risk of virus spread in the ware crop.*

Crop monitoring

Monitor ware crops regularly from May to July. Spraying will only be worthwhile if aphid numbers start to increase rapidly before end of July and if hot dry weather is forecast. Varieties susceptible to direct feeding damage may need to be sprayed a little earlier.

Chemical control: Before resorting to chemical control, take into consideration:

- location of crop
- over-wintering of aphid
- time of year
- aphid species and numbers present
- recent weather patterns and weather forecast
- susceptibility of variety to aphid feeding damage
- importance of prevention of virus spread
- aphid resistance to chemicals

ADAS research work indicates that feeding damage may be less of a problem than has generally been assumed and that the established threshold for feeding damage of 3 to 5 aphids per true potato leaf may be conservative for most varieties.

Aphid resistance and aphicide choice in ware crops

The Peach potato aphid , *Myzus persicae* can now be found with three different types of insecticide resistance. It is possible for some strains of M. persicae to have all three types of resistance which makes them immune to organophosphate, pirimicarb and pyrethroid insecticides. Organophosphate aphicides are no longer approved for potatoes.

The three types of resistance are esterase or E4, "Mace" and knockdown or kdr. The resistance mechanisms prevent certain insecticides from affecting the aphid.

There are newer insecticides that have no resistance problems yet acetamiprid (InSyst), flonicamid (Teppeki), pymetrozine (Plenum), thiacloprid (Biscaya) and thiamethoxam (Actara).. Where an aphicide has to be used the choice should be based on:

- environmental considerations, including the aphid predators present
- aphid species in the crop
- persistence of the chemical
- level and type of *M. persicae* resistance in the region if known
- prevention of resistance build up
- level of control required
- where applicable the type of insecticide used for cutworm control in the potato crop and in other crops near the potatoes

Pyrethroid products are probably best avoided. Recent aphid surveys show very high levels of M. persicae with "Kdr" resistance to pyrethroids.

Pyrethroid products will kill more beneficial predators than aphicides from other chemical groups. Where a population of predators is present or can be established, one well-timed application of acetamiprid, flonicamid, pirimicarb, pymetrozine, thiacloprid or thiamethoxam could allow natural predators to keep aphids below economic thresholds However, pirimicarb insecticides give no control of Mace resistant aphids or Aphis gossypii the Melon Cotton Aphid. If a second aphicide application is necessary, use a material with a different mode of action.

Potato aphicides and their modes of action

Trade name	Active ingredient	Chemical group	Mode of action	Resistance problems
Aphox & Phantom	pirimicarb	dimethyl carbamate	acetylcholinesterase inhibitor	Mace & some E4
Actara InSyst Biscaya Nico soap	thiamethoxam acetamiprid thiacloprid nicotine	nicotinoids	acetylcholine receptor agonist	None yet
Hallmark	lambda cyhalothrin	pyrethroid	sodium channel modulator	Kdr & some E4
Plenum	pymetrozine	pyrimidine azomethine	not known	None yet
Teppeki	flonicamid	pyridine carboxamide	not known	None yet

See also advice from the Insecticide Resistance Action Committee (IRAC) on the PSD web site. Currently approved aphicides are listed at Appendix 6.

8.10.2 Disease control

Introduction

Diseases should be controlled by the use of resistant varieties and cultural methods where possible. Chemical seed treatments can reduce disease incidence in the ware crop (see Section 5). If required the choice of chemical to protect the ware crop should be based on:

- *identification of the disease and estimate of likely damage*
- *environmental considerations*
- *persistence of the chemical*

- *level of known resistance in the region*
- *prevention of resistance build up*
- *level of control required*
- *harvest date/interval*
- *previous chemical applications*
- *varietal susceptibility*
- *market requirements*

The role of potato volunteers or groundkeepers

Volunteer potatoes can act as a soil reservoir for a number of potato diseases and pests. Every effort must be made to control groundkeepers (see Section 3.2.1.5)

Intensity of rotation and previous cropping

Increasing the frequency of potato cropping, particularly for main crop or longer season varieties, will increase the risk from stem canker, black scurf, black dot, powdery scab and Verticillium wilt.

Cultivations

Impeded drainage can lead to bacterial rotting and powdery scab. Very deep planting in difficult soil conditions may increase the incidence of stem canker.

Irrigation

Irrigation applied promptly at tuber initiation and for a further 4 to 6 weeks can reduce the severity of common scab. Excessive irrigation increases the risk from powdery scab, blackleg, black dot, pink rot, and creates conditions more favourable to late blight.

Harvesting

Early harvesting in good soil conditions is the most important cultural means of disease and quality control in the crop.

Early lifting of tubers with set skins reduces the incidence of silver scurf, skin spot, black dot, black scurf and bacterial rots. Late lifting increases the risk of tuber damage and poor fry quality. Avoid lifting tubers for storage with immature skins.

Storage

Storage regimes are dictated by market outlet. Very low store temperatures (2 to 3°C) increase the risk of skin spot and gangrene in susceptible varieties. Higher temperature (8°C+) storage favours the development of silver scurf, back dot dry rot, blight and bacterial rots.

Control of major diseases in ware crops

8.10.2.1 Common *scab (Streptomyces scabies)*

Recently developed molecular testing techniques are confirming the presence of several different scab types. Some of these scabs are not controlled by irrigation and thrive in acid soils.

Cultural control: *Resistant varieties should be used when possible. Common scab is especially prevalent on light sandy soils, after old grassland and sometimes after heavy applications of lime. Irrigation during tuber-initiation can reduce common scab on most varieties and soil types.*

Chemical control: None is available.

8.10.2.2 Blight (Phytophthora infestans)

Blight is the most important fungal disease of potatoes. Blight in the crop canopy can spread to the tubers resulting in marketing and or storage problems. The blight fungus is changing genetically and current strains are very aggressive and can develop very quickly in the crop if it is not protected by fungicide.

Cultural control: *Choose resistant varieties where possible.*

*Haulm growth on potato dumps **must** be destroyed with chemical desiccant or contained with black plastic sheeting. Groundkeepers should be controlled. Seed stocks should be blight-free.*

Depth of planting and ridge building should provide sufficient soil cover to minimise the risk of tuber infection from spores washing down from infected haulm.

Crops that are to be lifted green top are particularly vulnerable to tuber blight even if little foliar blight is visible. If levels of infection are unacceptable the crop should be desiccated and lifting delayed until at least 14 days after haulm death.

Blight forecasting techniques (Decision Support Systems) and electronic monitors can be used to determine optimum spray timings. Whilst these forecasting techniques are proving more reliable, they should be used in conjunction with local knowledge and experience to determine spray timings.

Chemical control: Blight cannot be eradicated once infection is present so fungicide sprays have to be prophylactic. Decision support systems can accurately predict blight spray timing and often reduce the number of sprays needed over a season.

Spray programmes start as plants begin to meet along the rows. If weather conditions conducive to blight occur before the plants meet along the row, spraying may have to begin sooner.

Subsequent spray timings are dictated according to crop risk and disease pressure. Crops are considered low, medium and high risk according to locality, local blight pressure, weather conditions, cultural practice, variety and planting date. Potato blight spray programmes **must** use the minimum number of sprays necessary for good blight control.

The crop needs to be protected until the haulm is completely dead. Harvest should be delayed until 14 days after complete haulm death. The spray programme should contain some fungicides known to protect against tuber blight.

Blight has been a serious problem in many crops in recent years. When blight is established in the crop it is still very important to follow the instructions on the fungicide label and adhere to good agricultural practice.

There are industry accepted phenylamide, Qol and Qil resistance strategies. Refer to the Fungicide Resistance Action Committee (FRAC) guidelines via the PSD web site and product labels for specific details.

Currently approved fungicides are listed in Appendix 9.

8.10.2.3 Powdery scab (*Spongospora subterranea)*

Also see Section 5.3.2.

The disease is both seed and soil-borne. Spores of the fungus persist in the soil for many years. The fungus causes skin blemishes, or gross tuber distortion and it is a vector for potato mop top virus.

Cultural control: *Powdery scab is often more serious when the soil moisture level fluctuates through the growing season. Compaction and poor drainage can also favour the disease. The disease risk is high on heavily irrigated light sandy soils.*

Irrigate with a scheduling scheme to avoid over-watering.

Select a resistant variety on "problem" sites. Avoid obviously infected seed, although the relationship between disease levels on the seed and that on the ware crop is not straightforward.

Chemical control: No reliable chemical control is available.

8.10.2.4 Stem canker/black scurf *(Rhizoctonia solani)*

Stem canker can be damaging in early crops where vigorous, early growth is needed for early bulking of the tubers. In main crops stem canker has a variable effect, according to the ability of the crop to compensate. Black scurf on the tubers spoils the appearance of the skin. Soil borne inoculum seems to be an increasing problem.

Cultural control: *The fungus is seed and soil-borne. Short rotations should be avoided to prevent a build-up of Rhizoctonia in the soil.*

Plant seed free of black scurf if possible. Techniques that ensure rapid plant emergence will reduce the incidence of stem canker. Late harvesting and or delayed lifting of skin set tubers encourage black scurf development on tubers in the soil.

Chemical control: Seed with obvious black scurf may benefit from fungicide treatment. Fields with soil infected by Rhizoctonia can be treated with a soil fungicide. Eye plug testing of seed and soil tests for Rhizoctonia solani can help determine the need for fungicide application. See Section 5.3.2 and Appendices 7 and 9. Operators applying the fungicide dusts and sprays must have the appropriate NPTC PA qualification.

8.10.2.5 Dry rot *(Fusarium spp.)*

Also see Section 5.3.2.

Cultural control: *Good skin set, gentle handling and rapid temperature pull down after curing should reduce incidence of dry rot. Very early harvesting in dry, warm soils is conducive to dry rot.*

Chemical control: Fungicides applied at store loading can be effective but thiabendazole resistant strains of *Fusarium* spp. are known to exist. Permissible thiabendazole and or imazalil residues can be detected in potatoes that have been correctly treated with these fungicides. Some markets will not use potatoes treated with thiabendazole or imazalil.

8.10.2.6 Silver scurf *(Helminthosporium solani)*

Silver scurf is found on most seed tubers. It is an important skin blemish of stored potatoes for washing and pre-packing.

Cultural control: *Crops should be desiccated early, lifted promptly, dry cured once in store, and then rapidly cooled and stored below 4°C. Low temperature storage can increase reducing sugar levels in the tubers which may affect their suitability for certain markets.*

Stored crops should be inspected regularly for disease development. The disease seems to develop slowly on some varieties.

Chemical control: Seed treatments, in conjunction with cultural measures, can help control the disease (see Section 5.3.2). Ware crops may be treated with thiabendazole and or imazalil at lifting but control may be disappointing if spray application is uneven or if thiabendazole resistant strains are present. Permissible residues of thiabendazole and imazalil can be detected in potatoes that have been correctly treated. Some markets will not use potatoes treated with thiabendazole or imazalil.

8.10.2.7 Black dot *(Colletotrichum coccodes)*

Black dot is primarily a soil-borne disease that frequently develops on stems bases and roots. More worrying and costly however is the increasingly common appearance of black dot on tubers destined for washing and pre-packing.

Cultural control: *Choose less susceptible varieties and fields which have not grown or not had a long history of potatoes if possible. Early lifting , dry curing and rapid cooling to 3^0 C can reduce black dot development. The disease is a particular problem on irrigated peaty soils. Close rotations encourage black dot. Avoid obviously infected seed.*

Chemical control: Fungicide soil treatments can be used in conjunction with cultural control methods to avoid black dot on pre-packing potatoes. Soil testing for Black dot is now available. Operators applying the soil fungicide must have the NPTC PA 2 qualification.

8.10.2.8 Skin spot *(Polyscytalum pustulans)*

Also see Section 5.3.2.

Skin spot is primarily a seed-borne disease. Infected tubers can be unsuitable for pre-packing or give peeling problems to potato processors.

Cultural control: *Use skin spot free seed from a known source.Lift ware crops early, dry cure and ensure complete healing of wounds. Do not apply chlorpropham (CIPC) before the crop is properly cured. Stores should be monitored frequently and if the disease is found, the crop should be marketed promptly. Low temperature storage and CIPC treatment may exacerbate the disease.*

Chemical control: Fungicides applied at lifting may help control skin spot. Thiabendazole resistance has been found but its effect on control is not known. Permissible residues of thiabendazole and or imazalil can be detected on correctly treated tubers. Some markets will not use potatoes treated with thiabendazole or imazalil.

8.10.2.9 Blackleg *(Erwinia now Pectobacterium spp.)*

Disease expression in ware crops is related to initial bacterial loading of seed, varietal susceptibility, seed storage conditions and soil conditions and temperatures at and after planting. High physiological age, very early planting in poor soil conditions and handling damage to seed tubers also encourage disease development.

Erwinia chrysanthemi (now called Dickeya spp.) another type of black leg has appeared in crops in recent years. Most infections seem to be associated with imported seed. It has become a serious problem in Holland. Control measures are the same as those for black leg.

Cultural control: *Blackleg control in ware crops follows the guidelines given in Section 5.3.2. Bacterial loading tests of seed tubers can be a guide to possible problems.*

Chemical control: None is available.

8.10.2.10 Other bacterial soft rots in store

These rots frequently develop after late, wet, cold harvests especially if tubers are badly damaged. Tubers lifted with (often unnoticed) infections of some soil-borne fungi or tuber blight usually develop soft rots.

Cultural control: *Harvest early in good soil conditions. Don't long term store "rained on" loads or crops with tuber blight or other soil-borne fungi. These crops should not be cured but thoroughly dried and cooled quickly.*

Avoid condensation on tubers in the store. Close store monitoring will identify the development of soft rots.

Chemical control: None is available.

8.10.2.11 Aphid-borne viruses

See Sections 5.3.2 and 8.2.

8.10.2.12 Spraing *(Mop Top Virus)*

Potato Mop Top virus is carried by the powdery scab fungus. Damage by MopTop Virus is unusual. Control is difficult but some varieties are tolerant of the virus. The moptop virus “spraing symptoms” in the tuber are similar to damage caused by Tobacco Rattle Virus and internal rust spot. A laboratory test is available that can confirm the precise cause of the damage.

8.10.2.13 Pink rot *(Phytophthora erythroseptica)*

Pink rot is a soil-borne fungal disease that is usually "overtaken" by secondary bacterial soft rots.

Cultural control: *Pink rot is favoured by wet soil conditions at the end of a hot dry summer. Over-irrigation, poor drainage and soil compaction are also implicated. Avoid growing potatoes in fields where pink rot has occurred.*

Chemical control: None is available.

8.10.2.14 *Verticillium* wilt

This is a common soil-borne disease that is not fully understood. In some seasons its presence accelerates crop senescence. The combined effects of PCN damage and *Verticillium* spp. invasion can be serious.

Cultural control: *Varieties that are susceptible to stress may be more sensitive to Verticillium attack. Disease risk is increased by frequent potato cropping, poor soil structure, high levels of PCN, water stress and growing other Verticillium susceptible crops such as peas, linseed or strawberries in the rotation.*

Chemical control: None is available.

8.10.2.15 Watery wound rot, violet root rot and rubbery rot

All these diseases are soil-borne fungi and their incidence is sporadic and not usually important.

Cultural control: *The watery wound rot fungus enters wounds made at harvest. Cool dry storage with little curing can suppress the disease in store if the problem is identified soon enough.*

Violet root rot also affects carrots and sugar beet. Avoid fields where severe attacks have occurred in

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the past.

Rubbery rot can be a problem after over-irrigation or heavy rainfall on poorly structured soil.

Chemical control: None is available.

8.10.2.16 *Botrytis rot*

This fungus may invade senescing or damaged haulm, especially during wet weather at the end of the season. On rare occasions tubers can be infected and a firm, dry rot develops during storage. No chemical treatment is available.

8.10.2.17 Early blight *(Alternaria solani and alternata)*

Early blight is unusual in the UK but when it appears it is poorly controlled by late blight fungicide spray programmes and so can be damaging. Some newer varieties are quite susceptible to this disease.

See: Discussion of potato early and late blight fungicides, their properties and characteristics. Bradshaw NJ 8th Workshop of a European Network for Development of an integrated control strategy for potato late blight September 2004.

8.10.2.18 *Sclerotinia* stalk break

Sclerotinia is a fungus that attacks a wide range of crops. Infection of potatoes is not common but the disease is seen in wet seasons and in Northern Scotland. Potatoes in rotation with rapeseed and beans may be at greater risk. There are no cultural or recommended chemical controls.

8.10.3 Physiological disorders

There are no chemical measures that give consistent or reliable control of these problems.

8.10.3.1 Internal rust spot

Crops grown on light sandy soils in warm dry seasons seem to be most prone to this problem. Varieties differ in their susceptibility to rust spot.

8.10.3.2 Glycoalkaloid accumulation

To prevent high levels of these naturally occurring, poisonous compounds developing in the tubers, avoid over exposure to light or stress. For example, ensure good ridges are formed in the field; at lifting potatoes should be removed from the field as soon as possible and damage kept to a minimum. During storage and grading potatoes should not be left exposed to light for unnecessarily long periods.

8.10.3.3 Pit rot

Pit rot is a poorly understood but sometimes quite serious disorder of tuber lenticels.

Stores should be kept dry and well ventilated to prevent pit rot.

8.10.3.4 Chilling injury

To avoid the possibility of internal flesh or vascular discolouration potatoes should not be stored below 0°C. Temperatures below -2°C will freeze potatoes.

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8.10.3.5 Blackheart

Potatoes stored at normal temperatures should not normally be susceptible to oxygen starvation that causes blackheart. Problems can occur in well-sealed or infrequently ventilated stores.

8.10.3.6 Growth cracks, secondary growth, hollow heart, internal browning and misshapen tubers

Also see Section 7.4.5.

Crops with steady tuber growth rates are usually free of these problems. A regular and even water supply is thought to be important in avoiding these disorders. Varietal susceptibility to each of these faults varies and choice of variety must be carefully matched to the site.

Crop desiccation in relation to rainfall following a drought can sometimes be timed to avoid the development of second growth in the tubers.

Correct seed spacing and timely haulm destruction will reduce oversized, cracked and hollow-hearted tubers

The causes of internal browning are not understood.

8.10.3.7 Enlarged lenticels

Also see Section 7.4.5.

Cultural control: *Carefully managed irrigation and cultivation will help avoid enlarged lenticels but very wet soils late in the season do induce the problem. Some varieties are known to be susceptible.*

8.10.3.8 Jelly end rot

Scheduled irrigation will help control jelly end rot.

8.10.4 Weed control

Effective weed control protects yield, eases harvesting and minimises tuber damage.

Cultural aspects

Herbicide programmes have largely superseded traditional inter-row cultivations. Cultivations can damage the growing crop and may create clods. However well-timed shallow cultivations are commonly and successfully used on lighter soils.

An integrated weed control strategy involves:

- *careful seedbed preparation, residual herbicides don't work well on cloddy soil*
- *ridging and inter-row cultivations where and when appropriate*
- *choice of appropriate herbicide*
- *planting healthy seed in good soil conditions to speed the development of a full canopy*
- *maintaining a complete crop cover for as long as possible*
- *controlling perennial weeds in previous crop*

Choice of herbicides

The factors to be considered when selecting a potato herbicide are:

- weed spectrum
- soil type
- variety
- previously applied herbicides
- post potato crop cultivations
- following crop considerations and requirements
- crop growth stage
- choice of follow up chemical treatment

Currently approved products are given in Appendix 10. Always read the product label for full information.

8.10.5 Chemical haulm desiccation

Desiccating haulm speeds tuber skin set, prevents disease spread from the haulm to tubers, eases mechanical harvesting and controls tuber size. Chemicals vary in the speed with which they kill the haulm but speed of skin set is similar for all correctly used desiccants. The crop needs to be protected against blight until the haulm is completely killed.

If using sulphuric acid always follow the “code of best practice” issued by the National Association of Agricultural Contractors.

The products currently approved are shown in Appendix 11.

8.10.5.1 Mechanical haulm removal

Careful crop flailing can reduce the use of chemical desiccants. Mechanical haulm destruction techniques were thought to spread diseases within the crop canopy but this does not appear to be a problem. Haulm re-growth may be a nuisance but is easily managed.

9 Harvesting and storage

9.1 Time of Harvest

Late harvesting is one of the biggest causes of loss of tuber quality. High quality crops that store well need to be lifted before soils become too wet and cold. For processing crops tuber dry matter and sugar levels may determine desiccation dates.

9.2 Staff motivation and careful tuber handling

Poor harvesting and handling techniques cause bruised and damaged tubers that are the commonest quality problems in the industry. All growers should ensure that personnel and equipment involved in harvesting and handling the crop operate to the highest standard possible.

Sophisticated potato handling equipment needs sensitive, properly trained and well-motivated operators. Through their training and management all staff need to appreciate the nature and implications of potato damage and bruising.

9.3 Training

a. The entire potato harvesting and handling staff should be trained or briefed annually on the importance of damage and how they can affect it.
b. Operators should receive specialist training on their machine, its correct operation and various

adjustments.

9.4 Machinery

Despite the excellent design of modern potato equipment, potatoes will still be damaged if the machinery is not operated correctly. To keep damage to an absolute minimum the following points should be followed closely:

- constant monitoring of machine settings and tuber damage to ensure optimum performance in the prevailing conditions.
- regular maintenance to ensure any potentially damaging features are eliminated.
- all machinery used needs to be compatible.
- wherever possible use proven technological advances in the harvesting and handling operation.

9.5 Damage monitoring techniques

Regular damage monitoring, hot boxing and peeling and use of electronic potatoes will help reduce damage and reinforce staff commitment to careful handling.

9.6 Hygiene

Members **must** ensure their potato crops are handled and stored to avoid contamination, damage or exposure to anything likely to affect their food quality.

Hygiene controls **must** include:

- trailers used for the transportation of potatoes from field to store are cleaned and the cleaning recorded.
- where potatoes are stored loose the stores are cleaned before use and the cleaning is recorded.
- Where boxes are used these should be checked for condition and contamination prior to use. This check should be recorded.

Also see Generic Standards and/or Generic Guidance Notes.

9.7 Post-harvest treatments

9.7.1 Store management

Also see Section 5.3.6

Curing

Curing to suberize or heal wounds reduces disease development and dehydration. Temperature and humidity affect the rate of curing.

"Dry curing" can reduce skin diseases and rots. It involves keeping the potatoes at about 12°C for about 10 days and ventilating each day with "dry" air for several hours to reduce humidity in the store.

Wet tubers and those suspected to be infected by blight and or blackleg are a special storage risk and need to be thoroughly dried, probably not cured, rapidly cooled, monitored closely and sold early.

Storage temperature

Properly insulated and ventilated stores will keep high quality potatoes well into the New Year. For longer term storage refrigeration is required to satisfy the rising quality standards of most outlets.

Optimum crop storage temperature depends on market outlet. Lower temperatures minimise silver scurf and sprout development but may encourage some diseases and can spoil fry quality

9.7.2 Post-harvest treatments

Storage chemicals

The need for storage chemicals can be minimised or even avoided by use of an integrated seed, harvest and store management strategy. The use of chemicals for disease or sprout control will depend on the crop's growing conditions, storage regime, disease risk and time of store unloading.

Treatment with some potato storage chemicals is unacceptable to certain market outlets. Growers should check that their market will accept treated potatoes before treatment. (See Generic Standards 8.2.6). All storage chemicals when applied correctly will leave detectable residues well within maximum residue limits. However some potato buyers now prefer potatoes with very low or even no detectable pesticide residues.

The use of chemical suppressants in many potato stores is still necessary. Current processing potato varieties cannot be stored at low temperatures and then fry or cook acceptably.

Non-processing potato crops can be stored for long periods without suppressants, using low temperatures.

Ethylene treatment systems are now available for controlling sprout growth in low temperature non-processing stores.

Application of storage chemicals

All storage chemicals must be used according to the instructions on the label and within the terms of the Code of Practice for the Safe Use of Pesticides on Farms and Holdings. The British Crop Protection Council's leaflet "Guidelines for the effective chemical treatment of potatoes" 1991 and the BPC's "Best practice guidelines for the use of CIPC sprout suppressant" 2007 should be followed with strict adherence to the correct product selection, application technique, dose-rate and harvest interval (see Appendix 16 in this protocol and Appendix A in the Generic Guidance Notes).

Application of CIPC (chlorpropham) sprout suppressant

CIPC should only be applied once the crop has been properly cured and before any sprouting begins.

Advice on the use of CIPC

The decision and recommendation to use CIPC on stored potatoes must (like any other crop protection product) come from a BASIS qualified adviser or, where such an adviser is not used the person responsible for the decision must be able to demonstrate their competence and training on pesticide use and application (see generic protocol 8.3).

Guidelines for the use of CIPC in potato stores

CIPC is a very important post-harvest product that is frequently found as a tuber residue in fresh market and potatoes for processing. These residues are usually low, within the MRL and are no risk to consumer health. To ensure safe and effective use of CIPC, store managers and their CIPC contractors or farm application operatives must be able to demonstrate responsible and minimum use of this product.

To achieve safe, even and effective application of CIPC, the following points and procedures **must be** implemented:

- Store managers **must** demonstrate that the least amount of CIPC for effective sprout control has been

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used.

- Store managers should plan their storage to ensure that only crops that need CIPC are treated and that only crops that need multiple treatments are treated as such. For example stored crops should, whenever possible, be segregated by dormancy characteristics, variety and duration of storage to avoid any unnecessary CIPC applications.
- CIPC applications must only be carried out by specialist, ISO (or an equivalent) accredited, insured operators who are members of an appropriate professional body (National Association of Agricultural Contractors or Agricultural Industries Confederation) or fully trained, qualified and experienced farm staff using appropriate equipment.
- Whether applications are carried out by farm staff or specialist contractors the store manager must be able to provide documentation showing complete traceability of all aspects of each CIPC application. See section on page 38 “Records of each CIPC application” and appendix 19 example of an application record sheet.
- Whether applications are carried out by farm staff or specialist contractors the operators **must be experienced, trained and fully qualified (PA1 and PA9) with records to prove this. (CFP) (See Generic Standards 8.4.2)**
- **The CIPC application equipment must be serviced annually and calibrated regularly. Service and calibration records must be available for inspection. (CFP) (See Generic Standards 8.4.6)** Contact the National Sprayer Testing Scheme (NSTS) for current information on CIPC application equipment testing.
- **Only approved formulations of CIPC can be used (CFP) (See Generic Standards 9.2.1)**
- **Statutory and general label instructions and harvest intervals must be adhered to. (CFP)** (See Generic Standards 9.2.1 and 9.2.4)
- Full safety equipment should be on hand during CIPC application.

CIPC application techniques that improve distribution and may help reduce the quantity of CIPC used and keep tuber residues of CIPC to a minimum.

1. Application and where necessary re-application timing.

   The store manager should ensure that the first application of CIPC is made after the crop is cured but before sprouts appear. This action should be supported with a formal recommendation from an appropriately qualified (BASIS) adviser.

   Late first applications of CIPC result in extra, unnecessary applications.

   The store manager should be responsible for identifying fresh or active sprout re-growth and the need to re-apply CIPC only when it is required.

2. Product selection and dose rates applied.
   Store managers must be responsible for selecting and following the label dose rates. There may be circumstances where lower rates are appropriate.

   New maximum dose rates of CIPC (from any label, or any combination of labels) apply from 14.12.2007:

3.
   i. Total amount for fresh market is 36 g active substance / tonne
   ii. Total amount for processing markets is 63.75 g active substance / tonne

4. Crop temperatures.

   Close crop temperature control and keeping the crop at its minimum holding temperature will improve sprout control and reduce the number of CIPC applications.

5. Using the recirculation fans prior to CIPC application will even out crop temperatures in the store and improve distribution of the sprout suppressant.
6. Do not raise the temperature of refrigerated stores prior to application of CIPC.

7. Box stacking patterns and CIPC application ports.

   Box layouts for best air circulation will improve CIPC distribution. Pallet apertures should be aligned and boxes should never be stacked tight to walls. Stacking around the store door should allow air to return through the crop to the recirculation louvres or fridge unit.

   Talk to your CIPC contractor about box layout and positioning of application ports.

   Fog should be delivered into the store unhindered and never be directed at the crop, boxes or walls.

8. Part filled stores.

   Whenever possible avoid treating part filled stores. Failing this try to contain the part store in a lesser air space

9. Store leakage.

   Leaky stores produce unwanted "fog drift" resulting in reduced doses, unnecessary repeat applications and environmental contamination. The store manager is responsible for excessively leaky stores. The CIPC applicator should alert the store manager of leaking stores.

10. Fans.

    Using very slow speed fans during and after CIPC application may improve distribution. However this technique is not fully developed and its use must be closely managed.

11. Application equipment and fog quality.

    The CIPC fogging equipment must be set to produce a dry "friable" fog. There must be no evidence of CIPC puddles or heavy crystalline deposits in the store. These are indicators of inadequate application technique.

Records of each CIPC application.

Store managers must be able to provide, for each CIPC application, records of (CFP) (see Generic Standards 9.2.2): -

- The date and name of the person requesting and or formally recommending CIPC application.
- The CIPC product name, MAPP number and dose.
- The reason/s for the timing and dose of the application.
- A declaration when the store may be re-treated with CIPC and when the crop may be moved from the store for sale or processing.
- Confirmation of recognition of the date/s of all previous applications.
- Confirmation that all application intervals have been observed.
- The length of time the application took.
- Any problems or irregularities that were noticed during application, for example, excessive store leaks, temperature gradients in the store, and inadequate "draw" of fog into the store, any CIPC spillage, and any difficulties in producing the fog.
- Batch number/s of the product/s used.
- Confirmation of the tonnage treated and volume (active substance) of CIPC used.
- Store managers must be able to produce a record of the total CIPC active substance applied to each “lot” of potatoes on hand and at the point of sale

As the use of all post-harvest treatments and tuber residues comes under closer customer scrutiny, store managers should prepare themselves for proposed, specialist, in-depth audits of their CIPC use in all stores.

These audits will require the information mentioned above and may be undertaken at random by approved Assured Produce auditors.

See appendix 19 for an example of a suitable record sheet

9.8 Refrigerant specification

See Generic Standards and/or Generic Guidance Notes.

9.9 Post-harvest washing

See Generic Standards and/or Generic Guidance Notes.

10 Pollution control and waste management

10.1 Waste and recycling management plan

See Generic Standards and/or Generic Guidance Notes.

10.1.1 Plastic and potato waste

Potato waste and recovered plastic covers must be disposed of or recycled in a responsible manner.

10.2 Pollution management plan

See Generic Standards and/or Generic Guidance Notes.

10.3 Holding areas of potential pollutants

See Generic Standards and/or Generic Guidance Notes.

11 Energy efficiency

See Generic Standards and/or Generic Guidance Notes.

12 Health & Safety

See Generic Standards and/or Generic Guidance Notes.

13 Conservation issues

See Generic Standards and/or Generic Guidance Notes.

Appendix 1 Nematicides currently approved for the control of potato cyst nematode

Active Ingredient	Product Features	Harvest Interval (1)	LERAP Category	Hazard Rating	UK MRL in PPM	Codex
ethoprophos	organophosphorus nematicide and insecticide. Also controls wireworms. Reduction in incidence of spraing. No aphid control. Less effective on organic soils. Dangerous to fish.	8 weeks	none stated	Harmful.	0.05	0.02.
oxamyl	soil-applied oxime nematicide and insecticide. Also controls migratory nematodes. Reduction in incidence of spraing. Some control of early aphid infestations. Dangerous to fish.	12 weeks for broadcast 17 weeks for “in furrow”	none stated	Harmful	0.01	0.1
fosthiazate	contact organophosphorus nematicide. Also controls wireworms. Reduction in incidence of spraing. Harmful to fish NO ”in furrow” application	117 days	none stated	Harmful	0.02	none set

Notes:

(1) or latest time of application

Not all formulations of these active ingredients may be currently approved for use on potatoes. Check before use. Label recommendations are revised regularly, read a current label before use.

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Appendix 2 Nematicides currently approved for the control of spraing vectors

Active Ingredient	Product Features	Harvest Interval (1)	LERAP Category	Hazard Rating	UK MRL in PPM	Codex
ethoprophos	organophosphorus nematicide and insecticide. Also controls wireworms. Reduction in incidence of spraing. No aphid control. Less effective on organic soils. Dangerous to fish.	8 weeks	none stated	Harmful	0.05	0.05
oxamyl	soil-applied oxime nematicide & insecticide. Also controls potato cyst nematode and some control of early aphid infestations. Dangerous to fish.	12 weeks for broadcast 17 weeks for“in furrow”	none stated	Harmful	0.01	0.01
fosthiazate	contact organophosphorus nematicide. Harmful to fish NO “in furrow” use	117 days	none stated	Harmful	0.02	none set

Appendix 3 Molluscicides currently approved for use on potatoes

Active Ingredient	Product Features	Harvest Interval (1)	LERAP Category	Hazard Rating	UK MRL in PPM	Codex
methiocarb	stomach-acting carbamate molluscicide and insecticide. Some control of cutworms. Harmful to fish.	18 days	none stated	Harmful	0.1	0.05

Notes:

(1) or latest time of application

Not all formulations of these active ingredients may be currently approved for these uses on potatoes. Check before use. Label recommendations are revised regularly, read a current label before use.

Control Document No: 00043/09

Appendix 4 Insecticides currently approved for wireworm control in potatoes

Active Ingredient	Product Features	Harvest Interval (1)	LERAP Category	Hazard Rating	UK MRL in PPM	Codex
ethoprophos	organophosphorus nematicide and insecticide. Also controls potato cyst nematode but not aphids. Less effective on organic soils. Reduction in incidence of spraing. Dangerous to fish.	8 weeks	none stated	Harmful	0.05	0.05
fosthiazate	an organophophorus contact nematicide harmful to fish	117 days	none stated	Harmful	0.02	none set

Appendix 5 Insecticides currently approved for cutworm control in potatoes

Active Ingredient	Product Features	Harvest Interval (1)	LERAP Category	Hazard Rating	UK MRL in PPM	Codex
chlorpyrifos	for use on seed potato crops only. contact and ingested organophosphorus insecticide and acaricide. Toxic to most beneficial insects. Dangerous to fish.	21 days	A	Harmful	0.05	2.0
cypermethrin & zeta-cypermethrin	contact and ingested pyrethroid insecticide. Extremely harmful to fish.	none stated	A	Harmful	0.05	0.05
lambda-cyhalothrin plus pirimicarb	a mixture of pyrethroid and carbamate	3 days	A	Harmful Dangerous to the environment	lambda 0.02 pirimicarb 0.2	lambda 0.02 pirimicarb 0.05

Notes:

(1) or latest time of application

Not all formulations of these active ingredients may be currently approved for these uses on potatoes. Check before use. Label recommendations are revised regularly, read a current label before use.

Control Document No: 00043/09

Appendix 6 Insecticides currently approved for aphid control in potatoes

Active Ingredient	Product Features	Harvest Interval [1]	LERAP Category	Hazard Rating	UK MRL in PPM	Codex
acetamiprid	neonicotinoid Harmful to aquatic organisms and slightly toxic to beneficials	14 days	**B**	none stated	0.01	none set
flonicamid	pyridine carboxamide systemic and protectant. Safe to bees and beneficials. Controls all peach potato aphid populations	14 days	none stated	dangerous for the environment	0.1	none set
lambda-cyhalothrin	contact and ingested pyrethroid. Extremely dangerous to fish.	none stated	A	Harmful	0.02	0.02
nicotine	contact alkaloid insecticide. Dangerous to fish.	2 days	none stated	Harmful Part II poison	none set	none set
oxamyl	soil-applied oxime carbamate nematicide and insecticide. When used for nematode control will give some control of early aphid infestations. Dangerous to fish.	none stated	none stated	Harmful	0.01	0.1
pirimicarb	carbamate insecticide for aphid control. Minimal effect on beneficial insects. Controls most populations of peach potato aphid. Dangerous to fish.	3 day	none stated	Harmful	0.2	0.05
pymetrozine	systemic azomethine insecticide high risk to bees. Harmful to fish. Controls all peach potato aphid populations	7 days	none stated	Harmful	0.02	none set
thiacloprid	A chloronicotinyl. Harmful to aquatic organisms. Controls all peach potato aphid populations	14 days	None stated	Harmful	0.02	none set
thiamethoxam	Contact and systemic neonicotinoid insecticide. Controls all peach potato aphid populations	7 days	none stated	Dangerous for the environment	0.1	none set

Notes:

[1] or latest time of application

Not all formulations of these active ingredients may be currently approved for use on potatoes. Check before use. Label recommendations are revised regularly, read a current label before use.

Appendix 7 Disease control spectrum of approved seed treatment fungicides

Disease	**Applied post- harvest**	**Applied at dressing**	**Applied at planting/** pre-planting
Skin spot	imazalil, thiabendazole	imazalil, thiabendazole	thiabendazole, imazalil
Gangrene	imazalil, thiabendazole	imazalil, thiabendazole	imazalil
Dry rot	imazalil, thiabendazole	imazalil, thiabendazole	-
Silver scurf	imazalil, thiabendazole	imazalil, thiabendazole	pencycuron + imazalil, imazalil
Black scurf and stem canker	iprodione, flutolanil thiabendazole tolclofos methyl	iprodione, flutolanil pencycuron tolclofos methyl	iprodione, flutolanil pencycuron thiabendazole tolclofos methyl

Notes:

Not all formulations of these active ingredients may be currently approved for use on potatoes. Check before use. Label recommendations are revised regularly, read a current label before use. Pay special attention to label instructions on the use of fungicide sequences or combinations and application timing in relation to chit development.

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Appendix 8 Fungicides currently approved for tuber-borne disease control in seed potatoes

Active Ingredient	Product Features	Harvest Interval [1]	LERAP Category	Hazard Rating	UK MRL in PPM	Codex
flutolanil	Systemic, protectant and curative benzanilide fungicide	prior to chitting	none stated	Irritant	0.5	none set
imazalil	systemic and protectant conazole fungicide. Harmful to fish. Broad spectrum (not *Rhizoctonia*).	none stated	none stated	Harmful Irritant	early 0.02 ware 5.0	5.0
iprodione	protectant dicarboximide fungicide with some eradicant activity. Harmful to fish. Effective against *Rhizoctonia*.	none stated	none stated	Irritant	0.02	10.0
pencycuron	non-systemic urea fungicide. Very effective *Rhizoctonia* control.	at planting	none stated	irritant	0.1	none set
pencycuron [a] + imazalil [b]	broad spectrum. Harmful to fish.	immediately prior to planting	none stated	Irritant	0.1[a] early 0.02 [b] ware 5.0 [b]	none set [a] 5.0 [b]
thiabendazole [2]	systemic, curative and protectant benzimidazole fungicide. Broad spectrum applied soon after harvest or dust pre-planting. Silver scurf, skin spot, *Rhizoctonia*, dry rot and gangrene reduced according to timing. Resistance developing in silver scurf and skin spot. Harmful to fish.	before planting	none stated	irritant	early 0.05 ware 15.0	15.0
tolclofos-methyl	protectant organophosphorus fungicide. Harmful to fish. Very effective *Rhizoctonia* control .	at planting	none stated	Irritant	0.2	0.2

Notes:

[1] or latest time of application

[2] also approved for use on ware potatoes

Not all formulations of these active ingredients may be currently approved for use on potatoes. Check before use. Label recommendations are revised regularly, read a current label before use.

Control Document No: 00043/09

Appendix 9 Fungicides currently approved for late blight control in potatoes

Active Ingredient	Product Features	Harvest Interval [1]	LERAP Category	Hazard Rating	UK MRL in PPM	Codex
benthiavalicarb-isopropyl [a] + mancozeb [b]	curative and locally systemic. Use with an adjuvant Dangerous for the environment	7 days	B	Harmful	0.05 [a] 0.1 [b]	none set [a] 0.2 [b]
copper products	protectant fungicide and bactericide. Harmful to fish and to some livestock. Some are suitable for organic crops. May scorch young crops.	7 days	none stated	none stated	none set	none set
chlorothalonil	protectant chlorophenyl fungicide. Harmful to fish. Some operators may be allergic.	zero to 7 days	B	Irritant	0.01	0.2
cyazofamid	contact protectant. Sold in twin pack with a wetter	7 days	none stated	Irritant	0.01	none set
cymoxanil [a] + famoxadone [b]	semi-systemic and contact. Dangerous to fish.	14 days	B	none stated	0.05 [a] 0.02 [b]	none set [a] 0.02 [b]
cymoxanil [a] + mancozeb [c]	protectant and translaminar fungicide. Harmful to fish.	zero to 7 days	none stated	Irritant	0.05 [a] 0.1 [c]	none set [a] 0.2 [c]
dimethomorph [e] + mancozeb [c]	systemic and protectant. Harmful to fish.	7 days	B	Corrosive	0.5 [e] 0.1 [c]	none set [e] 0.2 [c]
EBDC (various dithiocarbamates)	protectant dithiocarbamate fungicide. Dangerous/harmful to fish.	7 days	none stated	Irritant	0.1	0.2
fenamidone [a]+ propamacarb hydrochloride [b]	systemic, protectant and translaminar dangerous to fish	7 days	B	Irritant	0.02 [a] 0.5 [b]	none set [a] none set [b]
fluazinam	dinitroaniline protectant. Dangerous to fish.	none stated	B	Corrosive	0.05	none set
fluopicolide [a] +propamacarb hydrochloride	systemic, protectant and translaminar with protection of tubers dangerous to environment	7 days	none stated	Irritant	0.02 [a] 0.5 [b]	none set [a] none set [b]
mandipropamid	protectant fungicide harmful to aquatic organisms	3 days	none stated		0.01	None set
metalaxyl-M [e] or benalaxyl [g] + mancozeb [c]	systemic and protectant fungicide mixture. Harmful to fish.	7 days	none stated	Irritant	0.05 [e] 0.05 [g] 0.1 [c]	none set [e] 0.02 [g] 0.2 [c]
metalaxyl-M [i]+ fluazinam [f]	systemic and protectant fungicide mixture	7 days	B	Corrosive	0.05 [i] 0.05 [f]	none set [i] none set [f]
propamocarb hydro-chloride [j] + mancozeb [c]	systemic protectant and protectant mixture. Harmful to fish.	14 days	none stated	Irritant	0.5 [j] 0.1 [c]	none set [j] 0.2 [c]
propamocarb hydro-chloride[j] + cymoxanil [a]	systemic and translaminar fungicide mixture Harmful to aquatic organisms	14 days	none stated	Irritant	0.5 [j] 0.05 [a]	none set [j] none set [a]

Notes:

[1] or latest time of application. Not all formulations of these active ingredients may be currently approved for use on potatoes. Check before use. Label recommendations are revised regularly, read a current label before use.

Appendix 9 Fungicides currently approved for late blight control in potatoes (Cont'd)

Active Ingredient	Product Features	Harvest Interval [1]	LERAP Category	Hazard Rating	UK MRL in PPM	Codex
propamocarb hydro-chloride [j] + chlorothalonil [d]	contact and systemic mixture. dangerous for the environment	7 days	B	Irritant	0.5 [j] 0.01 [d]	none set [j] 0.2 [d]
zoxamide [k] + mancozeb [c]	contact protectant dangerous for the environment	7 days	B	Irritant	0.05 [k] 0.1 [c]	none set [k] 0.2 [c]

Notes:

[1] or latest time of application

Not all formulations of these active ingredients may be currently approved for use on potatoes. Check before use. Label recommendations are revised regularly, read a current label before use.

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Appendix 10 Herbicides currently approved for use on potatoes

Active Ingredient	Product Features	Harvest Interval [1]	LERAP Category	Hazard Rating	UK MRL in PPM	Codex
bentazone	post emergence. Risk of scorch. Split dose possible. Restrictions on varieties, including the use of adjuvants on some varieties	not after crop 15cm	none stated	Irritant	0.1	0.1
carfentrazone-ethyl	pre-emergence contact Dangerous for the environment. Also approved as a desiccant	pre-emergence	none stated	Irritant	0.01	none set
clomazone	pre-emergence residual	7 days pre-emergence	none stated	Irritant	0.01	none set
cycloxydim	post-emergence only.	56 days	none stated	Irritant	2.0	2.0
glufosinate-ammonium/ mixtures	contact foliar pre-emergence. Also approved as a desiccant. Harmful to fish.	pre-emergence	none stated	Harmful Irritant	0.3	0.5
linuron	foliar, residual pre- to early post-emergence. Reduced rates possible. Dangerous to fish.	none stated	B	Irritant	0.05	none set
metribuzin	contact, foliar, residual, pre-plant emergence (post-emergence on some varieties). Active on organic soils. Low dose programmes possible. Variety restrictions on light soils following crop restrictions Dangerous for the environment..	none stated	B	Harmful	0.1	none set
metribuzin [a] + flufenacet [b]	pre-emergence residual variety restrictions Dangerous for the environment.	none stated	B	Harmful	0.1 [a] 0.1 [b]	none set [a] none set [b]
diquat	contact folier pre- to early post-emergence Dangerous to the environment	very early emergence	none stated	Toxic	0.05	0.05
pendimethalin/ mixtures	contact, foliar, residual pre-emergence. Requires soil moisture to be effective. Dangerous to fish.	pre emergence	none stated	Irritant	0.05	none set
propaquizafop	post-emergence only. Harmful to fish.	28-56 days	B	Irritant	0.1	none set

Notes:

[1] or latest time of application.

Not all formulations of these active ingredients may be currently approved for use on potatoes.

Check before use. Label recommendations are revised regularly, read a current label before use.

Appendix 10 Herbicides currently approved for use on potatoes (Cont'd)

Active Ingredient	Product Features	Harvest Interval [1]	LERAP Category	Hazard Rating	UK MRL in PPM	Codex
prosulfocarb	residual pre-emergence Dangerous for the environment	at emergence	B	Irritant	0.05	none set
quizalofop-P-tefuryl	post-emergence, graminicide Dangerous for the environment	60	none stated	Irritant	0.2	none set
rimsulfuron	systemic post-emergence contact. No variety restrictions. Very toxic to aquatic organisms	up to crop 25cm	none stated		0.05	none set

Notes:

[1] or latest time of application

Not all formulations of these active ingredients may be currently approved for use on potatoes. Check before use. Label recommendations are revised regularly, read a current label before use.

Control Document No: 00043/09

Appendix 11 Chemical desiccants approved for use on potatoes

Active Ingredient	Product Features	Harvest Interval [1]	LERAP Category	Hazard Rating	UK MRL in PPM	Codex
carfentrazone ethyl	contact. Dangerous for the enviornment	14 days	none stated	Irritant	0.01	none set
diquat	contact. Speed of action moderate. Cannot be used when soil moisture deficits high.	none stated	none stated	Harmful Irritant	0.05	0.05
glufosinate-ammonium	contact. Speed of action moderate. Some restrictions on varieties and soil moisture. Use only after crops have started to senesce. Harmful to fish.	14-21 days	none stated	Harmful Irritant	none set	0.5
sulphuric acid	contact. Speed of action fast. Specialist contractor and equipment required. No variety restrictions. Can be used on immature crops. Follow the NAAC Code of Best Practice	none stated	none stated	Corrosive Part II poison	none set	none set

Notes:

[1] or latest time of application

Not all formulations of these active ingredients may be currently approved for use on potatoes. Check before use. Label recommendations are revised regularly, read a current label before use.

Appendix 12 Sprout suppressants and storage fungicides currently approved for ware potatoes

Active Ingredient	Product Features	Harvest Interval (1)	LERAP Category	Hazard Rating	UK MRL in PPM	Codex
chlorpropham (CIPC)	carbamate sprout suppressant. Harmful to fish.	2-28 days	none stated	Harmful Irritant	10.0	30.0
ethylene		3 days	none stated	none stated	none set	none set
maleic hydrazide	pyridazinone plant growth regulator.	21 days	none stated	none stated	50.0	50.0
thiabendazole (TBZ)	systemic, curative and protectant benzimidazole fungicide. Harmful to fish.	21 days	none stated	none stated	early 0.05ware 15.0	15.0
imazalil	systemic, protectant conazole fungicide. Harmful to fish.	none stated	none stated	Harmful Irritant	early 0.02 ware 5.0	5.0

Notes:

(1) or latest time of application

Not all formulations of these active ingredients may be currently approved for use on potatoes. Check before use. Label recommendations are revised regularly, read a current label before use.

Treatment with storage products is not acceptable to certain market outlets. Growers should check that their market outlet will accept treated potatoes before commencing treatment. (See Generic Standards 8.2.6)

Appendix 13 Fungicides for soil treatment

Active ingredient	Product features	Harvest interval	LERAP category	Hazard rating	UK MRL ppm	Codex
azoxystrobin	Soil applied, broad spectrum strobilurin fungicide. Dangerous for the evironment	At planting	B	None stated	0.05	none set

Appendix 14 Specific off-label approvals for potatoes

MAPP Number	Approval number	Active ingredients	Crop	Expiry date	Product
13101	20071965	Rhino	flutolanil	seed only	31.12.2013
11399	20041323	Rizolex Flowable	tolclofos-methyl	seed only	31.12.2013
10573	20060893	Shirlan	fluazinam	seed only	31.12.2013

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 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 extant approval of the specific product.

See also https://secure.pesticides.gov.uk/offlabels

Appendix 15 Scottish seed potato tuber minimum tolerances for export (by weight)

Rots - 0.2% in total

Common Scab -– 1.5% but tubers with under 12.5% surface area infected are not included

Powdery Scab (Spongospora subterranean) – 1.5% - but tubers with under 12.5% surface area infected are not included

Black scurf (Rhizoctonia solani) - 1.5% but tubers with under 12.5% surface area infected are not included

Skin spot (Polyscytalum pustulans) -0.5% but tubers with under 12.5% surface area infected are not included.
Total common scab, powdery scab, black scurf and skin spot = 3.0%

Appendix 16 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 alternative strategies.

Active ingredient	Target pest, weed, disease	Current position	Suggested guidelines
azoxystrobin	Black dot and black scurf	Very occasional residues near the lod MRL 0.05 ppm	Better application technique
chlorpropham	tuber sprouting in store	low residues (l.o.d to 5ppm) are common MRL of 10.0ppm	Avoid mixing varieties of differing sprout growth in the same store. Ensure uniform store temperatures, ideal box layouts and suitable wind conditions at application time. Use a qualified and experienced CIPC applier. Don't delay initial treatment as this results in increased applications. There are no proven differences in tuber residue levels between any of the currently approved formulations of chlorpropham.
dithiocarbamates (e.g. maneb & mancozeb)	late blight	very occasional residues of this non systemic fungicide are detected MRL 0.1 ppm	Residues are suspected to be direct contact of the fungicide spray with exposed tubers in cracked ridges. Plant deeper and build bigger ridges.
imazalil	fungal diseases in stored tubers	very low residues well within the 5 ppm MRL are found after application	Try not to use imazalil but ensure earlier harvesting, better management of store temperature and tuber drying. Refrigeration.
maleic hydrazide	volunteer potato suppression and sprouting in store	tuber residues well within the 50 ppm MRL are always detected after application	Avoid leaving potatoes on the field at harvest. Do not plough after potatoes. Grow "smothering" crops after potatoes. Use appropriate herbicides in set aside and other crops. Do not use MH unless spray conditions and crop growth are ideal
pencycuron	seed dressing for black scurf and stem canker control	Approval is for application to seed only MRL 0.1 ppm	Residues in ware may be the result of contamination of ware boxes by treated seed. Keep seed boxes separate or inspect and clean all boxes prior to ware harvest
propamocarb hydrochloride	fungicide for late blight control	Residues found are always very close to the lod of 0.02 ppm MRL 0.5 ppm	Investigations into the reasons for recent residue finds (even though well within the MRL) are not yet complete
tecnazene	tecnazene is not now approved for use on potatoes but previous applications continue to contaminate stored tubers	very low residues are very occasionally detectedThese are "carry over residues" from treatment several years previously MRL 0.05 PPM	Ventilate empty stores and boxes suspected to be contaminated
thiabendazole	fungal diseases in stored tubers	as imazalil MRL 15.0 ppm	As fungal resistance to thiabendazole is common, review continued use. Suggestions under imazalil apply.

Notes:

- When correctly applied potato blight fungicides, foliar insecticides, desiccants and herbicides rarely, if ever, leave tuber residues.
- Reducing harvest intervals and product dose rates is most unlikely to affect tuber residues for any of the approved potato products listed above.

Appendix 17 MRLs for active ingredients currently approved for use on potatoes

Active ingredient	UK MRL	Codex MRL for potato or root and tuber vegetables
azoxystrobin	0.05	none set
bentazone	0.1	0.1
benalaxyl	0.05	0.02
benthiavalicarb-ispropyl	0.05	none set
carbendazim / benomyl	0.1	3.0
carfentrazone-ethyl	0.01	none set
chlorothalonil	0.01	0.2
chlorpropham	10.0	30.0
chlorpyrifos	0.05	2.0
clomazone	0.01	none set
cymoxanil	0.05	none set
cyazofamid	0.01	none set
cycloxydim	2.0	2.0
cypermethrin	0.05	0.05
dimethomorph	0.5	none set
diquat	0.05	0.05
EBDC (dithiocarbamate) maneb mancozeb	0.1	0.2
ethoprophos	0.05	0.05
famoxadone	0.02	0.02
fenamidone	0.02	none set
fluazinam	0.05	none set
flufenacet	0.1	none set
flonicamid	0.1	none set
flutolanil	0.5	none set
fluopicolide	0.02	none set
fosthiazate	0.02	none set
glufosinate-ammonium	0.3	0.5
glyphosate (prior to planting potatoes)	0.5	none set
imazalil	0.02 early crops, 5.0 ware crops	5.0
iprodione	0.02	none set
lambda - cyhalothrin	0.02	0.02
linuron	0.05	none set
maleic hydrazide	50.0 ware crops	50.0
mandipropamid	0.01	None set
metalaxyl	0.05	0.05
metalaxyl-M and metalaxyl	0.05	none set
methiocarb	0.1	0.05
metribuzin	0.1	none set
oxamyl	0.01	0.1

Appendix 17 MRLs for active ingredients currently approved for use on potatoes (cont'd)

Active ingredient	UK MRL	Codex MRL for potato or root and tuber vegetables
pencycuron	0.1	none set
pendimethalin	0.05	none set
pirimicarb	0.2	0.05
propamocarb-hydrochloride	0.5	none set
propaquizafop	0.1	none set
prosulfocarb	0.05	none set
pymetrozine	0.02	none set
quizalofop-P-tefuryl	0.2	none set
rimsulfuron	0.05	none set
tecnazene (not approved on potatoes)	0.05	20.0
thiabendazole	0.05 early crops15.0 ware crops	15.0
thiacloprid	0.02	none set
thiamethoxam	0.1	none set
tolclofos-methyl	0.2	0.2
zoxamide	0.02	none set

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Appendix 18 B.P.C. technical publications

Copies of various publications on potato production, storage and marketing are available to levy payers and corporate members of the B.P.C. from:

British Potato Council
4300 Nash Court
John Smith Drive
Oxford Business Park South
Oxford
OX4 2RT

Tel: (01865) 714455
Fax: (01865) 782200
Web: www.potato.org.uk

Free publications can be ordered through the publications line on 01865 782222, by fax on 01865 782283, by e-mail to publications@potato.org.uk. Some reports are downloadable from the website at www.potato.org.uk.

Appendix 19 Suggested record sheet for CIPC use

Draft CIPC application record by courtesy of and thanks to Ajay Jina.

CIPC Application Record

Business name:	
Store name:	
Variety/Varieties	

Requested by:	**Date:**
Confirmed by:	**Date:**
Reason for application:	

Application date:		**Date and dose of all previous applications:**	

Dose and name of product used:	

Store contents	**Number of boxes**	**Total Weight Potatoes (t)**

Formulation:		**Batch Number:**	
Application Rate:		**Total Required for Store**	
Time Taken:		**Total Applied to Store:**	
Date / Time Treated:		**Harvest Interval:**	
Contrator		**Operator's name**	
Fogger Identity			

Comments:
(i.e. weather/wind conditions, problems during application, precautions taken, operator comments, condition of crop…)

Signed: _____ Date: _____

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Appendix 20 Control Points: Potatoes

CS.47 **POTATOES**

CS.47.1	You should be able to produce evidence to show that you take precautions to ensure that potatoes you handle or store are not contaminated by, damaged or exposed to anything that could affect their food quality -
	Protocol reference: Section 9.6
CS.47.2	You must be able to demonstrate that your potato blight spray programmes use the minimum number of sprays necessary for good blight control -
	Protocol reference: Section 8.10.2.2
CS.47.3	All potato waste and plastic covers should be recovered and disposed of, or recycled, in a responsible way -
	Protocol reference: Section 10.1.1
CS.47.4	The field to store haulage equipment and or the potato boxes must be inspected and cleaned before use -
	Protocol reference: Section 9.6
CS.47.5	Where potatoes are stored, the stores must be inspected and cleaned before use -
	Protocol reference: Section 9.6
CS.47.6	If you store potatoes and use CIPC (chlorpropham) you must be able to demonstrate that you have used the least amount of CIPC for sprout control -
	Protocol reference: Section 9.7.2
CS.47.7	You should be able to show that when selecting seed potatoes, you consider the effect that location, health, management and handling of the seed crop have on the ware crop -
	Protocol reference: Section 5.2
CS.47.8	Any haulm growth on potato dumps should be destroyed with chemical desiccant or contained with black plastic sheeting-
	Protocol reference: Section 8.10.2.2

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