Interpretation of efficacy data requirements for the authorisation of a plant protection product in potato (SOLTU) in the UK.

CRD Efficacy Team

This document is intended to assist applicants in addressing and interpreting current efficacy data requirements, and relevant accompanying EPPO standards, with specific focus on potato. It provides supplementary information on UK agronomy, including relevant UK targets and trials numbers, if applying for a UK-only authorisation.

This document covers application of plant protection products to potato in the field. It does not cover treatments to tubers in store for disease control or as a sprout suppressant.

All trials should be carried out under Good Experimental Practice (GEP) and using all relevant general EPPO Standards. Effectiveness and selectivity trials should be performed according to the EPPO Standard PP1/181 (available at http://pp1.eppo.int/).
All tests should be carried out with the formulation of the product intended for use. If other formulations were used such data may still be used to support the proposed formulation, however bridging data or a sound scientific justification should be supplied to demonstrate comparability of the formulations and allow bridging between formulations. Further details on supporting formulation changes can be found in EPPO PP 1/307 'Efficacy considerations and data generation when making changes to the chemical composition or formulation type of plant protection products'.

1. General information

The potato is a member of the family *Solanaceae* and is closely related to the tomato and the nightshades. *Solanum tuberosum* (SOLTU) is the species cultivated in Europe, and is a tuberbearing, herbaceous plant. The so-called root system of the plant is in fact an extension of the stem. The below ground portion of the stem gives rise to stolons which carry adventitious roots and terminate with the tuber. The tuber is therefore a highly adapted part of the stem organised for food storage and vegetative reproduction. When exposed to light, they become green.

2. Information on potato production in the UK

a) Planting

In the UK, the potato crop is largely planted in the period February to May, with the bulk of it in March and April, weather permitting. The term 'earlies' refers to all potatoes harvested on or before 31 July each year. First early potatoes are ready to harvest approximately 10 weeks from planting date. Second early potatoes are ready to harvest approximately 13 weeks from planting date. Potatoes are considered to be 'maincrop' if they are harvested after the end of July each year.

Planting date depends on a number of factors including:

- Region (due to different climate);
- Soil type (difficult to produce an early seedbed on heavy soils);
- Crop type/variety (i.e. earlies, 2nd earlies or maincrop).

Potatoes are sensitive to frost so should not be planted until after the last frost of winter. Early crops in the frost-free regions, such as Jersey, can be sown as soon as soil conditions allow, and this could be as early as January. Regions such as Cornwall, Pembrokeshire and Kent plant earlies in February. Planting 2nd earlies follows in March, while maincrop can be sown in most regions in late March to early April.

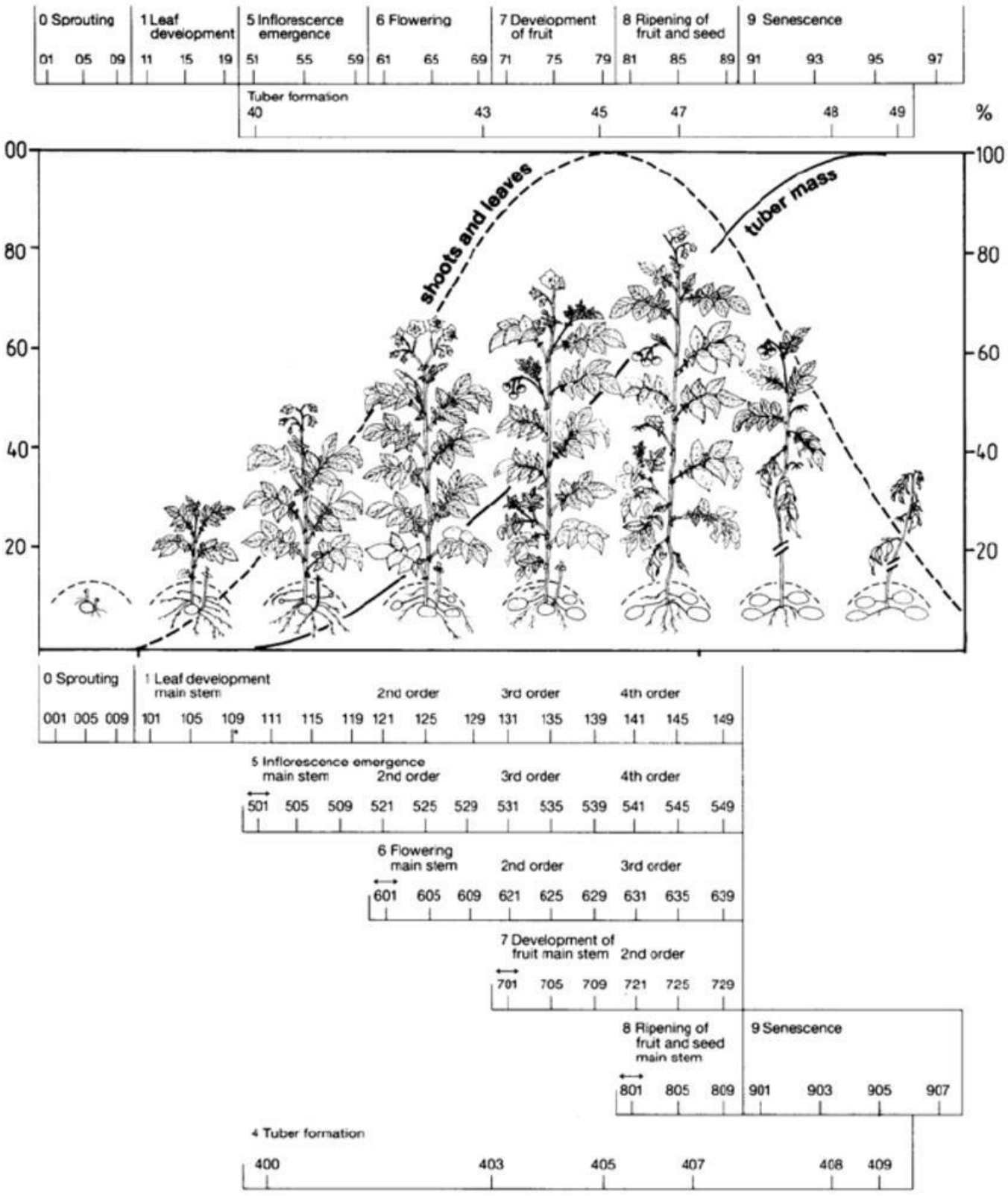
Potatoes are usually grown in ridges or beds, therefore deep cultivation is needed, but care should be taken not to bring un-weathered soil and clods to the surface. Potato fields are usually slightly acidic (pH 5.8-6.0). The minimum soil pH is 5.5. Early crops are grown on light soils which can be easily cultivated in early spring. Maincrops prefer deep moisturereretentive soils. Soils should preferably be well prepared and free from compaction and stones and clods, which damage the crop during tuber development and when it is harvested.

Once a potato seedbed has been produced, the seed potato (tuber) need to be planted into the ridges. This needs to be a delicate procedure to avoid damage, especially so if the seed has been artificially sprouted. This is known as 'chitting'. Chitting is the process where tubers are stored in trays and encouraged with light and controlled temperatures to break dormancy and produce sprouts ahead of planting. For details of how a potato planter operates see Appendix 2.

The amount of seed potato in weight to be planted to the hectare depends on a number of factors: the average weight of the seed tuber, the number of tubers to be planted per hectare, potato variety and target market. For varieties producing large tubers e.g. 'Desiree' and 'Pentland Crown', the seed rate is commonly 2.5-4.5 tonnes/hectare, while for small tuber varieties such as 'King Edward' and 'Record', the seed rate is lower, between 1.8 and 2.4 tonnes/hectare. The average is around 3 tonnes/hectare. Seed rates for earlies, seed production and canning vary.

b) BBCH Growth stages (see Appendix 1 for detailed information)

A diagram illustrating the growth stages is provided below:


0 Sprouting
01 05 09
1 Leaf development
11 15 19
5 Inflorescence emergence
51 55 59
6 Flowering
61 65 69
7 Development of fruit
71 75 79
8 Ripening of fruit and seed
81 85 89
9 Senescence
91 93 95 97
Tuber formation
40 43 45 47 48 49
%
00 80 60 40 20
shoots and leaves
tuber mass
100 80 60 40 20
0 Sprouting
001 005 009
1 Leaf development main stem
101 105 109 111 115 119
2nd order
121 125 129
3rd order
131 135 139
4th order
141 145 149
5 Inflorescence emergence main stem
501 505 509
2nd order
521 525 529
3rd order
531 535 539
4th order
541 545 549
6 Flowering main stem
601 605 609
2nd order
621 625 629
3rd order
631 635 639
7 Development of fruit main stem
701 705 709
2nd order
721 725 729
8 Ripening of fruit and seed main stem
801 805 809
9 Senescence
901 903 905 907
4 Tuber formation
400 403 405 407 408 409

c) Crop Protection

Typical water volumes for plant protection products used on potato tend to be in the range 200-600l/ha.

d) Harvesting

The UK potato harvest typically begins in Cornwall, Essex and south-west Wales in May, and spreads to the rest of the UK thereafter.

Average yield per hectare is approximately 40-50 tonnes/ha for maincrops. Earlies average 7.5-10 tonnes/ha.

e) Rotation

Potatoes are normally grown in a crop rotation with cereals. A minimum six year rotation is desirable where crops such as sugar beet, potatoes or oilseed rape are involved. Close rotations increase the risk of damage by potato cyst nematode (PCN) (HETDRO, HETDPA) and other soil-borne problems such as *Rhizoctonia* (RHIZSO) and black dot (COLLCC), which reduce yield and tuber quality. Double cropping and short rotations will rapidly buildup potato cyst nematode populations, *Rhizoctonia* spores and potato volunteers in following crops. Other soil-borne diseases (such as black dot, powdery scab (SPONSU) and *Verticillium* spp. (VERTAA, VERTDA)) will also increase become a problem. Most annual weed problems can be dealt with reasonably effectively within the potato crop. Perennial weeds can be more difficult to control in potatoes and can have detrimental effects on both yield and efficiency of harvesting and should be controlled through the preceding crop(s) of the rotation.

3. The potato market in the UK

Approximately half the crop is sold ‘off-the-field’ as fresh produce for immediate use, whilst the rest is stored for periods ranging from a few weeks to up to 11 months. If not sold ‘off-the-field’, crop destined for pre-pack sales, especially through the major supermarkets, tends to be cold-stored, using refrigerated stores at temperatures typically within the range 2.53.5ºC. These temperatures minimise development of most skin blemish diseases as well as sprouting. Crops destined for chipping or crisping are stored at temperatures typically within the range 8-11ºC. These higher temperatures minimise the build-up of reducing sugars (glucose and fructose) which can occur in many varieties held in cold storage conditions and which cause potatoes to produce excessively dark-coloured chips or crisps after frying. Crops stored at these temperatures for periods longer than a few weeks normally require chemical sprout suppression.
The range of crop uses has expanded enormously in recent years especially in the processed sector. Each outlet demands specific quality criteria which must be satisfied, including some or all of the following: variety, tuber size, appearance, dry matter content, fry colour, absence of sprouting, diseases, pest damage, disorders.

a) Planted areas in the UK

The potato crop makes up around 16% of the arable area of the UK .
The total UK crop area of ware potatoes was just under 121,000ha, as at June 2017 (source: AHDB Market Intelligence 2017-18).

UK Region	2013	2014	2015	2016	2017	% of total area
North East	900	1,000	800	900	900	1
North West	5,800	5,800	5,600	6,100	5,800	5
Yorks & Humber	13,900	14,400	13,600	13,800	15,400	13
East Midlands	16,500	16,800	16,200	15,900	16,600	14
West Midlands	14,700	13,900	12,800	13,500	13,800	11
East of England	32,800	32,300	30,300	31,300	32,300	27
South East	3,200	3,000	2,600	2,800	2,800	2
South West	6,000	5,800	4,900	5,500	5,800	5
Scotland	26,900	26,400	23,600	24,800	25,800	21
Wales	1,600	1,700	1,700	1,700	1,800	1
Grand Total	**122,400**	**121,100**	**112,000**	**116,200**	**120,900**	

Considering long-term trends, while the planted area has decreased considerably, production has remained at around the 5–6 million tonne mark. This is because yields have risen over the same period, compensating for the reduction in area. Increased yields have been driven largely by improved agronomy, crop protection, fertiliser regimes, variety changes and developments in irrigation practices. As with other arable crops, weather is the largest driver of short-term fluctuations in yield and production.

b) UK Varieties

Varieties grown in the UK in 2017 (ha) (AHDB Market Intelligence 2017-18)

Top 10 varieties	2017	2017 % of total area	2016 Rank
1. Maris Piper	16,300	14	1
2. Markies	5,900	5	2
3. Maris Peer	5,100	4	3
4. Melody	4,300	4	5
5. Lady Rosetta	3,400	3	4
6. Nectar	3,200	3	10

7. Estima	2,900	2	6
8. Taurus	2,800	2	7
9. Pentland Dell	2,800	2	8
10. Innovator	2,500	2	12

Planted area by sector in hectares in 2017 (AHDB Market Intelligence 2017-18)

Market sector	**2017**	**2017 % of total area**
Fresh bags	6,100	5
Fresh chipping	14,900	12
Pre-pack	45,600	38
Processing	35,200	29
Other ware	2,400	2
Seed	16,200	14
Total	120, 900	

4. Addressing Efficacy Plant Protection Product Data Requirements (IIIA 6)

(IIIA 6.1) Preliminary data

Results of preliminary tests and early screening studies can provide useful information on, for example, dose justification and evidence of safety to potential following crops.

(IIIA 6.2) Minimum Effective Dose

Minimum effective dose trials should be conducted to demonstrate that the proposed dose is justified for representative uses. The majority of data should be generated where target pressure is highest, but a proportion of trials should still include areas of more variable target pressure. Trials should be conducted in accordance with EPPO PP 1/225 *Minimum effective dose*. A justification for the number of applications applied may also be required if multiple applications are proposed. Minimum effective dose should be based on the key targets or representatives of them and these are presented below.

(IIIA 6.2) Effectiveness

a) Location of trials

As a general principle, data generated from outside the UK may support a UK authorisation. The acceptability of the data is dependent on detailed evidence and an appropriate case on the comparability to the UK of agricultural, plant health and environmental (including climatic) conditions, relevant to the use of the product, in the reference country. EPPO PP1/241 (1) Guidance on Comparable Climates, provides more detail on this approach. (In addition, EPPO PP 1/269 'Comparable climates on a global level' discusses the climatic relevance of data generated outside the EPPO region. This be relevant as part of an appropriate case, which should follow the principles above and additionally consider the conduct of trials in relation to EPPO standards).

Further, EPPO 1/278 (1) Principles of zonal data production and evaluation discusses the various factors involved in considering trials planning on a more regional basis, and ensuring all relevant conditions are tested. This may also be useful in considering the reasoned arguments on relevance of data to the UK, as well as if an authorisation in the UK may be sought as part of a wider, regional regulatory submission. (https://www.eppo.int/PPPRODUCTS/zonal_efficacy/zonal_efficacy.htm).

The precise distribution of trials should consider the major potato growing areas and relative importance of the target weeds/pests/diseases.

b) Number of trials

EPPO Standard PP 1/226 (2) *Number of efficacy trials* indicates that for authorization in a single country/climatic zone, 6 to 15 fully supportive results are required over two years for

each major use. Current UK requirements for demonstration of efficacy indicate that in general 10 trials are fully supportive for use against a major target species on a major crop Where a major target is appropriately supported, it may be sufficient to have a reduced number of trials for minor targets (see tables below for specific targets), typically a minimum of 3 and conducted in a single season. If, however, relevant major targets have not been supported then the primary target for that product should be supported by a minimum of 10 trials results (over two seasons).

EPPO PP 1/226 (2) also states that 'In some situations, there may be the opportunity to reduce the number of trials done, and a case may be made for this as follows'. It describes the situations where a reduced number of trials may be acceptable.

(As indicated above, if a UK authorisation is sought as part of a wider, regional regulatory submission, EPPO 1/278 'Principles of zonal data production and evaluation' may be relevant when considering trials numbers).

c) Trials reporting

Trials should be conducted in accordance with EPPO Standards PP 1/181 *Conduct and reporting of efficacy evaluation trials including good experimental practice* and PP1/152 *Design and analysis of efficacy evaluation trials*. The key information should be presented in appropriate summary tables which should include:

For all product types: crop growth stage (BBCH) at time of application and calendar timing range; pest population levels at time of application and at each assessment; number of trials; mean percentage control/effect and the range of minimum and maximum levels, for both the test product and also for the reference products, at each assessment timing.

For weeds: weed species; weed growth stage (BBCH) at time of application and time of assessment; weed numbers at application (percentage ground cover or number/m^2).

Results should only be included from trials conducted in accordance with EPPO Standards and where there are agronomically relevant pest populations present. It is not appropriate to have a prescriptive list of 'minimum populations' for all possible target organisms but indicative levels for weeds, pests and diseases are given below:

Target	**Minimum population**
Weeds	Broadleaved weeds - 5 plants/m^2 Major weeds (e.g.cleavers) higher population Grass weeds – head count -20/m^2
Diseases	5% plants infected or 5% leaf area
Pests	Specific agronomic threshold (or case) – provide appropriate published reference where possible

d) Number of trials for UK relevant pests

In determining the number of trials required for each target, the following should be considered, relating to the major or minor status of that pest/weed/disease in the UK. In addition, reference should be made to the UK differential labelling scheme, outlining appropriate label claims supported by the effectiveness trials data. For further information, see efficacy guideline 120 'GB and NI efficacy advice and product labelling' at www.hse.gov.uk/pesticides/efficacy-guides/guidelines.htm.

Insect Pests

Pest		
Aphids (ware potatoes)	Potato aphid *Macrosiphum euphorbiae* (MACSEU)	Buckthorn-potato aphid *Aphis nasturtii* (APHINA)
	Peach-potato aphid *Myzus persicae* (MYZUPE)	
Aphids as virus vectors (seed potatoes)	Potato aphid *Macrosiphum euphorbiae* (MACSEU)	Glasshouse-potato aphid (*Aulacorthum solani*)(AULASO)
	Peach-potato aphid *Myzus persicae* (MYZUPE)	Bulb and potato aphid (*Rhopalosiphoninus latysiphon*) (RHOSLA)
	Buckthorn-potato aphid *Aphis nasturtii* (APHINA)	

Aphids on ware potatoes can cause direct feeding damage and yield impacts where numbers build up, but if numbers remain low or stable, no treatment is necessary. (Unless showing virus symptoms and might be a source of infection for any close by seed crop). Typically in the UK, 1-2 applications only during the season would be required

Aphid species as virus vectors in seed potatoes are a major concern, and insecticide sprays will be made throughout the season. There are two groups of viruses:

a) persistent viruses (e.g. potato leaf roll virus (PLRV) which require prolonged feeding and therefore only transmitted by aphids which colonise potato plants);

b) non-peristent viruses (e.g PVA, PVY, PVV) which can be transmitted by brief probing of aphids determinig the suitability of the host plant.

This means there is a wide ranging complex of aphid species which could transmit nonpersistent viruses. The species listed above for seed potatoes are therefore those which colonise potato plants and considered appropriate targets to generate data supporting specific potato label claims. There are long established aphid monitoring schemes providing advice on timing of any insecticide treatments.

In terms of supporting claims for the above species, whilst 10 supportive trials is a minimum for a major target species, it is appropriate in this case where there are multiple aphid species to reduce the number on each individual major species and consider the group as a whole. Peach-potato aphid is considered the major species and a minimum of 4 supportive trials, as part of a wider data package, would be expected. It may be possible to directly extrapolate to the minor species.

In addition, a number of these species have a range of other crop hosts. For example (list not exhaustive): **Peach potato aphid** (oilseed rape, sugar beet, vegetable brassicas); **Potato aphid** (sugar beet). It may be possible to further support these claims on potato by relevant data on other hosts crops, but this is dependent on appropriate cases being made (and similarity of proposed/authorised GAP). In all cases, expert judgement will be used.		
Coleoptera	Wireworms (*Agriotes sp.*) (AGRISP)	
Wireworms can significantly impact marketability, even when present at low population numbers, due to feeding on tubers. A minimum of 10 fully supportive results are required. Reference should be made to EPPO minor use table for 'soil pests', for suitable extrapolations from any relevant crop to another for wireworms. This may be an acceptable approach, provided an appropriate case is made regarding relevance of the crop and proposed/authorised GAPs. In the UK other crops which may be significantly affected include cereals and sugar beet.		
Lepidoptera		Cutworms (various Noctuid species) (1NOCTF)
Cutworms are considered a sporadic pest on potato which may damage roots. Claims can be supported by extrapolation from data generated on other more susceptible crops, or by a minimum of 3 fully supportive results. Reference should be made to EPPO minor use table for 'soil pests'. This may be an acceptable approach, provided an appropriate case is made regarding relevance of the crop and proposed/authorised GAPs, which permits extrapolation from any relevant crop to another for cutworms. In the UK, the most vulnerable crops include lettuce. Moderately susceptible crops include brassicas, carrot, and sugar beet.		
Leafhoppers		Potato Leafhoppers *Edwardsiana flavescens* (EDWNFL), *Empoasca decipiens* (EMPODE), *Eupterycyba jucunda* *Eupteryx aurata* (CICLAU)
A minimum of 3 fully supportive results are required (inclusive of different species). It may be possible to support via appropriate extrapolations.		
OTHER PESTS		

<table>
<tr><td rowspan="2">Nematodes</td><td>Potato Cyst Nematode (Globodera rostochiensis and Globodera pallida) (HETDRO, HETDPA)</td><td></td></tr>
<tr><td>Free living (includes Stubby, (Para)Trichodorus spp. (TRIHSP) Needle, Longidorus spp.) (LONGSP) and Lesion nematodes (Pratylenchus penetrans).</td><td></td></tr>
<tr><td colspan="3">Potato cyst nematode (PCN) is a key major pest, and there is a range of advisory information on management decision-making tools for treatment. There are also statutory requirements requiring notification and control measures for seed and ware potatoes destined for export. G. pallida has become the primary UK species because of the widespread use of potato varieties that are resistant to G. rostochiensis. A minimum of 10 fully supportive results are required for potato cyst nematode.

Free living nematodes cantransmit tobacco rattle virus (TRV) which causes the disorder ‘spraing’ in potato tubers, affecting their marketability. Yield impacts are also possible if populations build up. A minimum of 6 fully supportive results are required for free living nematodes (inclusive of different species).

Reference should also be made to EPPO minor use table for ‘nematodes’ to consider extrapolation from other relevant crops, including carrot and Alliums. This may be an acceptable approach, provided an appropriate case is made regarding relevance of the crop and proposed/authorised GAPs.</td></tr>
<tr><td>Field Slugs</td><td>Grey field slug (Derocerus reticulatum) and other Derocerus sp., Garden slugs (Arion hortensis and A. distinctus) (ARIOSP)</td><td></td></tr>
<tr><td>Keeled slugs</td><td>Milax , Tandonia, Boettgerilla sp. (MILXSP, TANDSP, BOEGSP)</td><td></td></tr>
<tr><td colspan="3">Keeled slugs are the more major problem in potato because they are generally subterranean feeders and can cause significant damage tubers. There are two key periods for possible control measures to protect tubers: firstly between 50 – 75% canopy closure; and the second at the early stages of tuber bulking.

A minimum of 10 fully supportive results are required for keeled slugs and specific data for this species will be required to support a label claim.

A minimum of 10 fully supportive results are required for field slugs. Alternatively, extrapolation from an appropriate data set on Oilseed rape/Cereals may be possible, provided there is an acceptable case including relevance of the crop and proposed/authorised GAPs.</td></tr>
</table>

Applicants should refer to EPPO 1/95 'Slugs' for further information which also includes appropriate extrapolations and supporting claims for molluscicides on wide range of crops.

Principles of extrapolation

For major pests, a minimum of 10 fully supportive results are required, with a minimum of 3 results for minor species (unless a case for extrapolation has been made as described below).

It may be possible to reduce the number of required supportive results, or directly extrapolate from an existing data set, provided an appropriate reasoned case is made. This may be a relevant approach either for the same species on a different host crop; or extrapolating between closely rated species. The reasoned case must consider all relevant factors, including sufficient information on the pest biology and crop agronomy.

Diseases

Major Disease	Minor Disease
Late Blight (*Phytophthora infestans*) (PHYTIN)**	Early blight (*Alternaria alternata* and *Alternaria solani*) (ALTEAL, ALTESO)
	Bacterial wilt/brown rot (*Ralstonia solanacearum*) (RALSSL)
	Black dot (*Colletotrichum coccodes*) (COLLCC)
	Stem canker and Black scurf (*Rhizoctonia solani*) (RHIZSO)
	Dry rot (*Fusarium spp.*) (FUSASP)
	Gangrene (*Phoma exigua var. foveata*) (PHOMEF)
	Silver Scurf (*Helminthosporium solani*) (HELMSO)
	Skin spot (*Polyscytalum pustulans*) (PLSCPU)

** For more information on Late blight effectiveness trials, see Appendix 3

Principles of extrapolation

Potato diseases are generally specific. Although *P. infestans* also occurs on tomatoes and other Solanaceae (e.g. Aubergine), direct extrapolation from these crops to potatoes is not possible since neither are grown outdoors in those areas where *P. infestans* is most prevalent and destructive. Furthermore, the difference in crop structure, particularly in the case of tomato, is likely to require different dose rates.

In the case of the minor diseases, all apart from Early blight are traditionally treated by application made direct to the tuber or seed. Although these are all minor relative to *P. infestans,* given their potential impact on quality/marketable yield, more than the mean EPPO number of trials for a minor disease is required. For the minor diseases listed above, 6 trials would normally be required.

Weeds

Potatoes are poorly competitive up to canopy closure, however main crop varieties tend to be more competitive than first and second earlies, salad varieties and seed potato crops.

Climbing weeds such as black-bindweed and cleavers can cause problems, and fat hen, knotgrass, volunteer rape and annual meadow-grass cause harvesting problems.

Fat hen, common chickweed and cleavers tend to be the most commonly occurring weeds in potatoes. Other spring germinating weeds such as *Polygonum* spp., bindweed, black nightshade and fumitory are also common, depending on rotation and soil type.

Weed control needs to start whilst the weeds are accessible to treatment, that is, preemergence of the crop to before the crop shades emerged weeds. The treatment needs to be able to maintain weed control for up to 6-8 weeks after crop emergence to allow the crop canopy to close and shade further weed emergence. In less vigorous and less competitive varieties, canopy closure may take longer, or remain incomplete.

Volunteer potatoes are a key weed in the potato crop itself but the use of herbicides for their control 'in-crop' is practically difficult. Control is achieved across the rotation. Hence volunteer potatoes are often stated as a major weed of other crops e.g. cereals.

MAJOR WEED SPECIES (Please refer to EPPO PP 1/51 'Weeds in potato' for details on trials conduct).	
Broad-leaved weeds	**Grass weeds**
Common chickweed (STEME) Fat-hen (CHEAL) Redshank (POLPE) Black nightshade (SOLNI) Common orache (ATXPA) Black bindweed (POLCO) Cleavers (GALAP) Field bindweed (CONAR) Creeping thistle (CIRAR) Mayweed spp. (MATSS) Knotgrass (POLAV) Common fumitory (FUMOF) Pale persicaria (POLLA) Charlock (SINAR) Volunteer oilseed rape (BRSNN)	Annual meadow-grass (POAAN) Common couch (AGRRE)

Principles of extrapolation

For major weeds a minimum of 10 acceptable trial results are required, with 3 results for minor species (unless a case for extrapolation from another crop has been made).

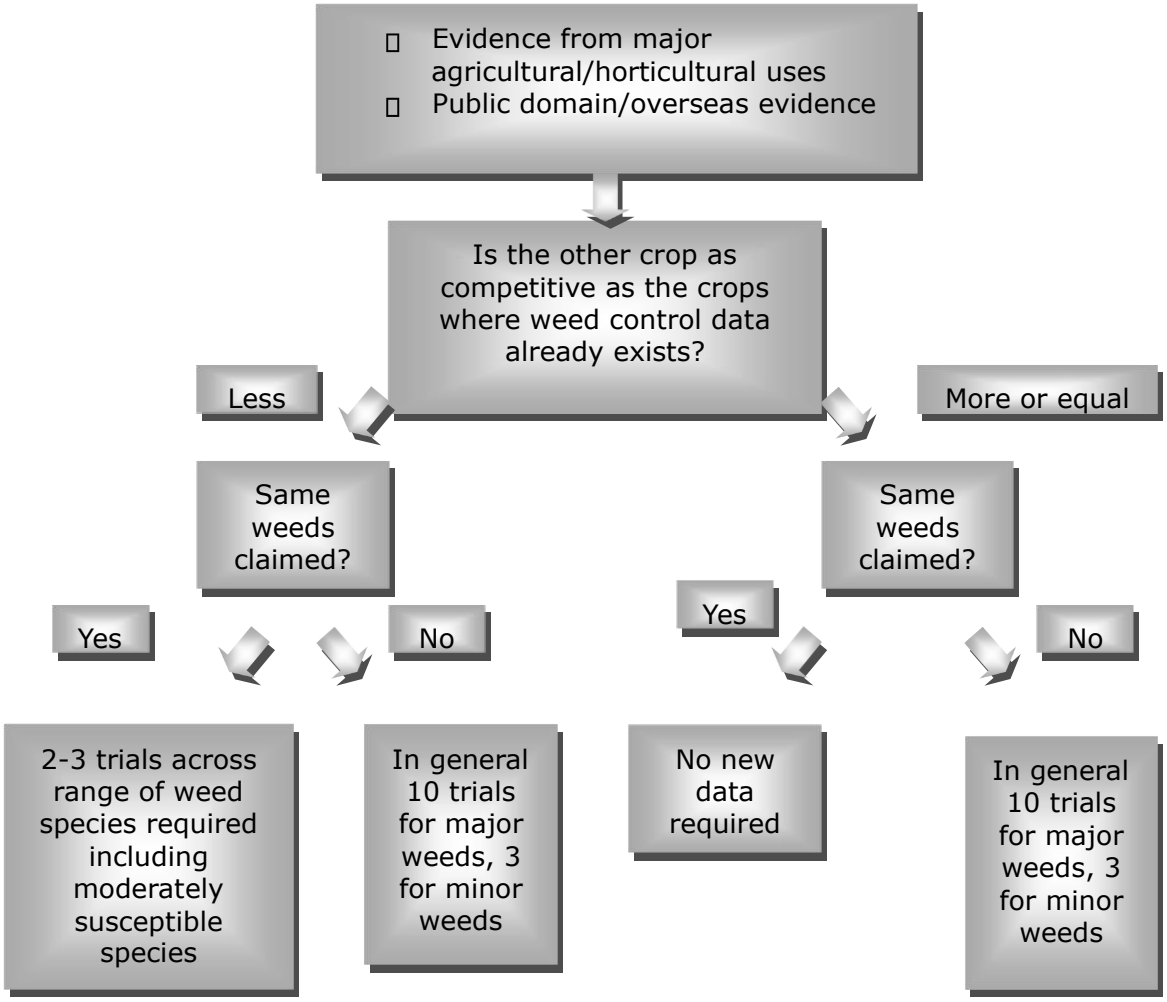
In many cases it will be possible to make a well-argued case for extrapolation from one crop to another if there is sufficient information on the weed control required, the competitiveness of the crop and the factors affecting acceptable weed control in both crops. This may follow the guidance below:

Situation	Crops	Notes
A- Arable – competitive crops	Cereals, grassland, oilseed rape	Extrapolation accepted within group and from B or C.
B- Arable/horticultural- poorly competitive crops	Sugar beet, peas, onions, linseed, brassicas	Extrapolation accepted within group and from C, but not A.
C- Other situations – noncompetitive crops	Orchards, HONS, amenity vegetation, land not intended to bear vegetation	Extrapolation accepted within group, but not from A, and possibly B.

It may also be possible to extrapolate from one weed species to a related species. There is the scope to extrapolate from charlock to shepherd's purse and vice versa if one of the species is treated as a major weed and is supported by sufficient data i.e. at least 10 trials.

Sporadic weeds may be supported by minimal data if a related major or minor weed species has been supported by data.

Weed extrapolation flow chart:



(IIIA 6.3) Resistance

Reference should be made to EPPO Standard PP 1/213 *Resistance Risk Analysis*.

Certain UK pests and diseases on potato are considered more likely to develop resistance, based on resistance history. Therefore, for a new active substance baseline sensitivity data should be generated, regular subsequent monitoring will allow sensitivity shifts to be detected and resistance management strategies to be updated if necessary. Populations need to be tested with standardized methods. Medium to high resistance risk targets in the UK are:

- *Myzus persicae* (MYZUPE)
- Potato blight (*Phytophthora infestans*) (PHYTIN)

Fat hen (CHEAL), common chickweed (STEME) and mayweed species (MATSS) have developed resistance in the UK and so should be considered in any resistance risk assessment.

For these targets, a resistance management strategy has to be presented. Reference may be made to relevant 'Resistance Action Committee' (RAC) recommendations, but should be tailored to the UK and reflect e.g. number of applications required, availability of other control options etc.

In particular for a UK authorisation, applicants should refer to the latest advice and guidance from the UK Resistance Action Groups (RAGs), which can be found at:

- The Fungicide Resistance Action Group (FRAG-UK) - https://ahdb.org.uk/knowledge-library/the-fungicide-resistance-action-group-frag-uk
- The Insecticide Resistance Action Group (IRAG) - https://ahdb.org.uk/knowledge-library/the-insecticide-resistance-action-group-irag
- The Weed Resistance Action Group (WRAG) - https://ahdb.org.uk/knowledge-library/the-weed-resistance-action-group-wrag

This includes IRAG-UK advice on *Myzus persicae* resistance management in potato (and other crops) and FRAG-UK advice on Fungicide Resistance management in Potato Late Blight.

Reference should also be made to any current CRD guidance on resistance.

(IIIA 6.4) Adverse effects on treated crops

(IIIA 6.4.1) Phytotoxicity to target plants (including different cultivars), or to target plant products

The tests should provide sufficient evidence to permit an evaluation of the possible occurrence of phytotoxicity or other harmful effects after treatment with the plant protection product. Reference should be made to EPPO Standard PP1/135 (4).

Evidence should be largely provided by conducting field experiments under conditions as near as possible to commonly accepted practice and which reflect the proposed GAP. Where soil

type, geographic location or planting date can affect safety to crops, products should be tested on a range of sites/situations.

All phytotoxicity tests should include the normal recommended dose. Observations on phytotoxicity should be made in both effectiveness and any specific crop safety trials considered necessary. Phytotoxicity can depend on BBCH growth stage at application, climatic conditions and the varieties grown. Ideally, the product should be tested on commercial varieties from each maturity class (first-early, second-early and main crop) on which use of the test product is intended. These should include the most commonly grown varieties.

Potatoes market information at https://potatoes.ahdb.org.uk/knowledge-library/potatoes-market-information).

Varietal sensitivity testing may also be required to be conducted (see EPPO Standard PP 1/135 (4) *Phytotoxicity assessment*).

Possible parameters that could be assessed include: emergence (only if very early treatments are made), vigour, chlorosis/necrosis of foliage, and damage to tuber quality (refer to EPPO PP1/135 (4) for examples). It is essential that the symptoms measured and recorded are described accurately. In the absence of any observable effects, it should be clearly stated that this was the case.

(IIIA 6.4.2) Effects on the yield of treated plants or plant products

For insecticides and fungicides, in line with EPPO PP 1/135, yield data are not normally required. Data for insecticides and fungicides are needed only for new active substances where a case for crop safety cannot be made.

For herbicides, specific crop safety trials in the absence of weeds must include applications at N and 2N doses and trials should cover the range of proposed growth stages and treatment times for each use. The tests should provide sufficient evidence to permit an evaluation of the possible occurrence of yield reduction (or effects on tuber size distribution) after treatment with the plant protection product.

In line with EPPO PP1/135, total yield (usually expressed as tonnes/hectare), and weight of tubers in each size class after grading (using a specified national or international standard), must be presented. The number of tubers in each size class may also provide useful information. Malformed tubers should be noted. Starch content is required only for potatoes for industrial use.

Evidence of no unacceptable adverse effects on yield (quantity) is particularly important in instances where use of the product has caused phytotoxicity.

There should be no unacceptable adverse effects on the total yield or size grade of tubers, except where the proposed label indicates appropriate limitations of use.

Specific crop safety trials should be located across the Zone in areas representative of potato cultivation. EPPO Standard PP 1/226 *Number of efficacy trials* indicates that for authorisation

in a single country/climatic zone, typically, at least 8 trials per major crop are required in an area of similar conditions, to cover the range of conditions of use, including soil types, weather conditions that are likely to be encountered.

It is essential that symptoms of phytotoxicity are clearly linked to any subsequent yield effects.

(III 6.4.3.) Effects on the quality of plants or plant product

a) Taint

The tests should provide sufficient evidence to permit an evaluation of the possible occurrence of taint or other quality aspects after treatment with the plant protection product. Taint data are normally required on potato, because much of the crop is processed and it is known that certain preservation processes can be sensitive to the formation of taints (see EPPO PP1/242 (2) *Taint tests* for full details).

b) Quality

The most important quality aspects which should be assessed are effects on the skin and flesh of the tubers. For potatoes for industrial use, starch content is a quality parameter which should be measured. Assessments should usually be based on a random sample of 100 tubers per plot. The sample size may be reduced to 50 tubers per plot, where estimates are made of the % surface area affected. Where necessary, tubers must be cut in half to examine the flesh. The incidence of affected tubers should be expressed in absolute figures (e.g. percentage by number of tubers affected). Estimates of severity of damage may be expressed, where possible, in absolute figures (percentage surface area affected) or by reference to a scale which should be recorded.

Effects on tuber size distribution are also considered to be a quality aspect and should be assessed in accordance with the respective EPPO standards (e.g. EPPO PP1/2).

There should be no unacceptable adverse effects on the quality of tubers or on the taint on tubers from treated plants, except where the proposed label indicates appropriate limitations of use. For example, use of the product could be restricted to crops not intended for processing. In the absence of any evidence, the label must state clearly that growers should consult processors before use on crops intended for processing.

(IIIA 6.4.4) Effects on transformation processes

Evidence on the effect of pesticides on transformation processes is not required because in the UK, the potato crop is not routinely subject to any transformation processes.

(IIIA 6.4.5 Impact on treated plants or plant products to be used for propagation

There must be no unacceptable adverse effects on tubers intended for use as seed, except where the proposed label indicates appropriate limitations of use. Data are generally only required if a product has systemic activity, is applied close to harvest and phytotoxic effects have been noted. Reference may be made to EPPO Standard PP 1/135 *Phytotoxicity assessment* which provides an indication of the circumstances under which data on plant parts for propagation are required. Where there is sufficient interval between application and harvest and no residues or metabolites are found in the relevant plant parts, it may be possible to address this issue by a case referring to residues and metabolism studies.

The tests should provide sufficient data to allow an evaluation of the effect of use of the plant protection product on tubers from a treated crop which are intended for use as seed. Evidence need only be provided in cases where tubers from the treated crop are intended for use as seed. The amount of evidence needed will depend on the extent of any harmful effects observed. Normally, it would be sufficient to provide evidence that neither rate nor final percentage of chitting/sprouting are affected. If, however, harmful effects on chitting/sprouting are observed, then further tests on field emergence, vigour and, possibly, yield may be necessary.

Reference to EPPO PP 1/143 (3) may provide useful advice on methodology.

(IIIA 6.5.1) Impact on succeeding crops

A step-wise approach should be taken following EPPO Standard PP 1/207 *Effects on succeeding crops*, starting with the herbicidal activity of the active substance, through glasshouse screening, laboratory bio-assays of treated field soils, field screening, monitoring of effectiveness/crop safety field trials and if necessary, specific following crop 'replanting' trials using risk mitigation measures such as different cultivation techniques. It is important to consider crops which are likely to be present in rotation with potato. For testing the biological activity of the test product, the product should be incorporated into the soil and the activity given as an EC (effective concentration). Endpoints from pre-emergence non-target plants tests presented in the Ecotoxicology Section of the dossier may be used to assess this risk to succeeding crops provided they are representative of the crops normally planted after potatoes.

(IIIA 6.5.2) Impact on other plants, including adjacent crops

A step-wise approach should be taken following EPPO Standard PP 1/256 *Effects on adjacent crops* and should be fully presented. It is important to consider crops which are likely to be present as adjacent crops to potato (either already emerged or yet to emerge) in the UK. Endpoints from the pre and post-emergence non-target plants tests presented in the Ecotoxicology Section of the dossier may be used to assess the risk to adjacent crops provided they are representative of the crops normally found adjacent to potato crops. In addition to spray drift, other routes of exposure (e.g. volatilization) should be considered for the formulated product as this may also affect sensitive adjacent crops.

(IIIA 6.5.1) Effects on beneficial and other non-target organisms

Visual observations in the field and relevant data produced for the Ecotoxicology section 9.5 may be used. However, if there are any specific positive claims of safety to beneficial organisms used in IPM systems, these must be supported. For specific guidance, discussions with CRD are recommended.

5. References

AHDB Factsheet 04 Integrated slug control

AHDB Potato pest and disease management
AHDB Market Intelligence 2017-18

Potato Council - Managing the risk of late blight

Fungicide Resistance Management in Potato Late Blight, The Fungicide Resistance Action Group - UK (FRAG-UK) 2016

Food Standards Agency Pesticide Residue Minimisation Crop Guide Potatoes: Bradshaw and Ogilvy

Red Tractor Assurance for Farms – Crop Module Potatoes

SRUC Crop Technical Notes (TN482: Aphids and Aphid-borne Virus Disease in Potatoes, TN624: Weed Control In The Potato Crop, TN603: Soil Dwelling Free-Living Nematodes As Pests Of Crops)

The Agricultural Notebook 20th Edition, R Soffe

Relevant EPPO Guidelines

Target Specific

PP1/2 *Phytophtera infestans*
PP 1/32 *Rhizoctonia solani* on potato
PP1/46 Wireworms
PP1/51 Weeds in Potato
PP1/71 Aphid vectors of persistent viruses on seed potatoes
PP1/95 Slugs
PP1/230 Aphids on potato
PP1/143 Potato desiccants
PP1/164 Sprout suppressants in potato: at storage or in store application
PP1/226 Aphid vectors of non-persistent viruses on seed potatoes
PP 1/266 *Alternaria solani* and *Alternaria alternata* on potato and outdoor production of tomato

General Standards

PP 1/135 Phytotoxicity Assessment
PP 1/152 Design and analysis of efficacy evaluation trials
PP 1/181 Conduct and reporting of efficacy evaluation trials (including GEP)
PP 1/207 Effects on succeeding crops
PP 1/213 Resistance risk analysis
PP 1/223 Introdcution to the efficacy evaluation of PPPs
PP 1/225 Minimum effective dose
PP 1/226 Number of efficacy trials
PP 1/241 Guidance on Comparable climates
PP 1/242 Taint tests
PP 1/256 Effects on adjacent crops
PP 1/278 Principles of zonal data production and evaluation

APPENDIX 1

a) BBCH Growth stages

- **00-09 Principal growth stage Sprouting /Germination**

The onset of sprout growth that follows dormancy termination is accompanied by substantial increases in cell metabolism; sprouts appear from the eyes of the primary tuber.

- **10-19 Principal growth stage 1: Leaf development**
- **21-29 Principal growth stage 2: Formation of basal side shoots below and above soil surface (main stem)**
- **31-39 Principal growth stage 3: Main stem elongation (crop cover).**

All vegetative parts of the plants (leaves, branches, roots and stolons) are formed; stages 2 and 3 last from 30 to 70 days depending on planting date, soil temperature and other environmental factors, the physiological age of the tubers, and the characteristics of particular cultivars.

- **40-49 Principal growth stage 4: Tuber formation**. Approximately 30-60 days after the seed tuber is planted, tuber formation begins. Tubers are derived from lateral underground buds developing at the base of the main stem that when kept underground develop into stolons due to diagravitropical growth. When the conditions are favourable for tuber initiation, the elongation of the stolon stops, and cells located in the pith and the cortex of the apical region of the stolon first enlarge and then later divide longitudinally. The combination of these processes results in the swelling of the subapical part of the stolon.
- During enlargement tubers become the largest sink of the potato plant storing massive amounts of carbohydrates (mainly starch) and also significant amounts of protein. Furthermore, tubers decrease their general metabolic activity and as such behave as typical storage sinks.

  Potato tubers are harvested from 90 to 160 days after planting and this may vary with cultivars, production area, and marketing conditions. Starch the typically represents 20% of the fresh weight of mature tuber. After potato vines die back the skin of tuber thickens and hardens, which provides greater protection to tubers during harvest and blocks entry of pathogens to the tuber.

- **51-59 Principal growth stage 5: inflorescence (cyme) emergence**
- **60-69 Principal growth stage 6: Flowering**
- **70-79 Principal growth stage 7: Development of fruit**
- **81-89 Principal growth stage 8: Ripening of fruit and seed**
- **91-99 Principal growth stage 9: Senescence**

b) Information on potato timings in the UK

POTATOES 1ST earlies

Date	GS	Comments
Sown mid Jan/Feb (Cornwall/Pembrokeshire)		
End Feb	GS 15	
Mid April		Harvest – Cornwall
Mid May		Harvest – rest of country
End July/Mid August		March planted – all harvested April planted – 2nd earlies still harvesting

POTATOES maincrop

Date	GS	Comments
Sown Mid April (South) End April (North)		60-90% complete end May planting 40-100% complete early May planting
Early May	32% crop emerged (2002)	
End May/Mid June	GS 15	Meeting in the row, 40% ground cover
End June		Meeting along the row to 100% ground cover. BLIGHT SPRAY BEGINS
Early/mid July	GS 39 +	Meet between rows, 100% ground cover
End July/August	Starting to bulk	
Early Sept	GS 89	Berry ripening
Late Sept	Crop still bulking	Desiccation starts
Harvest bulk mainly end Aug/end Sept but up to end Nov in most years	Ranges	10% lifted end Aug 2000. 13% lifted early Sept 2000 71% early Nov, 87% early Jan (2001). 72% lifted Nov (2001). 10% lifted by 5 Sept in 2002. 85% lifted end Nov (2002) 49% lifted end Sept 2003. 40% lifted end Sept 2004. 72% lifted 7 Oct 2005, 5% lifted 24 August 2006 17% lifted 12 Sept 2006. 30% crops lifted end Sept 2007
Early Nov		Range 71-97% lifted
End November		Mostly lifted
Jan		Still 13% of last years crop to be lifted (2001)

March		Still 10% of last years crop to be lifted (2001).

APPENDIX 2

Potato planter information

Once a potato seedbed has been produced, the seed potatoes (tubers) need to be planted into the ridges. This needs to be a delicate procedure to avoid damage, especially so if the seed has been artificially sprouted. This is known as 'chitting'. Chitting is the process where tubers are stored in trays and encouraged with light and controlled temperatures to break dormancy and produce sprouts ahead of planting.

A potato planter must be capable of dealing with a large amount of seed material, about 40,000 tubers is acceptable to save on re-filling time. Manual planters are still used but this requires an operator to remove tubers from a hopper onto a series of rotating cups. More sophisticated, labour saving planters are automatic. Tubers are collected from the hopper by a row of cups mounted on a belt and carried towards a slot in the ridge of soil created by a vshaped soil opener, the ridge is then re-formed, and the tubers covered by a set of mouldboards. To ensure that uniform spacing is achieved, tubers need to be released at regular intervals, the effectiveness of the process can depend on accurate grading so that all tubers are of similar size and match the cup size. Two row planters are the standard, but four row planters are available.

APPENDIX 3: Effectiveness testing for blight fungicides, *Phytophthora infestans* (PHYTIN)

The results of the trial series (or where appropriate, a reasoned case) should permit an evaluation of the effectiveness of the plant protection product for control of potato blight. Evidence should include results of tests on foliage blight and, if claimed on the label, tuber blight. Guidance on trials techniques are given in EPPO Standard PP1/2(4) *Phytophthora infestans* on potato.

Evidence should be submitted from field trials only. As far as possible, evidence should be provided from 'natural' blight epidemics. However, data from inoculated/irrigated trials may be submitted in support of an application. When planning and conducting trials care should be taken to minimise the possibility of them acting as a source of inoculum to infect neighbouring crops. Infected plots should be desiccated as early as is practicable and before they pose a significant risk to nearby crops.

Artificial inoculation of selected plants in buffer areas can be very useful in initiating the epidemic and because subsequent spread of disease on to the trial plots is by natural means, it can provide a realistic test of a product. Care should be taken to ensure that, as far as possible, trial plots were exposed to equal inoculum pressure. Furthermore, the selection of strains for use in artificial inoculation warrants careful consideration and, in general, the strains ought to reflect the natural field population. However, this technique, in combination with appropriate standard treatments, could be used to provide evidence to support claims of control of specific strains of the blight fungus e.g. phenylamide-sensitive and phenylamide-resistant strains. The technique of mist irrigation can be used successfully to maintain favourable conditions for disease development when natural conditions may not be favourable. However, care should be taken to ensure that conditions are similar to natural conditions because there is some circumstantial evidence to suggest that differences in performance can occur between mist irrigated trials and unmisted trials. The technique could also be useful to provide evidence to support specific claims, such as rain fastness.

The trials design usually consists of the test product(s), reference product(s) and untreated control arranged in a randomised block design. Due to the risk of cross infection between plots, it may be necessary to treat the control plot (or other plots) with quick-acting desiccant if damage increases to an unacceptable level. Alternatively, the use of imbricated controls (control plots arranged systematically around the outer side of the randomised blocks) or excluded controls (control plots selected outside the trial area) could be considered. See EPPO Standard PP 1/152 on design and analysis of efficacy evaluation trials for details.

Dose, volume, method and interval of application of the test chemical ought to reflect the proposed label recommendations. For potato blight fungicides, which are normally applied as a programme of sprays, the number of and interval between treatments tested in trials should be consistent with the intended use. Where it is not possible to authorise a full programme of applications evidence or a reasoned case must be presented to support the proposed reduced GAP. A registered product of proven effectiveness should be used as a reference product. Number of and interval between sprays should be consistent with the test product. In order to increase the chances of obtaining meaningful data and to support the minimum effective dose

(MED), a number of trials should include reduced doses of test and standard treatments. At reduced doses, control should break down earlier in the epidemic and treatments may be more easily separated.

Where the proposed label claims include recommendations for use of the product with other plant protection products or adjuvants, information on the performance of the mixture should be provided. Where the product contains more than 1 active substance then a justification of the need for each active substance must be provided. It is likely this will require additional treatments to be included in the trials (see EPPO PP 1/306, 'General principles for the develoment of co-formulated mixtures of plant protection products').

In trials to determine the effectiveness of a product against tuber blight, it is important to demonstrate that any reduction in tuber blight is not just the result of a reduction in the level of inoculum coming from infected foliage if a claim of control is desired. This will require careful consideration of the trials design and fungicide programmes used. One approach, for example, would be to compare the test product with one known to have no direct effect on tuber blight. Where a direct effect on tuber blight cannot be demonstrated the label claim 'By reducing foliar blight [product] can also reduce the incidence of tuber blight' may be acceptable.

Assessment on the effects on tuber blight usually involves a measurement of percentage by weight and/or number of blighted tubers after an appropriate period of storage. Assessments should usually be based on a random sample of 100 tubers per plot. Where necessary, tubers should be cut in half to examine the flesh.

Results of percentage foliage blight at each assessment over the whole season should be provided for each treatment for every trial. In addition to presentation of actual numerical values, graphical presentation of the data is very helpful and is strongly recommended. Two other useful ways of summarising overall control provided by the treatments, which can be presented in addition to individual results are: (a) calculation of 'days delay' to a specific level of blight e.g. 75% blight; and (b) calculation of the areas under the disease progress curves.

A minimum requirement should normally be **10 trials** showing acceptable results. Normally, results should be presented from tests conducted over at least **two** growing seasons.

Effectiveness of a spray programme of the test product will be judged in comparison to the untreated control and a spray programme of the reference product(s). Unless there are good reasons to accept a poorer level of control than that provided by a standard reference product, the level, duration and consistency of control of the test product must be similar to that provided by the standard. Current products often give between two to five weeks delay to 75% foliage blight depending on blight pressure. Demonstration of acceptable control should permit a label recommendation for 'control' of potato blight. It should be demonstrated that the intended recommended dose is the minimum necessary to achieve acceptable control of potato blight. Blight control may be extrapolated between the major maturity classes of potato, i.e. first-early, second-early and main crop.

Data on the product generated in other countries may be acceptable where it is considered to be relevant to conditions occurring in the United Kingdom. It is important that the applicant

justifies the basis for such extrapolation and this would be expected to include a consideration of the agressiveness of the blight strains and their relevance to UK populations.