FACTSHEET 03/18

Vegetable seed quality, storage and handling

Figure 1. Untreated onion, coriander and Brassica seed

Seeds represent a significant and essential proportion of the input costs in vegetable production. This factsheet has been produced following requests from growers for guidance on how to get the best from seed and therefore maximise the value returned from the initial investment.

Action points

- **Request information on germination levels for each seed lot and adjust drilling rates accordingly**
- **Do not assume that seed has been tested for seed-borne pathogens**
- **Request information on the seed health tests that have been performed (if any) and the tolerance standards that have been applied (or number of seeds tested)**
- **Do not assume that seed treatments (eg fungicides) are effective against all potential seed-borne pathogens**
- **Request information on the seed health treatments that have been applied and any post-treatment confirmations of efficacy**
- **Store seed in cool (<10°C), dry (<50% RH), stable conditions**
- **Store pesticide-treated seed securely, in original packaging with appropriate hazard and handling warnings**
- **Follow good practice and stewardship guidelines for pesticide-treated seed**
- **Sow or drill primed seed as soon as possible after receipt**
- **Ensure pesticide-treated seed is covered in the field**
- **Dispose of surplus pesticide-treated seed via a licensed waste contractor**
- **Keep records of seed lot numbers, treatments, labels, test results and operations**

Legislation and standards

The legislation governing the marketing and sale of commercial vegetable seed is contained in the **Seed Marketing Regulations 2011** and its subsequent amendments. There are parallel regulations for Scotland, Wales and Northern Ireland. The legislation interprets and refers to various EC directives and derogations, particularly EC directive 2002/55 on the marketing of vegetable seed and its subsequent amendments. Essentially, the vast majority of vegetable seed is sold as standard seed.

Standard seed is defined in the legislation as 'seed that is intended mainly for the production of vegetables and has been approved by the Secretary of State as having sufficient varietal purity and varietal identity'.

The requirements for standard seeds are listed as:

1. Crop inspections by official or licensed crop inspectors must be carried out in accordance with Article 2(4)(A) of, and Annex I to, Council Directive 2002/55/EC on the marketing of vegetable seed (5), and the crop must satisfy the conditions in that Annex.
2. The seed produced by the crop must be sampled in accordance with Article 25 of, and Annex III to, that Directive and must satisfy the conditions in Annex II to that Directive.
3. Sub-paragraph (1) does not apply in the case of standard seed.
4. Diseases and harmful organisms that reduce the usefulness of the seed must be at the lowest possible level.
5. After marketing, vegetable seed is subject to control by the Secretary of State for varietal identity and varietal purity.

The implications of this legislation are that a grower can expect **standard seed** to meet minimum standards of purity and germination (see Table 1) but it does not provide for any particular standards with respect to seed-borne diseases. However, the plant health legislation, **The Plant Health (England) Order 2015** (and its amendments and equivalents in Scotland, Wales and Northern Ireland), requires that seeds of a relatively few species that are hosts of specific quarantine pests and diseases either originate in an area known to be free from the quarantine pest/pathogen or have been tested and found free.

It should be noted that although a seed-borne pathogen may be considered a quarantine pathogen for the UK, there may not be any requirement for seed of the host species to be tested, eg *Xanthomonas hortorum* pv. *carotae* that causes bacterial blight of carrots is listed as a quarantine pathogen in the UK (but not in the EU) and is seed-borne, but there is no requirement for seed to be tested.

Germination and testing

For most vegetable species, the levels of germination required for standard seed are in the range 65–75 per cent (see Table 1). These minimum standards are less than ideal for most modern production requirements, so, at the very least, growers should request information from seed suppliers and adjust drilling rates accordingly.

Table 1. Purity and germination standards for standard vegetable seeds (EC Directive 2002/55)

Crop	Purity (%)	Germination (%)
Asparagus	96	70
Aubergine	96	65
Beet (Cheltenham)	97	50 (clusters)
Beet (other), chard	97	70 (clusters)
Broad bean	98	80
Carrot	95	65
Cauliflower	97	70
Celery	97	70
Chinese cabbage	97	75
Corn (sweet)	98	85
Cucumber	98	80
Endive	95	65
Fennel	96	70
French bean	98	75
Lamb's lettuce	95	65
Leek	97	65
Lettuce	95	75
Marrow/Courgette	98	75
Onions	97	70
Others	97	75
Parsley	97	65
Pea	98	80
Peppers	97	65
Radish	97	70
Runner bean	98	80
Spinach	97	75
Tomato	97	75
Turnip	97	80
Welsh onion, bunching onion	97	65
Witloof chicory, Italian	95	65

Many of the major seed suppliers voluntarily apply germination standards that are above the minima required by legislation and follow the higher standards defined in the European Seed Association (ESA) specifications for precision (graded) seed and pellets. More information about the standards that different seed suppliers aim to achieve can usually be found in their catalogues or online.

In order to ensure that seed meets the required germination levels, testing should be done according to the International Seed Testing Association (ISTA) standards. This is usually performed by seed companies in their own in-house laboratories but may also be done by independent laboratories. The ISTA standards set out the methods and conditions for germination tests for each species. The test conditions usually represent optimum conditions for the species concerned, so the reported germination is unlikely to be achieved in the suboptimal conditions of a real field situation.

It is also important to appreciate that emergence is not the same as germination. Germination can be considered as defining the maximum potential emergence, but actual emergence in the field depends on the interaction of a variety of different factors, such as vigour, seed age, seed health, seed treatments and enhancements, soil health and structure, temperature and moisture.

Seed health and testing

Seed health

Many important diseases of vegetable crops are seed-borne; (non-definitive) examples of some of the most significant are listed in Table 2. The most effective way to control these diseases is to use pathogen-free seed. For some diseases, particularly those caused by bacteria, where there are few, if any, chemical control options, the use of pathogen-free seed is the ONLY reliable means of effective control.

The production of pathogen-free seed should ideally start with growing seed crops from pathogen-free parent seed in areas where the pathogen is not known to occur. This should then be followed by regular inspections of the growing seed crop and appropriate management approaches to prevent disease development. Finally, further precautions need to be taken during harvesting, storage and cleaning to prevent cross-contamination.

Table 2. Examples of seed-borne diseases of vegetable

Crop	Pathogen (disease)
Aubergine	*Verticillium dahliae* (wilt)
Basil	*Peronospora belbahrii* (downy mildew) *Fusarium oxysporum* f.sp. *basilici* (wilt)
Beet, chard	*Cercospora beticola* (leaf spot); *Pleospora betae* (blackleg, leaf spot, damping off) *Pseudomonas syringae* pv. *aptata* (bacterial leaf spot) *Peronospora farinosa* f.sp. *betae* (downy mildew) *Curtobacterium flaccumfaciens* subsp *betae* (silvering, bacterial wilt) Beet western yellows virus
Brassica	*Alternaria brassicae, A. brassisicola* (dark leaf spot) *Mycosphaerella brassicicola* (ring spot) *Peronospora parasitica* (downy mildew) *Phoma lingam* (blackleg, canker) *Pseudomonas syringae* pv. *maculicola* (bacterial leaf spot) *Pseudomonas cannabina* pv. *alisalensis* (bacterial blight) *Xanthomonas campestris* pv. *campestris* (black rot)
Carrot	*Alternaria dauci* (blight) *Alternaria radicina* (black root rot, poor emergence) *Cercospora carotae* (leaf blight) *Xanthomonas hortorum* pv. *carotae* (bacterial blight)
Celery	*Cercospora apii* (leaf spot) *Septoria apiicola* (leaf spot, blight) *Pseudomonas syringae* pv. *apii* (bacterial leaf spot)
Coriander	*Pseudomonas syringae* pv. *coriandricola* (bacterial blight)
Cucurbits	*Pseudomonas syringae* pv. *lachrymans* (angular leaf spot) *Xanthomonas cucurbitae* (bacterial leaf spot) *Cucumber mosaic virus* *Zucchini yellow mosaic virus* *Didymella bryoniae* (gummy stem blight) *Acidovorax citrulli* (bacterial blotch)

Crop	Pathogen (disease)
French bean, runner bean	*Pseudomonas syringae* pv. *phaseolicola* (halo-blight) *Xanthomonas axonopodis* pv. *phaseolicola* (bacterial blight) *Ascochyta phaseoli* (leaf and pod spot) *Colletotrichum lindemuthianum* (anthracnose) *Bean common mosaic virus*
Leek	*Pseudomonas coronafaciens* pv. *porri* (bacterial blight)
Lettuce	*Septoria lactucae* (leaf spot) *Fusarium oxysporum* (wilt) *Verticillium dahliae* (wilt) *Xanthomonas campestris* pv. *vitians* (bacterial leaf spot) *Lettuce mosaic virus*
Onions	*Botrytis aclada/allii* (neck rot) *Pseudomonas coronafaciens* pv. *porri* (bacterial blight) *Xanthomonas axonopodis* pv. *allii* (bacterial blight) *Ditylenchus dipsaci* (nematode)
Parsley	*Septoria petroselini* (leaf spot))
Parsnip	*Itersonilia pastinaceae* (black canker)
Pea	*Ascochyta pisi* (leaf and pod spot) *Fusarium oxysporum* f.sp. *pisi* (wilt) *Mycosphaerella pinodes* (leaf and pod spot) *Pseudomonas syringae* pv. *pisi* (bacterial blight) *Pea seed-borne mosaic virus* *Pea early browning virus*
Peppers	*Xanthomonas vesicatoria* (bacterial spot) *Pepper mild mottle virus* *Tobacco mosaic virus* *Tomato mosaic virus*
Radish	*Pseudomonas syringae* pv. *maculicola* (bacterial leaf spot) *Pseudomonas cannabina* pv. *alisalensis* (bacterial blight)
Spinach	*Peronospora farinosa* f.sp. *spinaciae* (downy mildew) *Verticillium dahliae* (wilt) *Pseudomonas syringae* pv. *spinaceae* (bacterial leaf spot)
Tomato	*Clavibacter michiganensis* subsp. *michiganensis* (bacterial canker) *Pseudomonas syringae* pv. *tomato* (bacterial speck) *Xanthomonas vesicatoria* (bacterial spot) *Alternaria solani* (blight) *Pepino mosaic virus* *Tobacco mosaic virus* *Tomato mosaic virus*

Figure 2. Untreated, film-coated and pelleted onion seed

Despite precautions during seed production and the absence of visible disease symptoms in the seed crop, this is no guarantee that the seed is pathogen-free.

The most reliable way to determine the health status of a seed lot is to test it.

For some seed-borne diseases, treatments may be applied to the seed in an attempt to reduce or eliminate seed-borne pathogens (see Treatment section). Decisions on whether to treat a particular seed lot may be based on the results of seed health tests. In some cases, treatments are applied on a precautionary basis, ie irrespective of any test results or because it may be more cost-effective to treat all seed rather than test.

Seed health testing

Except for a relatively few quarantine pathogens on imported (into the EU) seed, there is no specific requirement or obligation for vegetable seed to be tested for seed-borne pathogens. It is likely that that major seed suppliers will test seed for certain high-profile pathogens, or alternatively they may simply rely on treatments. It is thus important to question seed suppliers about their policies.

Seed health testing requires specialist expertise and facilities and is perceived as expensive. Some seed companies may do this in-house and/or may have seed tested at independent laboratories.

It is important to appreciate that it is not possible to guarantee that a seed lot is completely healthy, and any claims along those lines should be treated with suspicion. This is because testing is only ever performed on a sample of seed from the seed lot as a whole, and no test method is completely reliable. Thus, associated with any test result are:

- **Tolerance standard** – the minimum percentage of infested seed that can be reliably detected in a sample (depends on the sample size)
- **Analytical sensitivity** – the minimum numbers of the pathogen which can be reliably detected in a sample (depends on the details of the method)

This means that a negative test result does not necessarily mean that a seed lot is completely healthy but that the seed lot **has an infestation level below the tolerance standard and analytical sensitivity of the seed test.**

The tolerance standards applied should ideally be based on an understanding of the particular disease epidemiology, particularly the rate of seed-to-seedling transmission and rate of spread. Unfortunately, such information is lacking for many seed-borne diseases of vegetable crops.

The sample sizes tested and hence the effective tolerance standards achieved may vary from supplier to supplier. Although generally accepted standard methods and sample sizes have been developed and agreed for some high-profile seed-borne diseases (ISTA , ISHI-Veg), this is not the case for many seed-borne pathogens.

Thus, test results and the effective health standards achieved may differ from supplier to supplier. It is therefore important to clarify these aspects with your suppliers.

Typically, in a direct test for many seed-borne fungal pathogens, a sample of 300 seeds may be examined for each seed lot. This would imply a tolerance standard of 1 per cent (at a probability level of 95 per cent[1]), ie a negative test result means that the infection level in the seed lot is likely to be less than 1 per cent. In the context of field crops, eg onions with a drilling rate of 500,000 seeds per ha, this means there could still be 5,000 infested seeds per ha despite a negative test result. Clearly, if the conditions are right, this could lead to significant disease development, despite a negative test result. For an indirect test for bacterial disease of transplanted crops, eg black rot in brassicas, a sample of 30,000 seeds may be tested for each seed lot. This would imply a tolerance standard of 0.01 per cent (at a probability level of 95 per cent). Further examples of the effective tolerance standard for different sample sizes are shown in Table 3.

Table 3. Effective tolerance standards achieved for different numbers of seeds tested. The tolerance standard represents the percentage infection that can be reliably detected (with a probability of 0.95) in a sample of the given size

No. of seeds tested	Effective tolerance standard (%)
100	3.0
300	1.0
400	0.75
1,000	0.3
3,000	0.1
10,000	0.03
30,000	0.01

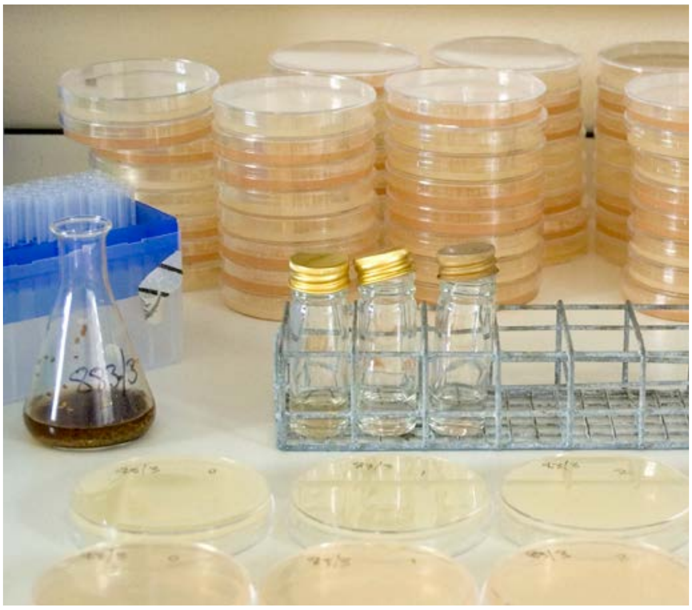

Figure 3. Seed testing for bacterial pathogens - dilution and plating

[1] A probability of 95 per cent means that, given the same negative result, the true level of infestation in the seed lot is less than the tolerance standard 19 times out of 20.

Seed treatments

Pesticides

Chemical, biological and physical seed treatments may be applied to seed to provide control of a range of pests and diseases. Application of pesticides via seed treatments is generally considered to be a relatively safe, cost-effective and environmentally-friendly means of crop protection.

Although it is common practice for many vegetable seeds to be supplied with at least a fungicide seed treatment, it is still an obligation as part of the **Pesticide Code**[2] to consider if a pesticide treatment is necessary or appropriate for the situation. For example, it might be considered that a specific fungicide treatment is not necessary if a seed test has shown that the target pathogen is not present on the seed. On the other hand, given the potential limitations of seed health tests, a precautionary treatment could still be considered appropriate, as the amount of pesticide applied may be far less than a field application if a disease were to develop in the field.

Typical pesticide seed treatments include:

- Insecticides
  - Control pests that may directly attack the seed or seedling
  - Provide early control of root and foliar pests
- Fungicides
  - Improve emergence and establishment by providing direct protection against soil-borne and seed-borne pathogens
  - Reduce seed-to-seedling transmission of seed-borne foliar diseases
- Physical treatments eg hot air, hot water treatment or aerated steam
  - Reduce seed-borne pests and pathogens

Figure 4. Seed testing for *Botrytis aclada/allii* (onion neck rot)

[2] Defra (2006) Pesticides: Code of practice for using plant protection products [http://www.hse.gov.uk/pesticides/resources/C/Code_of_Practice_for_using_Plant_Protection_Products_-_Complete20Code.pdf]

It is important to be aware of the targets and efficacy/mode of action of fungicide seed treatments in particular. Most general-purpose fungicide treatments are primarily effective against the soil-borne fungi that cause damping off and reduce emergence. They may have little activity or be ineffective against specific seed-borne pathogens. Some fungicides may be merely inhibitory to the target pathogen; subsequent seed tests may indicate the absence of the pathogen, but it may still survive on the seed and be transmitted to the seedling (see AHDB Horticulture-funded project FV 423a for an example in onions and neck rot).

Different suppliers may have different policies about seed treatments for particular pathogens. In principle, all pesticide treatments should be used on an ‘as needed’ basis, based on the result of specific seed health tests, but some suppliers may routinely apply precautionary treatments without testing or irrespective of test results.

A seed treatment is only as good as the test or trial used to evaluate it: claims of ‘eradication’ should be treated with great scepticism.

A list of seed treatments currently approved in the UK is given in Table 5.

Imported seed may be treated with pesticide products that are not approved in the UK. Seed may be exported for treatment with non-approved products and then reimported. The use of such seed does not infringe the pesticide regulations, but nevertheless it is incumbent on the supplier to ensure appropriate labelling (in English), and for growers to perform an appropriate health and environmental safety risk assessment.

Enhancements

As well as treatments targeting pests and diseases, seed may be subject to a number of other treatment processes aimed at enhancing their performance:

- Cleaning
  - Removes dust and crop debris that may be present in the seed lot
  - May improve health status
  - May reduce health status due to cross-contamination if machinery is not cleaned and disinfected between seed lots
- Grading
  - Results in seed with a more uniform size, within defined limits
  - Combined with precision drills, this results in more precise, even spacing in the field, leading to a more uniform crop
  - Contributes to optimisation of marketable yield
- Priming
  - Seed will emerge faster and more uniformly, to give an even plant stand
  - Contributes to optimisation of marketable yield

- Film coating
  - Coloured seed more easily visible in the soil or sowing medium
  - Improves the flowability of seeds through sowing or drilling equipment
  - Contributes to more accurate sowing or uniform drilling
  - Often used for, or combined with, application of pesticides
  - Facilitates accurate application of pesticides, resulting in a virtually dust-free product
  - Reduces environmental and health and safety concerns
- Pelleting
  - Increases size, weight and uniformity of seed
  - Often used for, or combined with, application of pesticides
- Micro-pelleting
  - Intermediate between film coating and pelleting
  - May improve drilling uniformity compared to film coating

Storage and handling

Storage

There is little definitive information on the practical storage of commercial vegetable seed. Most research has been conducted in the context of long-term storage of relatively small quantities of many different seed lots in 'genebanks'. The recommendations provided here should be considered as a general guide. More specific guidance may be provided by the supplier on the packaging or label and should be followed whenever possible.

Most vegetable crop species display 'orthodox' seed behaviour, in that they tolerate maturation drying and can remain viable for years. Apart from genetics, a number of factors influence the storability of seed – the most important are:

- Initial seed quality
- Initial moisture content of the seed
- Storage conditions (ie temperature and humidity)

The optimum moisture content for maximum storability varies for different species but is generally in the range 5–14 per cent (fresh weight basis). Too high and the viability will decline more rapidly, and may permit fungal and bacterial growth, too low and seed may become dormant or more easily damaged. Generally, seed will be supplied at the optimum moisture content for the species.

The general principle for storage conditions, to maximise the shelf life of most vegetable seed, is to keep it in a cool, dry and stable environment. This generally means at a temperature below 10°C and less than 50 per cent RH (relative humidity). Stability is important as, for example, fluctuations in temperature may increase the risk of condensation and promote deterioration.

Seed should be kept out of direct sunlight and extremes of temperature avoided. This is particularly relevant during transportation: temperatures in the boot of a car, main body of an unattended vehicle or enclosed tractor cab can easily reach over 40°C in less than an hour on a sunny day. **If you wouldn't leave your dog in the vehicle, don't leave your seed!**

Table 4. Storability categories and expected shelf life for a range of vegetable seeds

Crop	Storage category[a]	Life expectancy (years)[b]
Asparagus	1	3
Aubergine	2	4
Basil	2	-
Bean	1	3
Beet, chard	3	4
Brassica	2	3–5
Carrot	2	3
Celery	2	3
Coriander	1	-
Corn (sweet)	2	2
Cucurbits	2	4–5
Endive	2	5
Fennel	1	4
Leek	1	2
Lettuce	1	6
Onion	1	1
Parsley	1	1
Parsnip	1	1
Pea	2	3
Pepper	1	2
Radish	2	5
Spinach	2	3
Tomato	3	4
Other herbs	1	-

Notes:

a: Storability category from Justice & Bass (1978), where 1 = short (1–2 years), 2 = intermediate (3–5 years), 3 = long (more than 5 years).

b: Seed useful life expectancy from Maynard & Hochmuth (1997).

Small seeds are likely to be supplied in hermetically sealed containers or packets, already at the optimum moisture content for storage. It is therefore simply a matter of storing them in a refrigerator[3] or cool store, and packs should only be opened just before sowing or drilling. Once packets are opened and seed is exposed to ambient humidity, seeds can absorb moisture relatively quickly (hours). Therefore, surplus/unused seed should be returned to the original packaging and resealed into an air-tight container at low humidity as soon as possible and returned to the refrigerator or cool store. This can be achieved by placing opened packets into plastic boxes or other containers with a positive 'rubber' seal (eg 'clip boxes', Kilner jars, screw-top jars) together with some moisture-absorbent silica gel or similar desiccant (ideally self-indicating). Typically, the standard plastic boxes that do not have a 'rubber' seal do not provide an adequately air-tight seal. Vacuum sealing in purpose-made vacuum containers or plastic vacuum bags is another alternative.

Large seeds may be supplied in moisture-resistant (eg polythene-lined, waxed paper) sacks or in standard paper sacks or woven polypropylene that allow moisture exchange with the ambient air. If the sacks prevent moisture transfer, then, as with small seeds, it is a matter of storing as cool as possible and only opening packs just before drilling. If the seeds are supplied in packaging that allows air exchange, then ideally they should be stored in a conditioned storage facility where both temperature and humidity are controlled. Certainly, if in a store with cooling units, consideration should be given to humidity control, otherwise it may be better to store in a well-ventilated ambient 'cool' store. Of course, the need for storage can be avoided by ordering just what is required and having it delivered just in time for drilling.

Some seed suppliers may be happy to store surplus seed on behalf of their customers in their own seed storage facilities.

Storage facilities used for treated seed should be secure (from children, animals, unauthorised persons) and steps taken to prevent the risk of contamination of drains and water courses. There should be appropriate health and safety notices and/or labels, indicating the potential for hazardous pesticides, requirements for appropriate personal protection equipment and other precautions, and actions in case of spillage, etc.

Shelf life

Apart from the storage conditions, the key factor determining the useful shelf life of seed is the initial seed quality (ie germination, vigour and health status). There is little value in storing seed of low quality.

It is also important to be aware that at the point of delivery seed may already have been stored for one or more years by the supplier. Suppliers are obliged to label the seed with the year of packaging or the last germination test, but there is no requirement to indicate the year of production.

[3] This should be secure and not be used to store food and drink for human or animal consumption

Figure 5. Untreated carrot seed

The relative useful storability for different species, under ideal conditions, has been classified into three categories by Justice & Bass (1978):

1. Short (1–2 yrs)
2. Intermediate (3–5 yrs)
3. Long (>5yrs)

Recommendations of the useful life expectancy have also been provided by Maynard and Hochmuth (1997). Both values are provided in Table 4, but it should be noted that there are discrepancies between the two classifications for some species.

It is recommended that seed which has been stored from one season to the next should at least be tested for viability before use, and drilling rates adjusted to compensate for any reductions in germination. It may be feasible to perform a simple germination test on the farm, or alternatively the seed supplier may offer a testing service, or a sample should be sent to an independent test laboratory. However, it is important to be aware that the vigour of stored seed declines more rapidly than germination. Thus, whilst stored seed may apparently still have good germination in a standard germination test, its performance and emergence in the field may have deteriorated to inadequate levels. Low-vigour seed may also be more susceptible to disease. It may therefore be appropriate to request a vigour or stress test in addition to standard germination.

Treated seed

Seed which has been treated, particularly primed and chemically treated seed, can be expected to have a shorter shelf life than untreated seed. Primed seed has been physiologically activated and so may deteriorate quicker than non-primed seed and/or revert to normal germination.

Chemical seed treatments may have direct adverse effects on germination and vigour, which develop over time, or the chemicals themselves may degrade and become less effective.

For these reasons, seed suppliers tend to apply seed treatments to batches of seeds intended for use within a short period (months) and certainly within the same growing season. Primed seed in particular should be stored at 4°C, sown/drilled as soon as possible, and should not be expected to perform as 'primed' seed beyond 6 months. Pesticide treatments should not be expected to be as effective on seed stored into the following growing season.

Handling, health and safety

A general principle for the physical handling of all seed is to be as gentle as possible. This is particularly the case for large seeded legumes, where, for example, falls from significant heights can result in physical damage to the embryo and reduced germination/emergence. Primed seed may also be more easily damaged by poor physical handling.

Most of the remainder of this section is targeted at pesticide-treated seed, but some aspects, eg cautions about dust, potentially apply to non-treated seed.

Treated seed

Treated seed is considered a commodity. Seed which has received pesticide or other chemical or biological treatments should be considered as potentially hazardous to health and the environment and appropriate risk assessments relating to storage, operations and disposal performed (and recorded) in line with current legislation.

Treated seed should be labelled by the supplier. The label will include:

- Name(s) of the seed treatment product(s) applied and active ingredients
- Basic precautions
  - Do not handle unnecessarily
  - Do not use treated seed as food or animal feed
  - Keep treated seed secure from children, animals and wildlife at all times during storage and use
  - Bury or remove spillages
  - Do not reuse sacks or containers that have been used for treated seed for food or feed
  - Wash hands and exposed skin before meals and after work
  - Do not apply treated seed from the air
- Additional precautions (as appropriate for the treatment and as may be required by HSE), for example:
  - Operator protection: wear suitable gloves
  - Environmental protection: harmful to game, wild birds and animals. Bury spillages
- Contact details for the marketing company
- Additional advisory information, for example:
  - Storage recommendations
  - Drilling directions

Drilling

To maximise returns from the investment in seed, particularly precision and primed seed, it is essential that drills are accurately calibrated prior to commencing field operations. Whenever possible, drills should be calibrated using a sample of the actual seed that is to be drilled, as any treatments applied may affect its 'flowability' through the equipment.

Operators should be particularly aware of dust generated during filling of seed hoppers and take appropriate precautions. Exhausts from pneumatic or vacuum drills should be directed towards the soil to minimise dust drift.

It is particularly important to ensure that all treated seed is covered by soil so it does not attract birds and mammals. Ensuring that drills are well-maintained, operated at the correct speed and there is a good seedbed will go some way to achieving this. After drilling, check seed has been covered before leaving the field, especially in high-risk areas, eg headlands and corners.

Spillages of treated seed represent the greatest risk to the environment as these result in a high concentration of both seeds and pesticide in one location.

Minimise the risk of spillages by:

- Taking time and care when filling/emptying hoppers
- Avoiding filling where spillages are difficult to clear up, eg fill hoppers over hard standing rather than grass or headlands
- Ensuring no seed can be spilt when in transit to or from fields

Clear up spillages of treated seed immediately. Any field spillages of treated seed should be collected up and ideally drilled, returned to the original package and stored, or buried *in-situ* (small spills only).

Surplus seed that has not been sown/drilled should be returned to the original packaging and stored for further use or as a reference in case of subsequent issues. Surplus seed that is no longer required should be disposed of via a licensed waste-disposal contractor.

Empty packages or labels should be retained at least until the relevant details have been recorded (see Records) and then disposed of via a licensed waste-disposal contractor.

Records

Keep detailed records of the seed lot numbers, the treatments applied, the date of delivery from the supplier, storage conditions, and date of sowing/drilling, plus other relevant operational information and any other information obtained from the supplier, such as germination and seed health test results.

Figure 6. Untreated beetroot seed

Further information

Anon. (2014) Treated Seed: Best Practice Guide. [http://www.voluntaryinitiative.org.uk/media/1049/seed-treatment-mar-2014.pdf]

Bayer (2017) How to use seed treatments safely and effectively. [https://cropscience.bayer.co.uk/mediafile/100476675/bayer-stewardship-guide.pdf]

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Justice, O.L. & Bass, L.N. (1978) Principles and practices of seed storage. USDA Agriculture Handbook Number 506. 289 pp.

Maynard, D.N. and Hochmuth, G.J. (1997) Knott's Handbook for Vegetable Growers. 4th Edition. NJ, USA: Wiley & Sons. 640 pp.

The Seed Marketing Regulations 2011

The Plant Health (England) Order 2015

Figure 7. Untreated Dill seed

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