

Project title: Use of potassium hydrogen carbonate for powdery mildew control

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## SUMMARY

There is increasing interest among UK growers in using alternatives to synthetic fungicides as components of integrated disease management. One such option is potassium hydrogen carbonate (also known as potassium bicarbonate,  $\text{KHCO}_3$ ). This is a naturally occurring substance that is already widely used in the food industry. Potassium bicarbonate now has a Commodity Substance Approval (see Appendix) from the Pesticides Safety Directorate (PSD) for use as a fungicide on all horticultural crops. Research and grower experience, particularly in the USA, has shown that it is useful for the control of powdery mildew diseases on a wide range of crops.

The maximum approved rate for potassium bicarbonate is 20 g/L water (2% solution), with a maximum total dose of 60 kg/ha per year (for outdoor crops). Its efficacy against powdery mildew is improved by using an adjuvant in the spray mixture.

Potassium bicarbonate is useful as a component of an integrated strategy for management of powdery mildew. Since it acts as an eradicant fungicide on most crops, control of powdery mildew is most effective when it is used in a programme with protectant fungicides. Repeated applications are often required since the product is not persistent and development of powdery mildew diseases can be rapid. Potassium bicarbonate is reported to be effective against other diseases, such as black spot on roses and grey mould (*Botrytis cinerea*) on ornamentals, although the majority of experience with the product is against powdery mildews.

Advantages of using potassium bicarbonate are that there is a low risk of pathogen resistance, it is a natural product, it is cheaper than synthetic fungicides, it can be used close to harvest and meets the Food Standard Agency initiatives on reducing residues. Growers should note that there is little information on the use of potassium bicarbonate in mixtures, and that phytotoxicity can occur on some crops.

## USE OF POTASSIUM HYDROGEN CARBONATE FOR POWDERY MILDEW CONTROL

### 1. Report terms of reference

#### *Overall objective:*

To provide HDC members with a comprehensive guide to the use of potassium hydrogen carbonate (potassium bicarbonate) for powdery mildew control in both ornamental and edible crops.

#### *Specific objectives:*

- To comment on the history of potassium bicarbonate for the control of plant diseases
- To provide a review of the literature covering mode of action, diseases controlled, application rates and phytotoxicity
- To summarise observations by growers and horticultural consultants on its use in the UK in 2004
- Where possible, to provide recommendations for individual crops including use of adjuvants/wetters and interactions with other pesticides
- To provide recommendations on the use of potassium bicarbonate as a component of integrated disease management for powdery mildew
- To comment on any limitations on use or practical issues observed by those using the product
- To provide a list of relevant references and websites; both generic and crop specific

#### *Approach:*

The report was compiled in consultation with horticultural consultants, growers, and agro-chemical company representatives. Literature reviewed included papers from peer-reviewed journals, internet information, trade-press articles, and scientific reports (HDC and Defra).

### 2. Introduction

In March 2004, 99.0% w/w potassium hydrogen carbonate was granted a Commodity Substance Approval (see Appendix) by the Pesticides Safety Directorate (PSD), for use as a horticultural fungicide on all protected and outdoor ornamental and edible crops. This followed an initiative by Peter Glendinning (adviser and researcher to the National Hops Association) and the Horticultural Development Council (HDC), particularly the Soft Fruit Panel and Vivian Powell. Potassium hydrogen carbonate (chemical formula  $\text{KHCO}_3$ ) is also known as potassium bicarbonate (used throughout this report) and potassium acid carbonate.

Commodity substances are chemicals that have a variety of alternative and often widespread non-pesticidal uses, but also have potential for use as a pesticide. For a commodity substance to be used as a pesticide, it requires approval under the Control of Pesticides Regulations (COPR). Approval is granted only for the use of the substance; approval is not given for sale, supply, storage or advertisement. There is no approval holder, and no pesticide product label, but approval and associated conditions of use are published in the guide to approved pesticides on the PSD website ([www.pesticides.gov.uk](http://www.pesticides.gov.uk)).

There is increasing interest by UK growers in using alternatives to synthetic fungicides as components of integrated disease management. One such option is potassium bicarbonate, which is a naturally occurring substance that is already widely used in the food industry for example in baking powder and to control acidity in jams. It also has medicinal and industrial uses, such as in fire extinguishers. Its chemical formula is  $\text{KHCO}_3$  and it is an alkali.

Potassium bicarbonate has been used since at least 1933 in the USA and elsewhere for plant disease control. Research with a range of bicarbonates revealed that selecting the correct bicarbonate for a particular disease was important (Moore, 1996). For example ammonium and sodium bicarbonates had the strongest effect on grey mould on grapes (*Botrytis cinerea*), while potassium bicarbonate worked best against others. Potassium bicarbonate consistently provided the best control of powdery mildew.

Growers in the USA have found that potassium bicarbonate gives effective control and eradication of powdery mildew diseases on a wide range of horticultural crops (cucumbers, courgettes, pumpkins, fruit, roses and hops) making it an ideal alternative to synthetic fungicides. There is limited evidence of efficacy against other diseases, such as black spot on roses (*Diplocarpon rosae*), anthracnose in cucurbits (*Colletotricum lagenarium*), and alternaria, fusarium and downy mildew in a range of crops (Kuepper *et al.*, 2001).

Many UK growers are still unaware of the approved use of potassium bicarbonate as a horticultural fungicide.

It should be noted that products containing potassium bicarbonate at less than 99% are not classified as food grade, and are not covered by the Commodity Substance Approval. Such products are marketed for the horticultural industry as 'foliar supplements' or 'foliar feeds' and are being used by UK growers. Experience from UK growers and consultants suggests that under some circumstances, foliar feeds and supplements containing potassium bicarbonate may give incidental control of powdery mildew, but they are not marketed for this purpose. Reference will be made to their use in the crop specific pages (Section 6).

### 3. Mode of action of potassium bicarbonate

The precise mode of action of bicarbonates against fungi is not fully understood but it is thought to be due to a combination of factors. It was first suggested that bicarbonates affected fungal disease by changing the pH on the leaf surface. However, more recent work indicates that potassium bicarbonate damages powdery mildew spores, leading to dehydration and spore death, thus reducing disease spread. Other studies suggest that potassium bicarbonate causes an imbalance of potassium ions in the cell walls of fungal hyphae, causing their collapse. Since potassium bicarbonate acts against powdery mildews by more than one mode of action, the risk of strains developing resistance to the product is low.

Potassium bicarbonate has eradicant activity against powdery mildew fungi, in that it can delay or suppress disease development after symptoms are visible. It acts as a contact fungicide, killing spores and hyphae of powdery mildew on the plant surface within minutes. It is less effective as a protectant fungicide.

### 4. Product use information

#### *Rates:*

- The maximum approved rate for potassium bicarbonate is 20 g/L water (2% solution), with a maximum total dose of 60 kg/ha per year on outdoor crops (Appendix)
- For a high volume spray, a rate of 5 kg/1000 L of water (0.5% solution) is a suggested starting point
- Some researchers have used up to 2% spray solutions, but rates of 0.5-1% are generally found to suffice.

#### *Adjuvants:*

- The efficacy of potassium bicarbonate against powdery mildew is improved by using an adjuvant in the spray mixture
- Experience has shown that silicon-based wetters are particularly effective. Products based on di-1-p-menthene (e.g. the products Mangard, Spraygard, Sprayfast and, Spread and Seal), Silwet L-77, Codacide Oil, Activator 90 and Agral can also be effective. Insecticidal soap (10 g/L) has been used together with potassium bicarbonate for its surfactant qualities, reportedly giving better adhesion and more even spread of potassium bicarbonate over the leaf surface
- In the USA, potassium bicarbonate is often used together with a range of oil-based adjuvants ('horticultural oils')
- Adjuvants are generally used at 1 L/1000 L of spray solution.
- Check the PSD adjuvant information database to ensure the intended use is in accordance with the conditions of approval of the pesticide and that use is in accordance with any conditions to which use of that adjuvant with that pesticide is subject. In particular it should be noted that some adjuvants have a 30 day harvest interval.

#### *General points:*

- Potassium bicarbonate is most effective against powdery mildew when repeated applications are made, because it is not persistent on the plant and because disease development is potentially rapid
- It can be used in mixtures with a protectant fungicide such as sulphur

- Potassium bicarbonate should not be mixed with acids or with undiluted pesticides
- It is very hygroscopic and rapidly goes hard if it becomes moist in storage
- There is some risk of spray scorch or other phytotoxic damage on some crops (this is dependant on rates and crop)
- If using potassium bicarbonate on a crop for the first time, spot treat a few plants or a small area first
- With an application close to harvest a white deposit can be left on the leaf surface of some ornamental crops such as geranium. Crops with 'rough' leaves seem more susceptible
- Since good control is dependant on direct contact of potassium bicarbonate with the fungus, thorough and even coverage of the foliage is required. However the volume of water should be adjusted so that a concentration of the product does not remain on any part of the leaf surface, as scorch may occur
- There is evidence to suggest that regular treatments with a moderate rate (e.g. a 0.25-0.5% solution at 7-10 day intervals) are more effective than infrequent applications at a higher rate
- Ensure that you have a copy of the Commodity Substance Approval for potassium bicarbonate (potassium hydrogen carbonate) before you start using it either in a trial or on commercial crops.

## 5. Integrated management of powdery mildew

Powdery mildew is a common disease on a wide range of horticultural crops. There are many different species of powdery mildew fungi (e.g. *Erysiphe* spp., *Spaerotheca* spp. and *Podosphaera* spp.), with each only attacking specific plants. Symptoms usually first appear as small white spots, spreading as a sparse white/grey fungal growth over leaf surfaces, shoots and sometimes flowers and fruit. Severely affected leaves may turn completely yellow and fall off. The main source of powdery mildew during the growing season are the dispersal spores (conidia) produced on affected plant surfaces, which may be spread by air currents and water splash. Once present within a crop, disease spread can be very rapid. The powdery mildews only grow on living plant tissue. On perennial hosts such as roses and top fruit, powdery mildews may survive between seasons as hyphal strands in infected buds. They also commonly overwinter as small black resting bodies within crop debris. Unlike spores of many fungi, powdery mildews do not require free water for germination, however spore germination and plant infection is favoured by high relative humidity. Subsequent development of the fungus over the plant surface and spore production occurs most rapidly in warm, dry weather.

Cultural practices can be used to minimise the risk of disease development as follows:

- As powdery mildews can spread very rapidly under warm dry conditions, it is important to regularly monitor susceptible crops for first symptoms of the disease.
- For protected crops, reduce humidity where possible using for example, fans, venting and increased plant spacing, to lower the risk of plant infection
- Succulent plant tissue is more susceptible to powdery mildew infection. High levels of nitrogen fertilisers generally result in a more severe attack; use slow-release products where appropriate.

- Cultivars that are less susceptible to powdery mildew are available for some crops that are particularly prone to the disease, such as roses, cucurbits and Brussels sprouts.

Potassium bicarbonate and synthetic fungicides may each form an important component of a disease management strategy for powdery mildew. Timing and frequency will be crop dependent. For short-season edible crops (e.g. protected herbs) where there is limited scope for use of synthetic fungicides, use of potassium bicarbonate may only be necessary if cultural controls fail to prevent disease build up or if disease pressure is too great. For apple powdery mildew, a single application of potassium bicarbonate may be used as an eradicator at the pink bud stage. For some susceptible crops (e.g. parsnip and outdoor cucurbits), fungicides including potassium bicarbonate may be required late in the season when environmental conditions favour disease development. Some crops such as cut flowers, strawberries and Brussels sprouts are highly susceptible to powdery mildew and there may be zero tolerance of disease symptoms by retailers. For these crops, growers may need to use potassium bicarbonate routinely as part of a preventative fungicide programme, in sequence with protectant fungicide products applied before symptoms are visible.

#### 6. Reported efficacy of potassium bicarbonate on specific crops

UK research on potassium bicarbonate is minimal and the following comments are based on a combination of relevant research findings (mainly from the USA) and feedback from UK grower and consultant observations in 2004. For crops where there is no UK experience of its use, the suggested application rate and timings should be treated with caution and the effects on a small number of plants should be observed before overall application.

The use of potassium bicarbonate is at growers' risk. ADAS and HDC will not be responsible for any losses which may arise from the use of the information in this publication.



## Brassicas

Product	Potassium bicarbonate (99% pure)
UK grower/consultant experience	None
Disease(s) to be controlled	Powdery mildew ( <i>Erysiphe cruciferarum</i> ) on Brussels sprouts, turnips and swedes
Rate and water volume	5 kg/1000 L plus wetting agent
No. applications	As many as required within total dose rate of 60 kg/ha
In a programme with other fungicides?	Important to alternate with protectant and curative fungicides such as azoxystrobin and tebuconazole, respectively. Sulphur can be used before disease symptoms appear.
Addition of adjuvants	Horticultural oil is used in the US
Phytotoxicity	Unlikely to be a problem on a mature crop
Reference source	University of California (2001)

## Alliums

Product	Potassium bicarbonate (99% pure)
UK grower/consultant experience	None
Disease(s) to be controlled	Powdery mildew is not a problem on allium crops. No information could be sourced on the effect of potassium bicarbonate on e.g. onion downy mildew or leek rust
Rate and water volume	5 kg/1000 L plus wetting agent
No. applications	Use as many as required within total dose rate of 60 kg/ha
In a programme with other fungicides?	-
Addition of adjuvants	-
Phytotoxicity	-
Reference sources	-

## Carrots and parsnips

Product	Potassium bicarbonate (99% pure)
UK grower/consultant experience	None
Disease(s) to be controlled	Powdery mildew ( <i>Erysiphe heraclei</i> )
Rate and water volume	5 kg/1000 L plus wetting agent
No. applications	Use as many as required within total dose rate of 60 kg/ha
In a programme with other fungicides?	Potassium bicarbonate could be used in a programme with the several actives that are currently approved for powdery mildew control on carrots and parsnips. However, because of negligible information on tank mixing with other pesticides (required for management of other carrot pests and diseases), practical use may be limited.
Addition of adjuvants	Horticultural oil is used in the US
Phytotoxicity	No information available
Reference source	University of California, 2001

## Leafy Salads

Product	Potassium bicarbonate (99% pure)
UK grower/consultant experience	Used on outdoor crisp lettuce by at least one grower; use is not widespread since powdery mildew is not a major disease on salads
Disease(s) to be controlled	Found to be effective against powdery mildew ( <i>Erysiphe cichoracearum</i> ) in the USA, and grey mould ( <i>Botrytis cinerea</i> )
Rate and water volume	5 kg/1000 L plus wetting agent
No. applications	Use as many as required within total dose rate of 60 kg/ha
In a programme with other fungicides?	Should be used in a programme with fungicides approved for other lettuce disease problems such as downy mildew, basal rot, <i>Sclerotinia</i> and ring spot.
Addition of adjuvants	Horticultural oil used in the USA
Phytotoxicity	US experience suggests that injury can occur, so use with caution
Reference sources	Cornell University, 2005 Matheron & Porchas, 2003 University of California, 2001

Cucurbits including courgettes

Product	Potassium bicarbonate (99% pure)
UK grower/consultant experience	Limited experience with the approved Commodity Substance formulation
Disease(s) to be controlled	Powdery mildew ( <i>Erysiphe cichoracearum</i> , <i>Spaerotheca fuliginea</i> ), downy mildew ( <i>Pseudoperonospora cubensis</i> ) and anthracnose ( <i>Colletotrichum lagenarium</i> )
Rate and water volume	5 kg/ha in 1000 L water plus wetting agent
No. applications	Repeated applications are likely to be required, up to 60 kg/ha
In a programme with other fungicides?	Adequate control of powdery mildew should be obtained without using synthetic fungicides, although in the USA, potassium bicarbonate was more effective when used in a programme with protectant fungicides e.g. azoxystrobin
Addition of adjuvants	Horticultural oil; USA work indicates that application without oil is ineffective
Phytotoxicity	None seen
Reference sources	ATTRA, University of Arkansas Cornell University, 2005 Matheron & Porchas, 2001 McGrath, 2002 Olsen & Rasmussen, 2001 University of California, 2001

Cucurbits including courgettes (continued)

Product	Omex K50 (50 % potassium bicarbonate)* as a 'foliar feed'
UK grower/consultant experience	Some grower use in East Anglia in 2004
Disease(s) to be controlled	Incidental control of powdery mildew
Rate and water volume	2-3 L/ha in 300-400 L water
No. applications	Repeat applications may be required
In a programme with fungicides?	Should be used in conjunction with fungicides, with Omex K50 used nearer to harvest
Addition of adjuvants	Addition of Omex SW7** improved performance
Phytotoxicity	None seen at suggested rates
Reference source	Omex

\* Product not covered by the Commodity Substance Approval

\*\* Omex SW7 is designed to enhance plant uptake of nutrients. It is not included on the PSD adjuvant information database and is not to be used as an adjuvant with pesticides or with potassium bicarbonate.

Strawberries – outdoor and protected

Product	Potassium bicarbonate (99% pure)
UK grower/consultant experience	Extensive experience in 2004. Initial results from HDC project SF 62 show that the level of control achieved using weekly sprays of potassium bicarbonate were comparable to that using a single spray of myclobutanil (Systhane 20EW).
Disease(s) to be controlled	Powdery mildew ( <i>Sphaerotheca macularis</i> )
Rate and water volume	3-5 kg/ha, although more usually 10 kg/ha in 100 L water + wetter. Essential to use a high water volume to get good coverage of foliage and the higher product rate for effective control. On protected strawberries (Elsanta), 5 g/L + 0.3 ml Agral gave excellent control of powdery mildew symptoms in dense canopy. Regrowth of powdery mildew from previously infected areas was seen again after 7 d.
No. applications	Repeated applications necessary, up to 60 kg/ha. Experience of spray intervals varies between every 3-4 days and every 10-14 days. Where it has been used early in the season, the number of subsequent applications of potassium bicarbonate and other fungicides has been reduced. It is also useful for application during harvest, as there is no harvest interval.
In a programme with other fungicides?	Essential that it is used as part of an integrated programme with other fungicides. Depending on the time of year and other disease problems, a suggested programme is two potassium bicarbonates to one of sulphur or a synthetic fungicide. There is experience of tank mixing with sulphur, but this is not the norm.
Addition of adjuvants	Notably less effective without the addition of a wetter. Silwett L-77 has given good results
Phytotoxicity	None reported despite use on a wide range of varieties at suggested rates, but essential to try on a small area of plants before widespread use.
Reference sources	ADAS fruit consultants FAST Grower observations and trials HDC, 2005 Schilder <i>et al.</i> , 2003 University of California, 2001

Strawberry – outdoor and protected (continued)

Product	Omex K50 (50 % potassium bicarbonate)* as a 'foliar feed '
UK grower/consultant experience	Extensive experience in 2004
Disease(s) to be controlled	Incidental control of powdery mildew
Rate and water volume	1 L/ha or more usually 2-3 L/ha in 300-400 L water + wetter Omex SW7**
No. applications	Usually at least 3, but may be more in a long season crop.
In a programme with fungicides?	Essential that it is used as part of an integrated programme with fungicides, particularly early in the season
Addition of adjuvants	Incidental disease control seems much improved with the addition of a wetter such as Omex SW7
Phytotoxicity	None reported for outdoor and protected crops when used on a wide range of everbearers and June bearers from spring through to the autumn.
Reference sources	ADAS fruit consultants Grower observations and trials Omex

\* Product not covered by the Commodity Substance Approval

\*\* Omex SW7 is designed to enhance plant uptake of nutrients. It is not included on the PSD adjuvant information database and is not to be used as an adjuvant with pesticides or with potassium bicarbonate.



Other soft fruit (blackcurrant, gooseberry, raspberry)

Product	Potassium bicarbonate (99% pure)
UK grower/consultant experience	Limited experience of Commodity Substance use on gooseberries and raspberries
Disease(s) to be controlled	American gooseberry mildew ( <i>Sphaerotheca mors-uvae</i> ) and raspberry powdery mildew ( <i>Sphaerotheca macularis</i> )
Rate and water volume	3.3 to 5 kg/ha in 1000 L water; thorough coverage of foliage is essential
No. applications	Ever 2-3 weeks, up to a total application rate of 60 kg/ha
In a programme with other fungicides?	Apply when powdery mildew is first seen and alternate with sulphur and synthetic fungicides
Addition of adjuvants	Improved results were obtained with a wetter. Agral has been used on gooseberries, and soft soap on gooseberries and blackcurrants
Phytotoxicity	None observed but USA advice is not to mix with other fungicides
Reference sources	ADAS fruit consultants Grower observations Oregon state University, 2005 University of California, 2001

Other soft fruit (blackcurrant, gooseberry, raspberry) (continued)

Product	Omex K50 (50 % potassium bicarbonate)* as a 'foliar feed '
UK grower/consultant experience	Limited experience, particularly on blackcurrants in 2004
Disease(s) to be controlled	Incidental control of American gooseberry mildew ( <i>Sphaerotheca mors-uvae</i> ) but at the rate used, it was not particularly effective
Rate and water volume	1 L/ha with a high volume spray
No. applications	For blackcurrants, one application applied late after bushes are cut down.
In a programme with fungicides?	Essential that it is used as part of an integrated programme with fungicides, particularly early in the season
Addition of adjuvants	Incidental disease control seems much improved with the addition of Omex SW7**
Phytotoxicity	None reported
Reference sources	ADAS fruit consultants Grower observations Omex

\* Product not covered by the Commodity Substance Approval

\*\* Omex SW7 is designed to enhance plant uptake of nutrients. It is not included on the PSD adjuvant information database and is not to be used as an adjuvant with pesticides or with potassium bicarbonate.

Top fruit (apple)

Product	Potassium bicarbonate (99% pure)
UK grower/consultant experience	Some experience on apples in 2004
Disease(s) to be controlled	Eradicant action against primary infections of apple powdery mildew ( <i>Podosphaera leucotricha</i> )
Rate and water volume	5 kg in 1000 L applied at sufficient volume to wet the leaf and shoots i.e. 250-400 L/ha
No. applications	Two applications should be made, the first at pink bud (>5% of blossom clusters with mildew) and the second at petal fall. Do not apply during bloom
In programme with other fungicides?	Potassium bicarbonate must be applied alone, as tank-mixing with any other product may result in the high pH interfering with the efficacy of other pesticides and foliar feeds
Addition of adjuvants	Used with horticultural oil in the USA.
Phytotoxicity	USA experience suggests that potassium bicarbonate may cause russetting on some apple varieties, but so far this appears not to be a problem in the UK
Reference sources	FAST University of California, 2001

Protected edible crops (cucumber and pepper)

Product	Potassium bicarbonate (99% pure)
UK grower/consultant experience	Limited to cucumbers
Disease(s) to be controlled	Powdery mildews. Some success against powdery mildew on peppers ( <i>Leveillula taurica</i> ) in Israel.
Rate and water volume	Up to 5 kg/ha in 1000 L water plus wetting agent
No. applications	Repeated applications may be required
In programme with other fungicides?	Depending on crop and other diseases present
Addition of adjuvants	Wetter will improve results
Phytotoxicity	None reported even when used mixed with sulphur at above 25°C on protected strawberries. Advice from US is not to mix with any other pesticides.
Reference sources	ADAS consultants ATTRA, University of Arkansas Tsrer <i>et al.</i> , 2003 University of California, 2001

## Ornamentals and cut flowers

Product	Potassium bicarbonate (99% pure)
UK grower/consultant experience	Extensive use in a wide range of flowers including rose, aster, chrysanthemum, dahlia, phlox and zinnia. Encouraging results have been reported for scabious (very prone to powdery mildew) under protection. Used successfully on many ornamental species including acer, arbutus, berberidopsis, berberis, euonymus, euphorbia, fatsia, hawthorn, honeysuckle, ilex, mimulus, quercus and spirea
Disease(s) to be controlled	Primarily powdery mildew but many other diseases including references in the US to black spot of roses, downy mildew, botrytis, scab, anthranose, alternaria and cercospora on a wide range of species.
Rate and water volume	On flower crops 3-5 g/L in 200 L water, but 10 g/L used when symptoms of powdery mildew are already visible. Higher rates up to 10 g/l have been used on nursery stock
No. applications	14-21 days intervals, but for roses as frequently as every 3 to 4 days
In programme with other fungicides?	Invariably used as part of a strategy with either sulphur, compost tea or synthetic fungicides. There is no experience of tank mixing but there is interest in mixing with sulphur to boost powdery mildew control. For species very susceptible to powdery mildew such as roses and scabious, start the programme before symptoms are seen and alternate with a protectant fungicide. USA results suggest that powdery mildew on gerbera can be kept at low levels (<5%) by treating with potassium bicarbonate in sequence with myclobutanil.
Addition of adjuvants	Codacide oil (0.1%) mentioned many times as were insecticidal soap (particularly for roses) and Agral. In the USA, potassium bicarbonate (+ 1% v/v horticultural oil) gave effective control of powdery mildew on euonymus

Phytotoxicity	On some species there is a possibility of leaf scorch at rates of over 1%; spot treat a few plants first. Application close to harvest can result in a white deposit being left on the leaf surface of some ornamental crops such as geranium.
Reference sources	ADAS consultants ATTRA, University of Arkansas Uchida & Kadooka, 2001. UK and US Grower observations and trials University of Vermont Extension System, 2001 Ziv and Hagiladi, 1993

## Hops

Product	Potassium bicarbonate (99% pure)
UK grower/consultant experience	Trials experience from 2003 and extensive grower use in 2004
Disease(s) to be controlled	Powdery mildew ( <i>Sphaerotheca macularis</i> )
Rate and water volume	5 kg per 1000 L
No. applications	Depending on strategy adopted, could be up to 6 applications from May to August
In programme with other fungicides?	Results have shown that potassium bicarbonate can be substituted for a morpholine fungicide (fenpropimorph) in standard spray programmes with good control of powdery mildew and no reduction in alpha-acid content. It needs to be alternated with a protectant fungicide (e.g. quinoxifen) or sulphur if the spray intervals are to be greater than 5 to 7 days. Adding sulphur will improve control against powdery mildew
Addition of adjuvants	A suitable wetter/adjuvant/oil/soap should be added
Phytotoxicity	None observed
Reference sources	Peter Glendinning (National Hop Association of England) UK grower observations and trials

## Herbs

Product	Potassium bicarbonate (99% pure)
UK grower/consultant experience	Trial results in 2004, plus routine use by some protected herb growers
Disease(s) to be controlled	Powdery mildew on a range of herbs e.g. mint ( <i>Erysiphe</i> sp.), parsley ( <i>Erysiphe heraclei</i> ) and lemon balm
Rate and water volume	One grower routinely uses a 2 % solution on a range of protected herb species, but other growers have observed scorch on parsley at rates as low as 0.3 %
No. applications	Repeated applications are necessary (e.g. every 5 days). Under trial conditions with heavy disease pressure, two applications were insufficient for effective disease control
In a programme with other fungicides?	Fungicide use on protected herbs is minimal but azoxystrobin or sulphur could provide protectant activity
Addition of adjuvants	Grower observations suggest that use of a wetter can improve efficacy
Phytotoxicity	In a trial, leaf scorch was observed on parsley and mint when the maximum rate was used (2 % solution) and one grower reported scorch on parsley when a 0.3 % solution was used with and without a wetter.
Reference sources	Grower observations Defra, 2004



Herbs – continued

Product	Omex K50 (50 % potassium bicarbonate)* as a 'foliar feed '
UK grower/consultant experience	Trial results in 2004
Disease(s) to be controlled	Incidental control of powdery mildew; particularly effective on parsley
Rate and water volume	3 L/ha + 100 ml/ha wetter (in 1000 L water/ha)
No. applications	Two applications at a 7 day interval were used experimentally, but more would be required for longer term protection.
In a programme with fungicides?	Fungicide use on protected herbs is minimal but azoxystrobin or sulphur could provide protectant activity
Addition of adjuvants	The product was trialled in combination with Omex SW7**
Phytotoxicity	None observed at rates specified above
Reference sources	Defra, 2004

\* Product not covered by the Commodity Substance Approval

\*\* Omex SW7 is designed to enhance plant uptake of nutrients. It is not included on the PSD adjuvant information database and is not to be used as an adjuvant with pesticides or with potassium bicarbonate.

## 7. Use in organic production systems

As a naturally occurring substance, potassium bicarbonate has been used in the USA and Canada for many years in production of crops to organic standards. In the UK, however, the use of potassium bicarbonate by growers working to UK organic standards, is currently prohibited.

There have been discussions regarding the future use of potassium bicarbonate and Organic Farmers & Growers (OFG) have agreed to support a request that potassium bicarbonate is added to the UK organic standards. To facilitate this, a dossier of information prepared by OFG has been forwarded to the Certification Bodies Technical Working Group (CBTWG) for discussion (Richard Jacobs, OFG, pers. comm.).

If the CBTWG is supportive, then a proposal will be submitted to Defra to have this material added to the organic standards. If the product does not have approval elsewhere in the EU, the request will need further referral to the EU Commission, hence a decision may not be forthcoming in the short term.

## 8. Further research required

Aspects of research required on the use of potassium bicarbonate as a fungicide are as follows:

- Possible effects on the performance of other chemicals/pesticides used in mixtures
- Compatibility of potassium bicarbonate with biological control agents
- Efficacy of potassium bicarbonate against diseases other than powdery mildews
- A thorough evaluation of a range of wetters/spreaders and optimum rates of use
- Optimum use of potassium bicarbonate as a component of fungicide programmes for different crops
- Evaluation in conjunction with non-synthetic pesticides such as sulphur, potassium phosphite and insecticidal soap to give control of a wide range of disease and pest problems

## 9. Product availability

Some potassium bicarbonate products that are currently available and reported to be used in horticultural crop production are listed below. Availability of products changes quite frequently with the introduction of new products and the withdrawal of others. The mention of a product name in this factsheet does not constitute a recommendation; the absence of a product name does not imply a criticism of that product.

Potassium hydrogen carbonate (99% pure) products:

AgriKarb

Available from:

Farm-Fos Limited  
Builth Farm  
Eau Withington  
Hereford  
HR1 3NQ  
Tel: 01432 851822  
Fax: 01432 851829  
Email: [tomnellist@builthfarm.fsnet.co.uk](mailto:tomnellist@builthfarm.fsnet.co.uk)

P P Products  
Longmyned  
Tunstead road  
Hoveton  
Norwich  
NR12 8QN  
Tel: 01603 784367  
Fax: 01603 784367  
Email: [mail@ppproducts.net](mailto:mail@ppproducts.net)

Avoncrop Limited Potassium Hydrogen Carbonate

Avoncrop Limited  
Weighbridge House  
Station Road  
Sandford  
Winscombe  
North Somerset  
BS25 5NX  
Tel: 01934 820363  
Fax: 01934 820926  
Email: [sales@avoncrop.co.uk](mailto:sales@avoncrop.co.uk)

Potassium bicarbonate (99% pure) should also be available from agricultural merchants such as Hutchinsons and UAP. Details of the nearest depot can be obtained from directory enquiries or Yellow pages

H L Hutchinson Ltd  
Weasenham Lane  
Wisbech  
Cams.  
PE13 2RN  
Tel: 01945 461177  
Fax: 01945 474837  
Email: [information@hutchinsons-online.co.uk](mailto:information@hutchinsons-online.co.uk)  
Web: [www.hutchinsons-online.co.uk](http://www.hutchinsons-online.co.uk)

UAP Head Office and Central Distribution  
The Crossways  
Alconbury  
Huntingdon  
Cambs.  
PE28 4JH  
Tel: 01480 418000  
Fax: 01480 418010  
Email: [mail@UAP-Europe.com](mailto:mail@UAP-Europe.com)  
Web: [uap.eu.com](http://uap.eu.com)

#### Omex Product

Omex K50 (50 % potassium bicarbonate) (foliar feed) plus Omex SW7 (for enhanced uptake of foliar nutrients).

These products should only be used as a foliar feed, and not for the control of powdery mildew or other pathogens.

Omex Agriculture  
Riverside Industrial Estate  
Estuary road  
King's Lynn  
Norfolk  
PE30 2HH  
Tel: 01553 760011  
Fax: 01553 769784  
Email: [GidonB@omex.com](mailto:GidonB@omex.com)  
Web: [www.omex.co.uk](http://www.omex.co.uk)

It should be noted that products containing potassium bicarbonate at less than 99% are not classified as food grade, and are not covered by the Commodity Substance Approval. Such products are marketed for the horticultural industry as 'foliar feeds or supplements' and are being used by UK growers. Experience from UK growers and consultants suggests that under some circumstances, foliar feeds or supplements containing potassium bicarbonate may give incidental control of powdery mildew, but they are not marketed for this purpose

## 10. References and Sources of information

### Websites

ATTRA-National Sustainable Agriculture Information Service [www.attra.org](http://www.attra.org)

CSL Liaison <http://liaison.csl.gov.uk>

Farm-Fos Limited [www.farm-fos.com](http://www.farm-fos.com) (in preparation)

Pesticides Safety Directorate [www.pesticides.gov.uk](http://www.pesticides.gov.uk)

US Environmental Protection Agency

[http://www.epa.gov/pesticides/biopesticides/ingredients/factsheets/factsheet\\_073508.htm](http://www.epa.gov/pesticides/biopesticides/ingredients/factsheets/factsheet_073508.htm)

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<http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7406.html>
- University of Cornell. 2005. Botrytis blight (*Botrytis cinerea*). Plant Disease Diagnostic Clinic Factsheet.  
[http://plantclinic.cornell.edu/FactSheets/botrytis\\_blight.htm](http://plantclinic.cornell.edu/FactSheets/botrytis_blight.htm)
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## 12. Acknowledgements

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- Janet Allen, John Atwood, John Buxton, Andrew Hewson, David Hutchinson and Scott Raffle (ADAS UK)
- Harriet Duncalfe
- Peter Glendinning (National Hop Association of England)
- Gidon Bahari (Omex)
- Tom Nellist (Farm-Fos)

Copy of Approval document as of 26 July 2005

Food and Environment Protection Act 1985

Control of Pesticides Regulations 1986: Approval

Notice is hereby given that in exercise of the powers conferred by Regulation 5 of the Control of Pesticides Regulations 1986 (SI 1986/1510) (as amended) and of all other powers enabling them in that behalf, the Secretary of State, and the Scottish Ministers (as regards Scotland) and the National Assembly for Wales and the Secretary of State (acting jointly as regards Wales) have given full approval for use of the following commodity substance: Commodity Substance being >99.0% w/w Potassium Hydrogen Carbonate (Bicarbonate).

Commodity Substance: being 99.0% w/w Potassium Hydrogen Carbonate (Bicarbonate) subject to the conditions set out below:

Date of issue: 26 July 2005

Date of expiry: 31 December 2008 (unless earlier decisions are made of further prescribed extensions are granted).

Use:

*Field of use:* Only as a horticultural fungicide

*Situations:* Protected and outdoor crops

*Maximum total dose (outdoor crops):* 60 kg potassium bicarbonate/ha/annum

*Maximum individual dose:* 20 g potassium bicarbonate/litre

*Operator protection:*

1. Engineering control of operator exposure must be used where reasonably practicable in addition to the following personal protective equipment:  
Operators must wear suitable protective clothing (coveralls), suitable protective gloves, face protection (faceshield), and suitable respiratory protection when handling the concentrate.
2. However, engineering controls may replace personal protective equipment if a Control of Substances Hazardous to Health (COSHH) assessment shows they provide an equal or higher standard of protection.

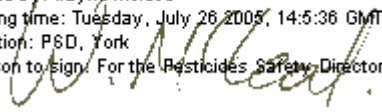
*Other specific restrictions:*

Food grade potassium bicarbonate must only be used.

Advisory Notes

1. Crop phytotoxicity can occur.
2. Approved adjuvants (see PSDs list of adjuvants approved for use in the UK and their conditions of use) may be used in conjunction with this commodity substance.

Signed by: wayne mcLeod  
Signing time: Tuesday, July 26 2005, 14:5:36 GMT  
Location: PSD, York  
Reason to sign: For the Pesticides Safety Directorate



PSD Digital Signature