Harness microbes to make your snowdrops thrive

The late **David Way**'s snowdrop collection was ravaged by disease when moved from Kent to Hertfordshire. With no licensed fungicide to control snowdrop disease, he found another solution. Pictures by David Way unless stated

Our snowdrop collection suffered disastrous destruction after it was moved from Kent to Hertfordshire in late May 2012. Two well-known pathogenic fungi, Leaf Scorch (*Peyronellea curtisii*) and Fusarium Basal Rot (*Fusarium oxysporum*) were quickly identified by laboratory examination as major causes of loss. In addition, *Illyonectria europea* was identified as a snowdrop pathogen in 2014 for the first time, on plants from our garden. Of the 130 cultivars planted in the new garden during July and August 2012 only 10 survived to February 2018.

With a loss rate of 93% over six years, our collection was on the verge of extinction. After reading an account by David Philby, a European primula specialist, who built up a collection of over 1,000 species and cvs over 40 years, and lost the lot quickly through disease, the future for snowdrops in our garden looked bleak. I realised that there were no licensed fungicides for use in gardens to control snowdrop diseases, and no likelihood of this situation changing. Consequently, I decided that a non-chemical means of control had to be sought.

I have visited a large number of sites around the country where *Galanthus nivalis* has become naturalised and examined them carefully in the hope of finding an interesting variant. One aspect that repeatedly impressed itself on me was that although the disease was terrible when I grew them as cultivated plants in our garden, I never saw evidence of disease in large populations of naturalised snowdrops. Many have grown on the same site for 100 years or more. Yet the spores of these pathogenic fungi are air-borne. It is illogical to postulate that air-borne spores only land in gardens; the same fungal spores must also land on naturalised populations of snowdrops too.

I reached the conclusion that naturalised populations must benefit from some natural process that provides protection by helping the plants to ward off disease. It seemed credible that such a process might exist, because it would provide impressive colony longevity. Could soil microbes sustain the naturalised snowdrops and be the key to saving our collection?

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Each year the root system of snowdrops die and are replaced in around 10 weeks

Soil microbes

Currently much scientific attention is centred on mycorrhizal fungi and certain beneficial soil bacteria. Both can separately benefit plants via their roots. Now research reveals that these types of organism can interact in ways that enhance their benefit to plants even further. One as yet little-known fact is that plants have immune systems which can be stimulated by soil microbes. Another is that grasses are strongly mycorrhizal. Most long-term sites of naturalised snowdrops are in permanent grassland. Thus, one explanation of the disease-free status on naturalised sites could be that a soil population of favourable microbes has naturally developed and formed a stable ecosystem. The absence of disturbance or cultivation would greatly aid this. The presence of permanent grass seems likely to play another valuable role.

Like many other genera of bulbs, *Galanthus* have impermanent root systems. Every year the bulb's root system dies and is replaced by a new one after an interval of up to 10 weeks. Every year the connection between the bulb's roots and appropriate microbes is broken and subsequently has to be re-established. The permanent grass must play a vital bridging role. The microbes benefiting the snowdrops are benefiting the grasses also. Their perennial roots provide easy access to microbes for the new snowdrop roots as they emerge in early autumn.

These benefits are being recognised by commerce, and products containing mixtures of various live micro-organisms are now readily available. However, the manufacturers provide no information specific to snowdrops. To make their products as broadly applicable as possible, manufacturers formulate on the 'blunderbuss principle'. A wide range of microbe species are mixed together to maximise the potential range of uses one product can be used for. Because no specific information was available to meet my aims I accepted this principle and extended it to additional actions, including the use of Biochar and deep organic mulches.

An initial test

A start was made to test these ideas in early spring 2014 by visiting an estate with extensive areas of long term naturalised *Galanthus nivalis* and obtaining samples of growing plants and of the soil round them. About eight plants 'in the green' were then potted in small lattice containers using the soil they had been growing in, moderated by adding John Innes Seed compost to improve its physical properties to suit the potting process. Ten such containers were then planted randomly across the garden. All grew well, showed no foliar symptoms of disease, died down naturally and were lifted the following June. When the dormant bulbs were tipped out of their containers, no signs of disease were found. This result was taken as a sign that a local root environment containing appropriate soil microbes had helped ward-off fungal pathogens.

But other questions needed an answer. One was whether or not natural resistance to soil fungal diseases existed in *Galanthus*. To test this a quantity of healthy plants from one site was obtained 'in the green'. Two cultivars were chosen; 'Atkinsii' as representing hybrids which have stood the test of time, plus 'Sutton Courtenay', a *G. gracilis* hybrid with a reputation for a weak constitution. Small groups of each were planted side by side without any additives. This was repeated in five positions in the garden. A year later they were lifted and examined. The 'Sutton Courtenay' had declined in number and showed disease symptoms at some sites. The 'Atkinsii' had grown better but a few bulbs showed signs of disease underground. I decided this was not a route to follow.

Instead I chose to treat the entire garden with a broad spectrum commercial product which I mixed with biochar pellets (pure charcoal processed into small pellets). Charcoal helps make the soil more favourable for bacteria. The microbe/biochar mix was broadcast overall at an application rate of 0.2 litres per square metre by hand in March 2016, as far as possible as a complete sheet. The presence of many existing herbaceous perennials and a few shrubs meant that total uniformity could not be achieved. To protect germinating microbes from late frosts, maintain moist conditions at the soil surface and increase the humus content of the soil, I added a deep layer of shredded and composted conifer bark with a pH of 6.0. In March 2017 the

Galanthus 'David Baker' is a green tipped variant of *G.* 'Atkinsii', grown for its disease-resistance

entire process was repeated.

Because bacteria are thought to be the most important microbes which stimulate plant immune systems, a policy of spot dosing with a commercial product supplying appropriate soil bacteria only was introduced in early spring 2018. In theory this could boost the bulbs' immunity just as vegetative growth peaks. Each snowdrop clump received three teaspoons of product to be washed in by rain. A distinction needs to be recognised in the utilisation of mycorrhizal fungi and bacteria. The former need to be in the soil and in contact with plant roots to germinate whereas bacteria can be surface applied and move down through soil with the aid of rainfall.

Establishment

When new cultivars are acquired, many gardeners find that a proportion do not prosper. There may be no evidence of pests or diseases, just a failure to grow well or survive. This experience can be divided into two categories: (a) so called 'five-minute wonders' which grow for their first year but are never seen again, for which I coin the term 'rapid establishment failure' and (b) others, which typically persist but fail to bulk up into a sizeable clump over time, a state for which I coin the term 'static establishment'. The first category may include bulbs which fail to establish any effective soil microbe connections. The second category may represent bulbs where the microbe connections are not ideal with regard to the species of microbes involved.

In 1998 one enthusiast, Rob Cole, moved to a new garden in Feckenham, Worcs and started a snowdrop collection. He published a note in 2013 (*HPS Galanthus Group Newsletter No. 4*) that he had lost 140 snowdrop acquisitions over 15 years, thus averaging nine per year; most were rapid establishment failures. This illustrates how severe establishment losses can be.

The soil in our former garden in Kent had a 500-year history of diverse use linked to habitation and farming. The performance of snowdrops varied from location to location. Two areas persistently showed problems. In one, new additions were short-lived, in the other almost all new additions persisted, but although they looked in normal health, they failed to increase in number. Examples of the latter category are provided by the acquisition in February 2011 of 'Oreleton', 'David Baker' and 'Sentinel'. The chief merit of the first cultivar was described by the introducer as its vigour, 'an incredibly vigorous hybrid (*G. plicatus* x *nivalis*) clumping ferociously'. 'David Baker' a green tipped variant of 'Atkinsii', would be expected to have the same robust constitution as the type. All three were planted in separate locations in our former garden in Kent for two years before moving them to our garden in Herts. For the past seven years these cultivars have remained reluctant to flower or increase, each remaining at the two-bulb level and providing one or two scapes in some years. In spring 2018 after the soil management was drastically modified, a transformation took place, all three produced several more bulbs and flowers and began to thrive. Even more striking was the change in performance of another cultivar, *G. elwesii* 'Grumpy'.

Snowdrops in the new garden

The new garden, barely 50 square metres in area, occupies former allotment land. Once the hard landscaping and soil preparation were complete in July 2012, planting of 130 lattice baskets containing snowdrops began, all from the Kent garden and left undisturbed in their lattice containers. All grew and flowered in the following spring, but as the season advanced I began to realise that many clumps of bulbs were suffering severely from fungal pathogens.

I considered that my soil had been so disturbed during building that an all-over programme of improvement was needed. This started in February 2016 with a generous dressing of commercial broad-spectrum microbial products mixed with biochar to the soil surface. The soil surface was then immediately

Galanthus elwesii 'Grumpy' improved greatly as a result of soil microbes

coated with a very deep layer of fine conifer bark mulch. This application was repeated in the succeeding year.

This treatment seems to have triggered an unexpectedly beneficial change in the performance of the snowdrops in the new garden. The first indication came only one year after changing the soil management regime when I noticed a dramatic shift in the performance of *G. elwesii* 'Grumpy'. This cultivar was first acquired in 2007. In all this time the clump remained small, never exceeding four bulbs, only two of which normally flowered. Apparently experienced galanthophiles regard this as frustratingly characteristic of this cultivar. However, throughout the 2017 growing season it was strikingly noticeable on account of its increased vigour, and a sudden increase in clump size to 18 bulbs. Because it was in the smallest size of lattice container, there was severe overcrowding in the clump and in the dormant season I was forced to lift it and replant.

A new test in 2017

Having observed the effect of microbes across the whole garden, I wanted to find a way of ensuring the success of new plantings. Potting dormant bulbs in bioactive compost might not work as the fungal and bacterial elements are waiting to establish associations with plant roots necessary for their survival, but new snowdrop roots only emerge slowly from August onwards.

Consequently, there is a time gap of uncertain length between supply and need. Can it be bridged? Yes, by introducing a 'bridging' host plant, which will quickly provide roots which the microbes can link with and pass on to the new snowdrop root system. Grasses are known to be highly mycorrhizal, and studies show common plantain (*Plantago lanceolata*), is also in that category. Most grasses have deep and extensive root systems, so when their role is over and they need to be removed, immense damage can be done to the ecosystem in the pot. To avoid this, I wanted to see if annual grass species, *Eragrostis tef* could work as a bridging host. It is not winter hardy. My logic was that the pot of snowdrops can safely be planted in the knowledge that the grass will die and the microbes in the pot, by now with links to the snowdrop roots, will remain undisturbed.

In July 2017 I potted ten dormant bubs of 10 cultivars, five to a pot. My standard microbe-rich compost was used for half of them. For the remainder the inoculant was chunks of plantain roots from plants grown in soil from a long-term site of naturalised *G. nivalis*. The pots were then sown with *Eragrostis tef*. Once the bulbs had developed strong root systems, planting sites were found across the garden.

Two sites and their occupants call for special mention. Both sites were extreme examples of precise locations where previous snowdrops rapidly died, even when replanted. These were deliberately chosen as known hostile locations to increase the rigour of the test. One was occupied by 'Green Ribbon', the other by 'Lambrook Greensleeves'. When assessed in March 2018, none of the ten cultivars had failed in any location, indeed all were growing very strongly and had flowered well. After natural leaf senescence in early June, all were lifted and the bulbs in each pot examined. With the exception of 'Dodo Norton', all bulbs were firm and showed no visible sign of disease. This bulb had shown leaf symptoms of leaf scorch and was now rotting. As expected, the rate of multiplication varied between cultivars, some producing twice the number of bulbs compared to others. Averaged across all cultivars the increase was 180%. A conservative estimate of increase in bulbs of flowering size indicated a figure of 150%. The presence or absence of the outer bulb scales forming the tunic was strikingly variable between cultivars.

Diseases

The comment "If a snowdrop cultivar does not succeed in one position, lift it and try it in another" is sound. It reflects the fact that the microbial content of soil is not universal. In the recent past, although infection by several pathogenic fungi has raged relentlessly through my snowdrops, the extent and severity of the problem has not been expressed via leaf symptoms. Judged by conventional leaf symptoms alone my losses should have been moderate, not extreme.

Experience has taught me to recognise other less precise symptoms. Important among these are (a) loss of an overall appearance of 'thriving and prospering' (b) decline in bulb number per clump (c) decline in clump leaf size (vigour) and even (d) total failure for any leaves or flowers to show above soil level for a season. Clumps showing these types of ill health only may take longer to die than those with conventional leaf symptoms.

Galanthus 'S. Arnott' recoved from decline after the application of microbes

Recovery from diseases

It may seem surprising to some that recovery is possible without the use of chemical fungicides. However, this investigation has produced clear evidence that this can occur, and that microbial activity is the agency. One old stalwart, 'S. Arnott', repurchased to restock the new garden, established well but soon showed symptoms of decline. By spring 2018 the clump returned to its former glory. Several once-thriving clumps that went into sharp decline, even to the point of not showing above ground for an entire growing season, were left undisturbed for study. All have reappeared after the overall application of microbes. By spring 2018 'Ballerina', 'Sentinel', 'Ailwyn' and 'White Cloud' were back to full vigour. In contrast 'Hill Poë' has only survived as three very small bulbs. The condition of 'Hill Poë" should not be interpreted as differential response to the application of microbes: it probably reflects the difficulty of effectively applying microbes to existing clumps in soil.

Pre-planting inoculation

Intense involvement with snowdrop diseases has led me to adopt an anti-disease strategy based on the premise gardens can be hostile environments. This became clear when I moved from Kent to Hertfordshire six years ago. The strategy is simple: prepare all new acquisitions for the garden to a common standard by inoculating them first with appropriate mycorrhizal fungi and soil inhabiting bacteria. We all acquire new species or cultivars from a range of sources which increases the level of risk.

New shoots emerging among *Eragrostis tef*

Inoculation is not difficult and is most easily achieved by potting bulbs or growing plants in a microbe-rich compost which you can prepare for yourself. As a base I use John Innes Seed and Cutting compost. To this I add and mix in 30ml (two tablespoons) Rootgrow and 30ml 'Afterplant' per five litres of compost. When potting dormant bulbs, I invariably sow seed of *Eragrostis tef* on the surface, cover with grit and lightly water. The pots are stood in shade and not planted out until the bulbs have developed a strong root system. If the grass grows strongly, keep it in check by cutting back. An advantage of using grass as a bridging host is that the roots fill and stabilise the soil in the pot. Thus, when the pot is removed to place the bulbs in the planting hole, the contents of the pot remain entirely undisturbed.

Recommendations

Few snowdrop collections are likely to suffer from pathogenic diseases to the extent that has been my experience. For that reason, the overall blanket treatment approach I adopted with microbes, biochar and mulch is rarely likely to be justified. In most gardens the soil may naturally contain the desired microbes although they may not be uniformly distributed. However, there is no simple test to check the microbe status of soils.

I am not alone in recognising a positive link between soil microbes and good growth of snowdrops. As early as 2010

a few Belgian galanthophiles, notably Valentin Wijnen of Hasselt, concluded that areas of soil where snowdrops always grow better than other areas, were a reflection of variability in the soil content of mycorrhizal fungi. Consequently, they used soil from good growth areas as an inoculant by placing it in the holes in the soil made for new plantings. But they had no knowledge of the link with appropriate soil bacteria. Although a step in the right direction, this procedure can never be as immediate or complete in its benefits as pre-planting inoculation.

The common standard I use applies to all new plants with the exception that plants received already growing in pots need no grass seed. After potting all bare root ('in the green') plants and dormant bulbs, Tef grass seed is immediately sown, top-dressed with grit and lightly watered. Pre-planting inoculation may be the only action needed to insure a collection against future disaster and ensure that it continues to thrive.

My standard procedure is as follows:

1) Never plant a new acquisition directly into the garden.
2) For bulbs acquired as growing plants, pot or repot using a prepared bioactive compost. When the leaves have died down, treat as for dormant bulbs.
3) For dormant bulbs, pot in a microbe-rich compost, sow *Eragrostis tef* and cover lightly with grit. Once potted, avoid any further root disturbance and stand outdoors in a suitable shady place.
4) Plant out the snowdrops in late autumn, when a strong root system has developed.

Seedlings of *Eragrostis tef* provide a bridging host for snowdrop microbes

Suppliers

Bark *Scotbark Ltd.* Tel: 0044 (0)1795 411522; www.scotbark.com
Biochar *Four Seasons Fuel Ltd.* Tel: 0044 (0)1403 783379
Microbes *Rootgrow* Tel: 0044 (0)01795 411523; www.rootgrow.co.uk
Symbio Ltd. Tel: 0044 (0)1428 685762; www.symbio.co.uk
Seed *Vreeken's Zaden* www.vreeken.nl, email info@vreeken.nl

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