National Cut Flower Centre/
AHDB Horticulture Information Sheet 11

Maintaining successful control of downy mildew in protected crops of cut flower column stocks

Figure 1. Healthy cut flower column stock crops

Grower summary

- Downy mildew diseases are best managed via a combination of cultural and chemical control measures within an integrated crop management programme
- Cultural control measures include adequate structure ventilation, use of trickle irrigation and application of appropriate levels of crop nutrients
- Growers should obtain fungicide application records from their plug plant suppliers and take these into account when creating crop fungicide programmes
- Select fungicide products with an appropriate mode of action to achieve the desired effect, taking into account stage of crop growth, disease development and application method
- Programmes based on protectant fungicides must be implemented three to five days after planting and before the onset of any visible disease symptoms
- Fungicides from at least three different fungicide groups, as specified by the Fungicide Resistance Action Committee (FRAC), should be used in any programme
- Products from different groups can be used in tank mixes (where manufacturers permit this), or alternated within spray programmes
- Spray intervals should be reduced; for example, from 14 to seven days when environmental conditions favour downy mildew; and less than seven days when the temperature is between 15°C and 21°C and the relative humidity is above 70%, or during long periods of leaf wetness
- Spray applications must achieve good coverage of leaves throughout the crop canopy
- Where rapid vegetative growth occurs in the early stages of the crop while overhead irrigated, the intervals between spray applications should be shorter, especially under favourable environmental conditions, to protect new growth
- Minimise the application of solid formulation fungicides at the point of flowering to reduce the risk of potential leaf deposits on cut flower stems at marketing

Background

Column stocks are currently the main non-bulb, protected cut flower crop grown in the UK. Around 15 million stems were produced during 2018. Under conducive weather conditions, column stocks can be susceptible to downy mildew caused by the pathogen *Peronospora parasitica.* The pathogen was traditionally prevented or managed by adopting a regular spray programme based on specific fungicides, including products containing the active ingredient metalaxyl-M. However, during the early part of 2018, crops grown in the Netherlands reportedly suffered from a very severe infection of downy mildew that did not respond to standard fungicide spray programmes. By mid-May, UK crops were also beginning to suffer from this disease. Despite using the usual range of fungicides, growers found that the pathogen caused severe damage, with infections appearing almost overnight. Even a reduction in the spray interval did not appear to achieve the necessary level of control and work was urgently needed to evaluate the pathogen for its sensitivity to different fungicide active ingredients.

Disease development and symptoms

P. parasitica is an oomycete, a fungus-like organism that develops internally within the host plant. The pathogen only becomes visible at sporulation, for which high humidity is required. The optimum temperature for infection and sporulation is between 15°C and 21°C, at this temperature, infection can take place in as little as four hours of leaf wetness. Under optimum conditions, the latent period between infection and symptom development can be as little as five to six days.

It is worth noting that, although spore germination is low at 21°C, the degree of sporulation and percentage level of infection are still high. This suggests the pathogen is very aggressive under late spring and early autumn conditions, when the temperatures are sufficient and the relative humidity in glasshouse structures is still high. It is important to note that sporulation will start in temperatures as low as 4.5°C and will stop completely at 27°C.

Figure 2. Typical upper and lower leaf symptoms and pathogen sporulation resulting from an infection of *Peronospora parasitica*

The first indications of disease are the appearance of light green areas on the upper leaf surface. On the lower surface, corresponding to these areas, a white sporulation can be seen (Figure 2). The infected areas increase in size and coalesce, very often covering the entire leaf lower surface. Infected areas turn yellow and become necrotic, with infected leaves falling prematurely. The flowers of infected plants frequently fail to open and often die. The disease is most destructive when plants are infected at the seedling stage.

Sensitivity testing

Following a Cut Flower Centre (CFC) organised meeting at the end of June 2018, representatives of the UK cut flower industry agreed that the pathogen, which is possibly a new isolate, would be subjected to sensitivity testing against a range of fungicide products (Table 1).

Table 1. Fungicide products examined as part of the Fera sensitivity testing work

Example product	Active ingredient	FRAC code*	Rate applied
Fenomenal	Fenamidone + fosetyl aluminium	11 + 33	2.25 kg/ha
Fubol Gold WG	Mancozeb + metalaxyl-M	M3 + 4	1.9 kg/ha
HDC F253**		21	0.5 L/ha
Paraat	Dimethomorph	40	0.36 kg/ha
Percos	Ametoctradin + dimethomorph	40 + 45	0.8 L/ha
Previcur Energy	Fosetyl-aluminium + propamocarb hydrochloride	33 + 28	2.5 L/ha
Revus	Mandipropamid	40	0.6 L/ha
Signum	Boscalid + pyraclostrobin	7 + 11	1.35 kg/ha
Subdue	Metalaxyl-M	4	1.25 L/ha

* The Fungicide Resistance Action Committee (FRAC) has developed a code of numbers and letters that can be used to distinguish the different fungicide groups based on their mode of action

** Used under experimental permit

To enable this, samples of the pathogen on infected plant material were collected from five nurseries in different geographical locations: one in Northern Ireland, one in Cornwall, two in Norfolk and one in Lincolnshire. The samples were submitted to Fera, where staff inoculated column stock seedlings to permit the pathogen to establish, develop and build up (the pathogen is an obligate parasite and cannot be cultured in vitro). Testing then commenced, using the spores generated to inoculate the trial plants.

As part of the sensitivity testing, nine different fungicide products were examined, each containing a different active ingredient or mixture of active ingredients. The replicated trial was undertaken on small plants grown in 9 cm containers in a glasshouse structure.

All five of the pathogen samples obtained were resistant to the active ingredient metalaxyl-M (Subdue). It was assumed that the mancozeb element within Fubol Gold WG gave this product the recorded level of disease control. Dimethomorph (Paraat and as a mixture in Percos) and mandipropamid (Revus) gave the best levels of control in the trial (Figure 3).

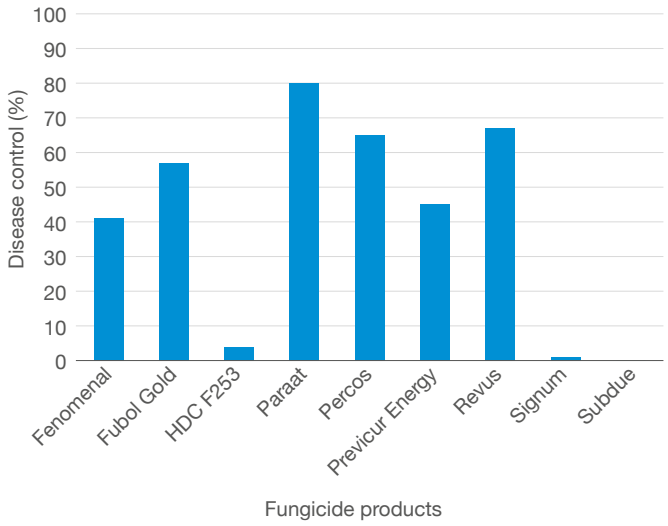

Figure 3. Average levels of disease control achieved by each product for the pathogen collected from all five geographical locations

Disease control strategies

An integrated crop management approach is required to control downy mildew diseases on crops and cultural control measures must be combined with a robust fungicide programme to manage the pathogen. Several appropriate cultural control measures are described below.

Varietal resistance in column stocks

Unfortunately, none of the commercially grown varieties are known to be resistant to the pathogen, although differing levels of susceptibility have been observed.

Nursery hygiene

All production areas, tools, benches, trolleys and glasshouse structures should be disinfected before new crops are planted. It is important to note that, if reused, crates or any other production materials can act as sources of infection and the background disease pressure will quickly build up if not addressed. All crop debris should be thoroughly swept up and disposed of and any weeds removed.

Crop management

In the UK, both early and late planted column stock crops are at risk of infection from downy mildew. However, the highest risk of infection is associated with late planted crops.

As with all downy mildew diseases, leaf wetness (including condensation on the leaf surface) is the most important factor that encourages the disease. If the leaf wetness duration can be reduced to below four hours on most days, the risk of infection is lessened. Consider adopting the following measures:

- Plant young plant material as soon as it is delivered and avoid cold storage if possible
- If cold-stored, ensure the cold store temperature setting is between 2–4°C and the young plant material is weaned before it is taken into a warm glasshouse (take out the cold stored product the night before the day of planting)
- Ventilate structures as much as possible and ensure sufficient airflow through the crop
- Use fans to move air around the structure where natural ventilation is limited and air may be stagnant
- Avoid extreme temperature fluctuations, which will exacerbate leaf condensation
- Avoid overhead irrigation from midday onwards and especially during the evening or at night
- Switch from full overhead to spot watering and then to trickle irrigation as soon as crop establishment allows (Figure 4)

Figure 4. Use of trickle irrigation helps to keeps crop foliage dry

Crop nutrition

Ensure that the residual level of available nutrients in the soil from previous cropping is not too high (Table 2). If the previous crop received an intensive balanced fertiliser regime with high ammonium content, it is advisable to delay fertigation to the column stock crop for the first couple of weeks to allow ammonium levels to deplete within the soil. Afterwards, provide a constant liquid feed of 150–200 ppm of nitrogen using a 14-0-14 (NPK) liquid feed, reducing levels to 50–100 ppm nitrogen as flowers develop.

As a crop, column stocks are only moderately demanding in terms of nutrients and additional nitrogen in the early crop stage will encourage soft growth and increase disease susceptibility. Moreover, use of phosphorus-rich proprietary liquid fertilisers will also encourage excessive growth. It is important to deliver the small amount of phosphorus required via foliar feeds and use fast-acting, highly mobile phosphite-based fertilisers. No more than five applications of phosphite base fertilisers should be used, especially under cool conditions, because this may result in stunted growth and a change of leaf colour to bronzed/dark blue. Once the crop has reached 10–15 cm in height, it is recommended to use an additional potassium foliar fertiliser to help tone plants and improve flowering.

Use of plant protection products

Devising downy mildew spray programmes for column stock crops

Foliar-applied fungicide products remain the cornerstone of downy mildew control for most growers. Unfortunately, the number of different active ingredients available in the UK has reduced over the last few years, making it more difficult to create robust control programmes covering several months of production. For effective control, it is important that:

- Growers obtain fungicide application records from their plug suppliers (covering active ingredient/product used, rate applied, timing of application, etc.) and take these into account when creating their own fungicide programmes
- Fungicides are used in combination with the other cultural control measures outlined in this factsheet
- Products with an appropriate mode of action are selected to achieve the desired effect, taking into account crop growth stage, any signs of disease development and application method
- Programmes based on protectant fungicides are implemented three to five days after planting and before the onset of any disease symptoms
- Fungicides from at least three different fungicide FRAC groups are used (see Tables 1 and 6)
- Products from different groups are used in tank mixes (where manufacturers permit this), or alternated within spray programmes
- The spray interval is reduced (for example, from 14 to seven days) when environmental conditions favour downy mildew (and is reduced to less than seven days when the temperature is between 15°C and 21°C and relative humidity is above 70%, or during long periods of leaf wetness)
- Spray applications achieve good coverage of leaves (both upper and lower surfaces) throughout the crop canopy
- Where rapid vegetative growth occurs in the early stages of the crop while using overhead irrigation, the intervals between spray applications are shortened, especially under favourable environmental conditions, to protect new growth

Once a crop is infected, the lack of effective eradicant fungicides makes it very difficult to eradicate the pathogen. However, it is possible to reduce infection of new extension growth by utilising integrated crop management practices and applying fungicides with anti-sporulant activity.

The fungicide products currently available for use against downy mildew diseases in the UK are summarised in Table 3. Example fungicide programmes are shown in Table 4, along with general guidance (both located in the wallet at the back of the Information Sheet).

Adjuvants, water volumes, spray quality and application methods

(a) Adjuvants

Some active ingredients do not require the addition of adjuvants; for example, those products pre-formulated with an adjuvant, or fully systemic active ingredients such as fosetyl-aluminium, metalaxyl-M and propamocarb-hydrochloride. A number which are contact in action, for example, mancozeb, will benefit from the addition of adjuvants such as organosilicons and anionic surfactants. Where active ingredients have locally systemic properties, it is best to tank-mix with

Table 2. Base fertiliser applications based on nutrient level soil indices for cut flower column stocks

Base dressing	Nitrate, phosphorus, potassium or magnesium index						
	0	1	2	3	4	5	Over 5
	g/m^2						
Ammonium nitrate	30	15	Nil	Nil	Nil	Nil	Nil
Triple superphosphate	150	140	130	110	80	45	Nil
Sulphate of potash	350	300	240	130	Nil	Nil	Nil
Kieserite	240	210	160	80	Nil	Nil	Nil

RB 209, 1988

non-ionic adjuvants, such as Activator 90, to help the active ingredient to penetrate through the leaf cuticle. Certain active ingredients perform better in acidic conditions and it is recommended, where possible, to utilise acidifying adjuvants such as Li-700 (Table 5).

(b) Water volumes

Most of the products outlined in Table 3 have Extensions of Authorisation for Minor Use (EAMUs) permitting their use. It is always recommended to refer back to the original label recommendations if water volumes are not mentioned in the EAMU. EAMUs for some products specify a higher water volume and it is a legal requirement to follow these guidelines. For products where a minimum water volume is stated and no maximum, growers must consider the mode of action of the product, the level of crop canopy development and crop growth stage when making a decision about the water volume to be used (Table 5 and Figure 5). Note, the optimal water volume suggested is often below the volume used in commercial practice.

Table 5. Water volume and adjuvant requirements for a range of foliar-applied fungicides with activity against downy mildew pathogens

Example product	Active ingredient	Specific requirement on water volume (L/ha)	Optimal performance water volume (L/ha)	Advice on adjuvant selection
Amistar	Azoxystrobin	Min 200	400–600	Surfactants required (Activator 90)
Fenomenal	Fenamidone and fosetyl-aluminium	Min 1,000	1,000	Not required
Folio Gold	Chlorothalonil and metalaxyl-M	Min 350	600–800	Surfactants required (Activator 90) DO NOT USE organosilicon-based adjuvants
Fubol Gold WG	Mancozeb and metalaxyl-M	Min 250	600–800	Acidifiers required (Li-700, Ranger, X-Change)
Manzate 75 WG	Mancozeb	Min 500	1,000	Acidifiers required (Li-700, Ranger, X-Change)
Paraat	Dimethomorph	Min 600	600–1,000	Surfactants required (Activator 90, organosilicons)
Percos	Ametoctradin and dimethomorph	Max 1,000	500	Surfactants required (Activator 90, organosilicons)
Previcur Energy	Fosetyl-aluminium and propamocarb hydrochloride	Min 200	500–1,500	Not required
Proplant	Propamocarb hydrochloride	1,500	1,500	Not required
Revus	Mandipropamid	Min 200	400–600	Surfactants required (Activator 90, organosilicons)

Figure 5. Uniform spray droplet distribution using the optimum water volume

(c) Spray quality and application methods

Generally, all fungicides are applied as a fine to medium spray, attaining a droplet size of 100–200 microns. Although the nozzle choice will help with the delivery of the product to the correct area, it is the water volume and pressure that will make the largest impact. Generally, two to three bars at the nozzle and constant pressure is required to deliver accurate application volumes. Although most column stock growers utilise hand-held equipment that is difficult to calibrate (Figure 6), it is crucial that this is undertaken at least once every two months to ensure the correct water volume and delivery of the fungicides. The benefit of hand-held equipment is its ability to deliver products with contact or locally systemic action under the leaves, by directing the spray slightly horizontally. Products can also be delivered into the canopy using the air turbulence generated by the action of the applicator.

Avoiding fungicide resistance

It is important to adopt a robust anti-resistance management strategy by alternating products from different fungicide groups and by strictly following the FRAC UK guidelines, where relevant.

The development of fungicide resistance is a real risk in downy mildew pathogen species, especially when specific fungicides are used intensively and are insufficiently rotated with other products. The most at-risk groups are the phenylamides (Fubol Gold) and strobilurins (Amistar), as outlined in Table 6 (located in the wallet at the back of the Information Sheet). To minimise the risk of selecting resistant pathogen strains, it is recommended that:

- Fungicides alone are not used for disease control; cultural control methods, varietal selection (where relevant) and good enhanced foliar nutrition should be part of the holistic approach to controlling the pathogen
- Fungicides are used according to the programmes shown, or similar programmes designed to avoid resistance development
- No more than two sprays of the same fungicide or fungicide group are used in sequence; thereafter, a fungicide from a completely different fungicide group is used
- No more than 50% of the total sprays applied to the crop are strobilurin fungicides
- The label and EAMU recommendations are carefully followed, especially those concerning the dose rate and water volumes

Further information on the National Cut Flower Centre project and trials work

Further details can be found in the following project reports, available from either the AHDB Horticulture website **horticulture.ahdb.org.uk** or the CFC website **thecutflowercentre.co.uk**

- Annual reports on AHDB Horticulture Project PO/BOF 002a (2013-2016): The National Cut Flower Trials Programme for 2013-2017
- Annual and final reports on AHDB Horticulture Project PO/BOF 002 (2010-2012): The National Cut Flower Trials Programme for 2010-2012
- Final report on AHDB Horticulture Project PC/BOF 268a (2009): Establishing a trials centre for the cut flower sector
- Annual and final reports on AHDB Horticulture Project PC/BOF 268 (2008): Establishing a trials centre for the cut flower sector

The industry-led National Cut Flower Centre was set up at Kirton Research Centre, Kirton, Lincolnshire in 2007 with the support of AHDB Horticulture and Lincolnshire Fenlands LEADER+. In 2009, with AHDB Horticulture funding, the CFC moved to a dedicated site at Rookery Farm, Holbeach St Johns, Lincolnshire. The basic remit of the CFC is the stimulation of UK polythene tunnel and field-grown cut flower production through providing know-how from practical trials carried out under UK conditions.

Figure 6. Variable nozzle type applicators are common in the cut flower industry

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Compiled by Lyndon Mason, CFC Project Manager, with assistance from Phil Jennings, Fera.

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Table 3. Foliar applied fungicides available in the UK with activity against downy mildew pathogens

Product name	Active ingredient	Eradicant/ protectant activity	Outdoor/ protected use	Maximum number of applications	Water volume (L/ha)*	Dose rate	Concentration	Approval status	Expiry date
Amistar	Azoxystrobin	E/P	Outdoor/ protected	4	500 (min 200)	1 L/ha	2 ml/L	EAMU 0888/17	30/06/2024
Fenomenal	Fenamidone + fosetyl-aluminium	E/P/anti-sporulant	Outdoor/ protected	2	1,000 (min 1000)	2.25 kg/ha	2.25 g/L	EAMU 1990/13	14/11/2019
Folio Gold	Chlorothalonil + metalaxyl-M	E/P	Protected	2	700 (min 350)	2 L/ha	2.9 ml/L	EAMU 0032/12	30/04/2021
Fubol Gold WG	Mancozeb + metalaxyl-M	E/P	Outdoor/ protected	3	700 (min 250)	1.9 kg/ha	2.7 g/L	EAMU 2288/13	31/07/2021
Manzate 75 WG	Mancozeb	P	Outdoor/ protected	8	1,000 (min 500)	2 kg/ha	2 g/L	On label	31/07/2021
Paraat	Dimethomorph	P/anti-sporulant	Protected	2	800 (min 600)	0.36 kg/ha	0.36g/L	EAMU 2585/11	31/01/2022
Percos	Ametoctradin + dimethomorph	P/anti-sporulant	Outdoor/ protected	4	500 (max 1,000)	0.8 L/ha	1.6 ml/L	EAMU 0819/13	31/01/2022
Previcur Energy	Fosetyl-aluminium + propamocarb hydrochloride	E/P/anti-sporulant	Outdoor/ protected	2	1,000 (min 200)	2.5 L/ha	2.5 ml/L	EAMU 1845/13	31/10/2020
Proplant	Propamocarb hydrochloride	P	Outdoor/ protected	3	1,500	1.5 L/ha	1 ml/L	EAMU 3100/12	31/01/2021
Revus	Mandipropamid	E/P/anti-sporulant	Outdoor/ protected	1	500 (min 200)	0.6L/ha	1.2 ml/L	EAMU 2763/16	31/01/2026

* Optimal water volume followed by specific approval requirement in brackets (if different). A water volume of 1,000 L/ha is often common practice in industry for many products.

This table includes information available on the Health and Safety Executive (HSE) website (pesticides.gov.uk), on product labels and in supplier technical leaflets. Please check the HSE website or with an appropriate adviser before using the information as regulations may have changed.

EAMU – Extension of Authorisation for Minor Use.

Growers must hold a paper or electronic copy of an EAMU before using any product under the EAMU arrangements. Anyone using a plant protection product via an EAMU should follow EAMU (or label) recommendations. Use is carried out at the grower's own risk. If specific crop safety information is not available, consider undertaking small-scale trials and/or obtain professional advice before widespread commercial use.

If in doubt about which products are permissible, or how to use them correctly, seek advice from a BASIS-qualified consultant.

Table 6. Mode of action and resistance risk potential for fungicides with activity against downy mildew pathogens

Fungicide group	Example active ingredients and products	FRAC Code	Mode of action and mobility	Resistance risk
Carboxylic acid amides (CAA fungicides)	Dimethomorph (Paraat, Percos, second active); mandipropamid (Revus)	40	Interferes with phospholipid biosynthesis and cell wall deposition Locally systemic	Resistance known in *Plasmopara viticola* Cross-resistance between all members of the CAA group Low to medium risk
Carbamates	Propamocarb hydrochloride (Previcur Energy, second active, Proplant)	28	Affects cell membrane permeability Systemic	Low to medium risk Resistance management required
Chloronitriles (phthalonitriles)	Chlorothalonil (Folio Gold, first active)	M5	Multisite inhibitor Protectant, non-systemic	Generally considered to be a low risk group with no signs of resistance to the fungicides developing
Dithiocarbamates	Mancozeb (Fubol Gold WG, first active)	M3	Multisite inhibitor Protectant, non-systemic	Generally considered to be a low risk group with no signs of resistance to the fungicides developing No resistance detected Have been used globally since the 1960s
Phenylamides (PA fungicides)	Metalaxyl-M (Folio Gold, second active, Fubol Gold WG, second active)	4	Single-site inhibitor Interferes with synthesis of ribosomal RNA Systemic	Resistance and cross-resistance well known in various oomycetes, but mechanism unknown High risk
Phosphonates	Fosetyl-aluminium (Fenomenal, second active, Previcur Energy, first active)	P7 (33)	Spore germination inhibitor Systemic and anti-sporulant	Few resistance cases reported in fungal species Low risk Reclassified from U33 in 2018
Quinone outside inhibitor (QoI fungicides)	Azoxystrobin (Amistar); Fenamidone (Fenomenal, first active)	11	Single-site inhibitor Inhibits fungal respiration Locally systemic	Resistance known in various fungal species Cross-resistance shown between all members of the QoI group High risk
Quinone outside inhibitor, stigmatellin binding type (QoSI fungicides)	Ametoctradin (Percos, first active)	45	Mitochondrial respiration inhibitor Locally systemic	Not cross-resistant to QoI fungicides Resistance risk assumed to be medium to high (single-site inhibitor) Resistance management required

FRAC – Fungicide Resistance Action Committee

Table 4. Example production and fungicide programmes for early and main season crops of column stocks

	February			March			April		
Spray application	1	2	3	4	5	6	7	8	9
Product*	Manzate 75 WG	Previcur Energy	Percos	Fenomenal	Manzate 75 WG (2)	Amistar + Paraat	Revus	Fenomenal (2)	Percos (2)
FRAC group	M3	28 + 33	45 + 40	11 + 33	M3	11 + 40	40	11 + 33	45 + 40
Liquid fertiliser regime	14-0-14 (20-5-30) @200 ppm N			9-9-36 @100 ppm N					
Foliar fertiliser regime	Phosphite	None	Phosphite	None	Phosphite	None	Phosphite	Phosphite	None
Irrigation regime	Overhead	Overhead	Overhead + drip	Overhead + drip	Drip	Drip	Drip	Drip	Drip

	April			May					June
Spray application	1	2	3	4	5	6	7	8	9
Product*	Percos	Manzate 75 WG	Previcur Energy	Percos (2)	Folio Gold WG	Fenomenal	Manzate 75 WG (2) + Revus	Amistar + Paraat	Fenomenal (2)
FRAC group	45 + 40	M3	28 + 33	45 + 40	M5 + 4	11 + 33	M3 + 40	11 + 40	11 + 33
Liquid fertiliser regime	14-0-14 (20-5-30) @200ppm N						9-9-36 @100ppm N		
Foliar fertiliser regime	Phosphite	None	None	Phosphite	Phosphite	None	Phosphite	None	Phosphite
Irrigation regime	Overhead	Overhead	Overhead + drip	Overhead + drip	Drip	Drip	Drip	Drip	Drip

* Bracketed numbers refer to product application number within the programme

This table has been created for demonstration purposes only and adoption should take into account site and crop specific requirements.

This table includes information available on the Health and Safety Executive (HSE) website (pesticides.gov.uk), on product labels and in supplier technical leaflets. Please check the HSE website or with an appropriate adviser before using the information as regulations may have changed.

Growers must hold a paper or electronic copy of an EAMU before using any product under the EAMU arrangements. Anyone using a plant protection product via an EAMU should follow EAMU (or label) recommendations. Use is carried out at the grower's own risk. If specific crop safety information is not available, consider undertaking small-scale trials and/or obtain professional advice before widespread commercial use.

If in doubt about which products are permissible, or how to use them correctly, seek advice from a BASIS-qualified consultant.

General guidance when devising spray programmes for downy mildew control on column stocks

- Fungicide selection should take into account the product mode of action, prevailing weather/environmental conditions and stage of crop growth
- The aggressive nature of the pathogen means that growers are advised to adopt a strict fungicide programme, even if there are no visible symptoms in the crop
- For successful management of downy mildew, any fungicide programme should begin early. The first spray application should occur as soon as possible after planting
- During the early growth stage, it is recommended to apply products based on active ingredients with contact modes of action (azoxystrobin, chlorothalonil, fenamidone, mancozeb). This will allow the accurate application of such products while the crop canopy is more open to achieve thorough coverage
- Growers should continually assess spray application intervals because sporulation following infection can occur within five to six days, especially under favourable conditions
- Column stocks are generally slow-growing, but the period immediately after planting and two weeks prior to harvest are ‘rapid growth stages’ and plants can tolerate downy mildew to a certain extent. Fungicides with anti-sporulant activity play a key role at this stage because they will supress further infections occurring later on when plant growth slows down
- During the rapid growth stage it is important for growers to take into account the crop liquid fertiliser regime. Where growers apply proprietary fertilisers, the phosphorus content can trigger a quick growth response if temperature conditions are above 8°C. It is worth switching to potassium boosters, such as 20-5-30, or plant finishers, such as 9-9-36, and delivering the phosphorus content with foliar-applied fertilisers based on phosphites, which can be tank-mixed with most fungicides
- Please note, where fungicides with fosetyl-aluminium actives are used, it is not recommended to mix these with phosphite-based foliar fertiliser
- Once the flower buds start to open in the latter stage of production, growers should be aware of potential spray deposits. Some solid formulation fungicides (WP, WG and WDG) are likely to leave deposits
- As all available fungicide products are used under Extensions of Authorisation for Minor Use (EAMUs), the products are applied at the grower’s own risk. If used for the first time, small-scale applications to check for toxicity are strongly recommended.

As a result of the prevailing temperatures experienced during the early crop, the potential for downy mildew sporulation is low at the beginning of the production cycle but will rapidly increase towards the end. In the case of this crop, the interval between fungicide applications can be more generous during the first half of the production cycle but should be reduced towards the end, to reflect the favourable conditions for disease development. The later planted main crop of column stocks will require a more intensive spray programme, with reduced intervals between fungicide applications. So, for example, the early crop may receive 8–10 spray applications, while the main crop receives 9–12 applications, depending upon the production techniques and nursery hygiene protocols employed, varietal selection, source of plant material and background disease pressure.