



Managers can create the habitat to encourage bees and other pollinating insects without impinging on members play. Undisturbed rough around the course at Bowood Golf and Country Club in Wiltshire (Picture Syngenta)



a total of 250 hectares of pollen and nectar rich habitat across 500 golf courses in the UK and Ireland, to provide essential food sources and nesting sites for pollinating insects and especially bumblebees and wild bees in general.

“For members there is an enhanced visual and playing experience, and for managers a fast response to their endeavours. Experience shows an Operation Pollinator programme can deliver beneficial results and effects 60% quicker than conventional management techniques”.

What's being done?

Operation Pollinator sites are established on free draining soils receiving sufficient light to encourage and promote both flowering and insect activity. South facing sites are ideal, whilst cold, north-facing sites with inherently prolonged wetness should be avoided. Site selection is based on these environmental and ecological considerations.

Out of play and undisturbed rough, alongside water resources, on fairway carries, alongside walkways between holes, around the backs of greens and woodland margins are all prime sites. Sites at the woodland edge, along hedge lines and across sunny banks will furnish additional nesting habitats for bumble bees and other pollinating insects.

Seed mix selection is very much a 'horses for courses' choice with

Operation Pollinator recommending, rather than dictating, appropriate species combinations. Three seed mixtures - Parkland, Heathland and Links - are recommended with the exact species formulation created by specialist ecologists and entomologists, in conjunction with golf course designers and agronomists.

Syngenta is not prescriptive in its approach to seed mix selection and choice. “We simply recommend these mixtures as a template, but courses do not have to use them”, said Caroline. “Greenkeepers know their courses best and from experience what species of wild flowering plants are already established and thriving.”

Different species of plant obviously have different requirements, revolving around factors like soil pH and nutrient status, while different species of bees clearly have differing flower and food requirements dictated by flower morphology (shape and structure).

But courses should aim for plant species and an overall selection with established successful flower formation and display extending over the longest possible period of flowering.

According to Syngenta the speed and end result of habitat creation will largely depend on whether a course uses a perennial or annual plant seed selection. Perennial plants will not yield much in the way of flowers during the first year,

while picking up in the second year and coming into their prime in year three onwards. Courses wanting a quick fix and to get members engaged in the project could initially opt for annuals, to provide a fast stunning display and quick source of pollen and nectar in the year of planting. The question is, what will come up the following year depending how successful self-seeding has been?

This is an instance where greenkeepers can take the initiative and develop an appropriate mix of perennials and annuals according to the course, their experience of wild flowers and of course their particular preferences. Some courses are opting for non-wild annual flower mixes giving stunning displays of cosmos daisies and other garden Asteraceae (Compositae) which are 'honeypots' for bees. Wildlife organisations and purists might be a bit 'sniffy' about sowing non-native species, but after all golf courses are not universally natural landscapes and many feature trees species from across the world.

And it's not all about flowers because these mainly dicot (broad-leaved) species will be growing within grass swards. Grass sward composition will have significant impact on seedling establishment and flowering success and therefore the visual and entomological impact of the end result. Caroline recommends encouragement of fescue grasses over rough grasses,



like Yorkshire Fog (*Holcus lanatus*), in roughs. Not only will there be a better seeding success rate but the end result will look much better if the flowers are borne in a wispy open fine rough with fescue panicles blowing in the wind.

Who's in?

Caroline says 42 clubs are signed up and when the Marriott hotel group comes on board next year this number will rise to over 50. And you don't have to be in Operation Pollinator to be doing the right thing. "Kings Hill Golf Club in Kent, for example, is doing everything within the objectives of Operation Pollinator without actually being part of it. However, the more that become part of the initiative, the greater weight it carries in promoting golf's true potential for ecological enhancement."

Syngenta has identified the following clubs as carrying out best practice and designated them Operation Pollinator 'Champions': Bowood Golf and Country Club, Cleveland Golf Club, Chesterfield Golf Club, Hanbury Manor Golf and Country Club, Hockley Golf Club, London Golf Club, Massereene Golf Club, Minchinhampton Golf Club, Naas Golf Club, Rutland County Golf Club, St Andrews Links Eden Course and The Grove.

Many greenkeepers are clearly

enthused and already convinced of the worth of the Operation Pollinator Programme. Steve Thompson, greenkeeper at John O' Gaunt Golf Club, said: "As we establish more wildflower areas around the course, the aim is that it will add to the experience of playing in a natural environment."

What's in it for greenkeepers?

The success of Operation Pollinator ultimately rests with the level of enthusiasm shown by greenkeepers, and bluntly - what's in it for them.

Good results from an Operation Pollinator programme will clearly raise the profile of the whole course management team giving a sense of pride and motivation. Enhancement of knowledge and skills is clearly a major benefit.

One benefit perhaps not automatically obvious is the incentive to properly manage rough through 'rescue of the fescue'. Operation Pollinator should automatically increase the level of care when applying fertiliser and pesticide with more careful targeting providing better effect and less waste.

It will give greenkeepers a broader and stronger profile for improved career development at the club or elsewhere. Last and perhaps most importantly it provides a way of engaging members and the club

ABOVE: Wispy, open fine fescue rough at Kings Hill, West Malling (Picture Syngenta)

TOP RIGHT: *Bombus pascuorum* on Greater Plantain (*Plantago major*) (Picture Syngenta)

RIGHT: Annual garden flower mixes (including cosmos daisy shown here) give a quick colourful show which is highly attractive to bees and other pollination insects

BELOW: Bird's foot trefoil is prostrate weed of fine turf but in other situations it is an upright and valuable wild flower which attracts bees (Picture Syngenta)

management, and a valuable reason to promote continuous dialogue.

And if greenkeepers doubt members are inside they should consult a survey conducted by Syngenta: 81% of players say that it is important to have a natural looking course; 60% are not satisfied with environmental initiatives on their course; and 74% strongly agree with the statement "I enjoy seeing wildlife - birds, bees and butterflies - when I play."

Caroline concluded: "If a club creates just 0.5 ha of Operation Pollinator it is the same effect as 600 club members sowing a 2 x 4 m flower border at home."





Ely City gets the buzz of promoting pollinators

The Operation Pollinator wildflower areas established at Ely City Golf Club have generated many very positive comments from members over the summer, reported the club's Deputy Head Greenkeeper and environmental champion, Simon Winters (above).

He believed a key aspect of its success has been the highly visible location of blocks selected for wildflowers - on the walkthrough to the tee for the 15th and surrounding the back of the green - meaning players are fully immersed in the colour and buzz of insect activity in the clearly signposted areas. Secondly, the decision to sow a mix of flowering annuals in the first year has created a blaze of colour and an instant response in pollinator and insect numbers.

"We have also been very proactive with telling the members what we are doing," he said. "Having got them engaged with the initiative and its objectives, and demonstrating quickly what could be achieved, they are very keen for more and to see it extended."

Whilst the wildflower areas have been focused on Sherriff Amenity annual seed mixes so far, Simon is keen to incorporate more native perennial wildflowers into the areas in the future. "The annuals have worked incredibly well and proven a big attraction for insects and players, but they will need to be recultivated and sown each year. That carries a cost and time element that is fine on a small scale, but could prove prohibitive on the larger Operation Pollinator ecological areas scheduled for the coming years.

"Adding and developing areas of native perennial wildflower mix will add ecological diversity and a more natural appearance, and will also be easier to manage in the long-term."

He added that the initiative has generated real interest and enthusiasm among the greenkeeping team. "Our first priority is producing the best possible playing surface. That has really improved over recent seasons and is now looking better than ever, which gives us the chance to give extra attention to the Operation Pollinator areas."

Although the course covers just 94 acres in total, Simon and Course Manager, Andy Baker, identified a number of areas where wildflower could be established without interfering with play, and still providing a visual enhancement to players' rounds.

Andy added: "I believe our experience shows that Operation Pollinator could be incorporated onto every golf course, and would add a beneficial feature for the environment, the greenkeeping team and the players, as well as the golf industry as a whole."

Researching Endophytes in UK Sports Turf

Jonathan Knowles from Myerscough College unveils his latest research findings on endophytes – potentially a solution for sustainable turf management

Relationships

All plants have relationships and associations with animals, invertebrates, other plants, and microbes. This relationship or symbiosis can be beneficial, antagonistic or neither. Turf diseases are a good example of an antagonistic association and conversely, mycorrhizal fungi are a classic example of a beneficial relationship. In this article I want to introduce, or at least review a symbiosis which may be new to you; a clandestine microbe - the aboveground fungal-endophyte.

Greenkeeping, or sports turf management, is a skill requiring specialist training, education and an understanding of the balance between ecology, horticulture and agriculture.

I want to discuss how microscopic fungi could potentially open up a new area of knowledge and broaden the understanding and fusion between ecology and sports turf. This area of microbe-interaction is already making progress in crop biotechnology and we are starting to see some early marketing for endophyte-infected seeds for the sports turf market already. The truth is this type of microbe-interaction has been applied and used in turf and grassland management in other countries such as New Zealand for many years.

Defining an Endophyte

An endophyte is a symbiont, typically a fungal or bacterial infection that lives within the plant. Some endophytes spend part of their

life within the plant, while others spend all their lifecycle within the plant. Mycorrhizae is described as an endophyte, however, this article focuses on the fungal-endophytes that spend their life in the aerial shoots and leaves (plate 1 and 2).

Grass-Endophyte Ecology & Sports Turf

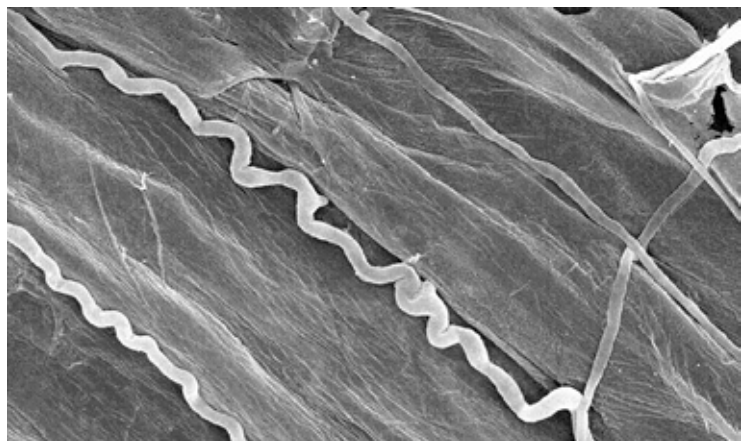
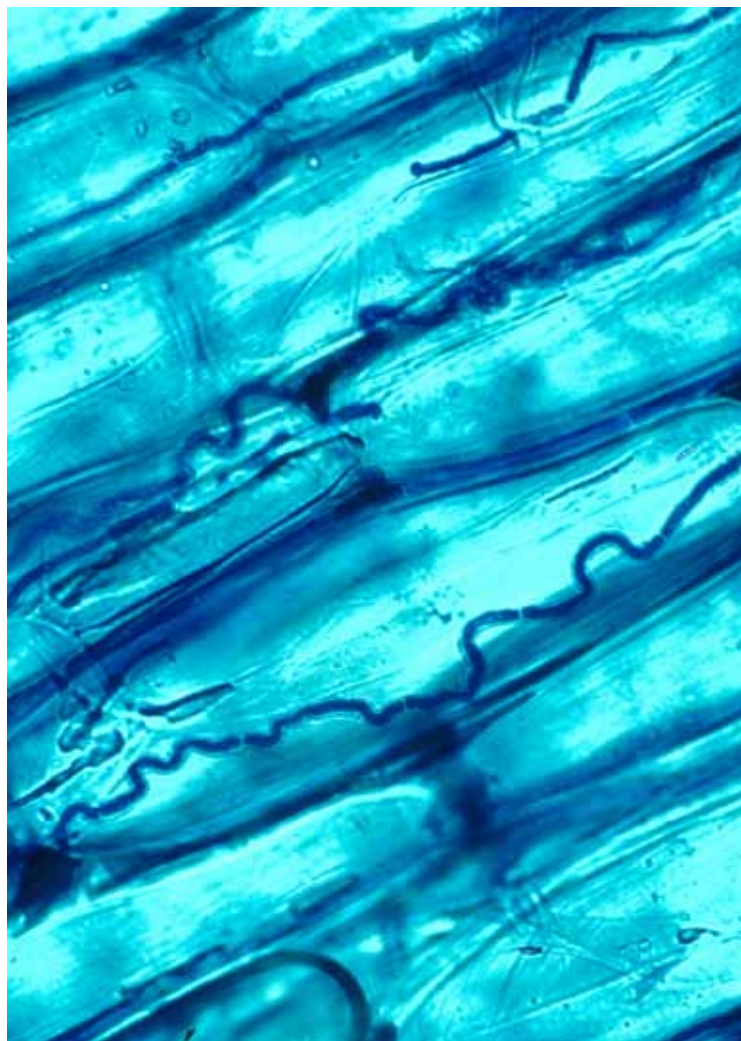
The grass-endophytes symbiosis is not new knowledge. In wild grassland ecology there is a rich source of information discussing the relationship – good and bad.

At the moment sports turf endophyte research is limited, nevertheless, many of the grasses found in ecology and agricultural research are the commonly used in sports turf. So, from what we understand at the moment, there are around six different species of fungal-endophyte infecting UK sports turf species.

That is they have the potential for infection, note we don't have the data to suggest distribution or infection levels in UK sports turf just yet. These six species belong to one family of fungal endophyte - Clavicipitaceae.

A mycologist may be familiar with ergot and choke the pathogenic fungal infections found in grasslands and pasture of rye-grass, cocks foot, tall fescue, red fescues, bent-grasses and purple moor grass.

These antagonistic endophyte infections are caused by *Epichloe* spp. and *Claviceps purpurea*. Neither of these present an obvious threat to sports turf surfaces,



TOP: The sheath cells of tall fescue stained blue with endophytic hyphae threading intercellularly X400 magnification. Image sourced - Prof. N. Hill, University of Georgia.

ABOVE: Electron Scanning Microscope image of endophytic hyphae (tubular, white and branching) situated here between the cell walls of the sheath tissue of tall fescue. Image sourced - Prof. N. Hill, University of Georgia.

RIGHT PAGE: Image from the 2005 investigation of the suppression of red thread (*Laetisaria fuciformis*) and pink patch (*Limnomyces roseipellis*) using endophyte infected red fescues. From the two plots it is clear to see endophyte infected turf on the right suppressing the onset of disease. Image source Dr. S. Bonos, Rutgers University.

Quiz

1. Select the three correct reasons why endophytes could benefit sports turf?
2. Where is the evidence that endophytes in sports turf may be beneficial?
3. There is no evidence of *Poa annua* being endophyte infected in UK sports turf. However, what species of endophyte could we

especially as they are diseases of the inflorescence. However, seed houses may have concerns over choke, especially as it known to castrate some turf species. Interestingly, for sports turf there is one prominent fungal-endophyte of significance - *Neotyphodium* spp. a derivative of *Epichloe* spp., for which infection is transmitted via the seed of the next generation.

Importantly, this means there are no signs of disease or the associated outward visible growing fungal parts, such as sclerotia or conidia. So this type of endophyte (*Neotyphodium*) typical to our sports turf species is asymptomatic, hence it's secretive infection.

The Justification of Endophyte Research in Sports Turf

Endophytes have been subject to many grassland, forage and ecology research studies mostly associated with the aspects of grass growth and development.

Neotyphodium infection has been reported to have an effect on increased leaf area, tillering, root development, drought tolerance, pest resistance, nutrient deficient soil, and even an increased competitive ability against inter and intra-specific species. This sug-

gests infected grasses are invasive in areas of non-infected broadleaf weeds and grasses. However, some studies show little to no effect of the infection, and there are some contradictions.

These complications could be related to the environmental conditions, grass species, the interacting endophyte species, and even the research methodology used. When these variables are combined with the fact that the symbiotic association between endophyte and host is changeable, difficulties arise.

The association can be beneficial (mutualistic) and in contrast, under other conditions it can be detrimental (parasitic), so it can be difficult to conclude the benefits or otherwise. Indeed the benefits of the association have to be interpreted for the context in which they are set. It's not clear cut, these associations must be tested in a sports turf context to realise if the endophytes matter to the grasses and playing surfaces for sport.

Endophyte Research Matters

Stateside, Rutgers University are slightly ahead of the game studying endophytes and sports turf (plate 3). Their research has seen a *Neotyphodium* endophyte-mediated resistance to Dollar Spot and Red

GLOSSARY

Endophyte Endo- meaning within and -Phyte meaning plant. Endophytes are typically fungal or bacterial. But not limited to viral or any other microbial interaction within the plant. Endophytes are obligate biotrophs.

Clavicipitaceae A family of fungi which consist of more than forty genera. *Claviceps purpurea* is an example, commonly known as Ergot. This grass disease leaves blackened fungal parts extruding (sclerotia) from the inflorescence.

Alkaloid A naturally forming chemical compound. Toxic alkaloids are common in fungal-endophytes. These toxins can cause Ergotism when consumed by humans (in cereals). Many beneficial drugs such as anti-cancer, anti-viral, anti-malarial, and even against migraines (ergotamine). All are derived from endophytic alkaloids.

Ecosystem A community of living organisms within an environment. Where both biotic and abiotic elements are considered to be linked through nutrient cycles and energy flows.

Immunoblot A commonly used analysis method for the recognition of anti-bodies.

DNA Sequencing A process for determining the order of the nucleotide molecules specific to the DNA being analysed.

Neotyphodium Genera of fungal-endophytes, for which there are fourteen species. Reproduction by asexual or vertical means. Example species: *N. lolii*. Example host grasses: *Festuca*, *Lolium*, *Bromus*, *Melica*, and *Poa*.

Epichloe Genera of fungal-endophyte, for which there are ten species. Reproduction by Sexual or horizontal means. Example species: *E. typhina*. Example host grasses: *Agrostis*, *Bromus*, *Dactylis*, *Elymus* and *Poa*.

Choke See *Epichloe*.

Interspecific competition Competition between different species.

Intraspecific competition Competition between the same species.

Ergot See *Clavicipitaceae*

Mycorrhizae A mutualistic association between root and fungi. Grasses typical form associations with vesicular arbuscular mycorrhizae.

Sheath tissue The basal part of the grass. Leaves surround the stem in multiple layers.

Symbiosis An association or relationship between individual species. A symbiotic association can be antagonistic, parasitic, mutualistic, or commensalistic (no benefit or detriment to host).

Sustainability An approach which safeguards the future by limiting environmental damage, maintaining social equity and enduring economic demands.

Inflorescence The flower head of grasses. An aggregation of flowers on the stem.

Mutualistic A beneficial association for both host and symbiont.

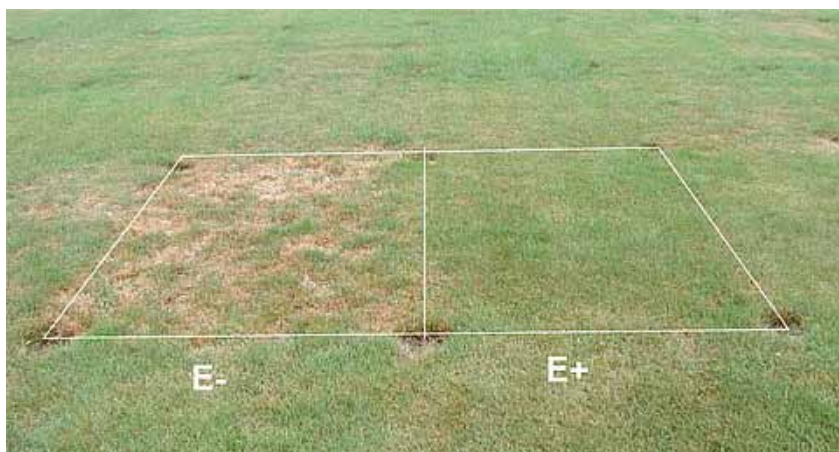
Parasitic A beneficial association for symbiont organism or parasite. Causes harm, not necessarily immediate death.

Biotechnology Loosely means; applying technology that uses a biological system, living organism, or derivative whether modified or not.

Propiconazole Active ingredient of a broad-spectrum fungicide. Example, Syngenta's Banner Maxx to control *Fusarium*, dollar spot, anthracnose, rhizoctonia and bipolaris.

Argentine stem weevil A small brown weevil (3 mm in length). A significant turfgrass pest in New Zealand.

Claviceps purpurea See *Clavicipitaceae*



expect to detect living within *Poa annua*?

4. What methods are being used to detect infection at the University of Central Lancashire and Myerscough College?

5. The immunoblot membrane image, on page 46, shows endophyte-infected grasses.

What percentage on the membrane is infected?



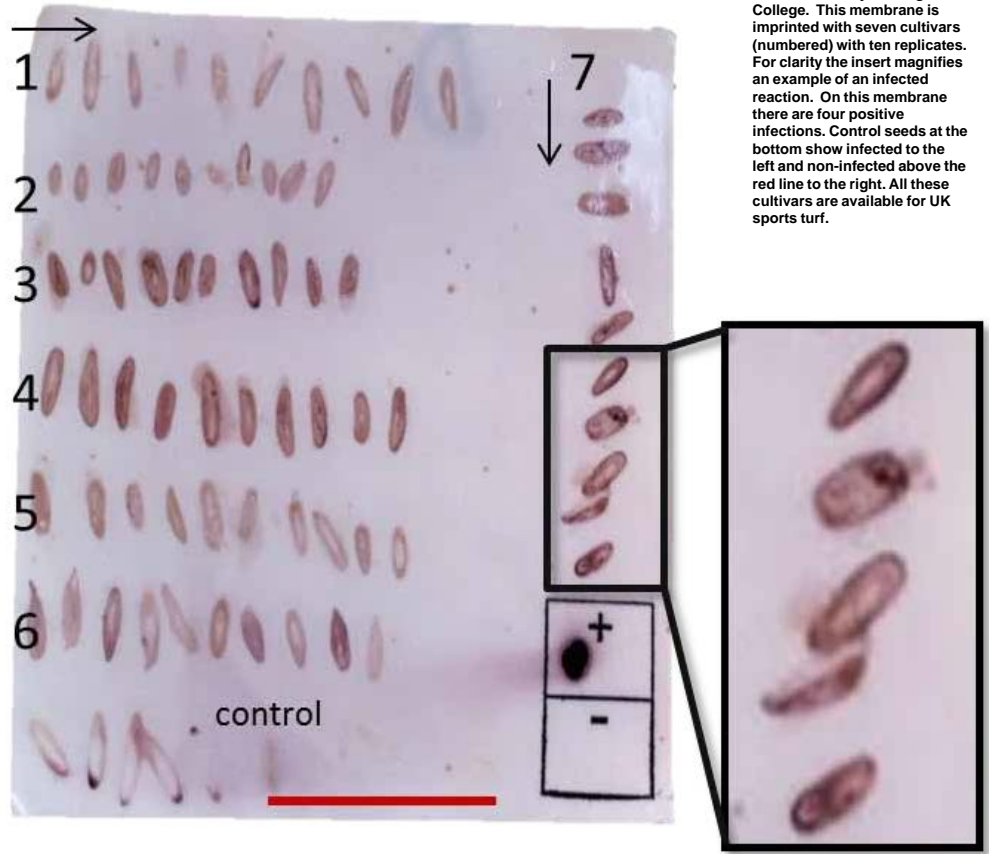
Thread in red fescues. Potentially we could be unearthing a biotechnical answer for the future of sustainable turf disease management. But, there is no evidence to suggest endophytes benefit UK sports turf.

While we interpret the benefits we must also understand the relationship being changeable. For example, it has been discovered that a *Neotyphodium* sp. can prevent wilt during drought, however, following the drought period the infection becomes parasitic diverting the plants resources for its own survival weakening the plant to further stress.

Another example is the hastening of the grass's maturity. There is some evidence to suggest endophyte-infected plants die prematurely.

Possibly not an issue with an over-seeding regime, but we can assume a weakening of the sward that could be susceptible to the threats of disease, pests and weeds.

Also there is evidence that alkaloid producing endophytes have the ability to deter pests such as the Argentine stem weevil in New Zealand, however there is no evidence the effect would be similar in UK sports turf against pests such



BELOW: Immunoblot testing carried out at Myerscough College. This membrane is imprinted with seven cultivars (numbered) with ten replicates. For clarity the insert magnifies an example of an infected reaction. On this membrane there are four positive infections. Control seeds at the bottom show infected to the left and non-infected above the red line to the right. All these cultivars are available for UK sports turf.

Proven performance across the UK



Richard Cutler
Course Manager
La Moye Golf Club

“Medallion TL quickly stopped disease and allowed turf to recover.”



Marcus Oakey
Head Greenkeeper
Moor Allerton Golf Club

“Even with snow cover we achieved five weeks disease prevention.”



Stan Power
Head Greenkeeper
Hanbury Manor Golf Club

“The greens treated with Medallion TL came through the harsh winter period with no signs of disease.”

as chafer grubs or even parasitic nematodes.

After all, many of the cool-season turf grasses have evolved in northern Europe with the endophytes and the associated turf feeding invertebrates.

It is reasonable to hypothesize the pests could be unaffected by the toxins, without the testing we would not know.

Similarly for nematodes, it is only a limited species of endophyte that produces the alkaloids that have the anti-biological toxins to resist invertebrate herbivores.

There are many species of endophytes, it may be a case that certain endophyte infections hold beneficial traits against herbivorous insects while other species are ineffective.

about the author



Jonathan Knowles

Jonathan started his greenkeeping career 20 years in Nottinghamshire. He is part of the Myerscough College team supporting the delivery of sports turf qualifications. Through a scholarship at the University of Central Lancashire and support of the college he is undertaking a PhD, researching the interaction of fungal endophytes in sports turf. For further information about the research please contact him at jkknowles@uclan.ac.uk

Even so there needs to be an understanding of endophytes in our surfaces.

The understanding or management of endophytes will need introducing as a new area of knowledge in sports turf.

A good example is the storage of seed; infection in the seed will only survive for around a year stored at 21C, however it is reported to persist for a decade stored at 4C. Moreover, there is an issue with the application of commonly used broad-spectrum fungicides eradicating the infection, particularly by Propiconazole.

Endophyte infected cultivars are starting to appear in sports turf management and quite possibly managers are starting in earnest to incorporate these endophytes into the surface with good intentions.

However, they could be unwittingly removing the endophyte with a fungicide application (unproven, but theoretically possible).

Current Research for Sports turf

Myerscough College and the University of Central Lancashire are investigating potential sustainable methods for sports turf manage-

ment, and endophytes are a current area of research. The aim is to examine some of the fundamental questions and whether endophytes matter in sports turf management.

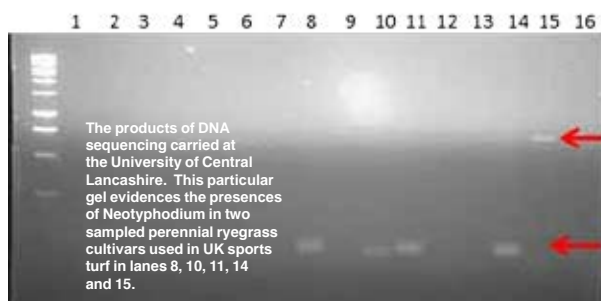
Using DNA analysis and immunoblot technology (plate 4 and 5) we have started detecting the presence of endophytes in UK sports turf, both in seed and surface.

The next stages will be to trial whether the infection has benefits or detriments for sports turf against the stresses of pests, disease and drought; and look at the effects of endophytes interaction with the immediate ecosystems of sports turf.

Endophytes could potentially be a solution towards sustainable turf management through a better understanding; and potentially reduce the application of harmful plant protection products and synthetic fertilisers.

Ultimately endophytes could bio-technically enhance the performance of sports turf surfaces, nevertheless, we need to know more about their ecology and our sports turf management towards them.

Acknowledgement: Dr Andy Owen (Myerscough College)



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Greenkeeper Training



A guide to the range of training provided throughout the UK

BIGGA is actively involved in raising the standard of Greenkeeper Training. The Association is a member of the Greenkeepers' Training Committee and strives to enhance the level of education through various means, including Section, Regional and National workshops, seminars and conferences.

The range and quality of training now available throughout the UK means there is a training course for every greenkeeper.

This should improve the quality of greenkeeping and help to produce better quality golf courses to the benefit of all within the industry.

Golf Course Managers should ensure that their staff are trained to the highest standards.

This begins by selecting a training provider that meets the criteria laid down by the GTC.

There is a clear link between education, training and economic success and all clubs should invest in the education of their staff.

There are now a number of GTC Quality Assured Centres and Training Providers identified by the GTC Quality Assured logo



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ENGLAND

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For more information contact the GTC on: 01347 838640 or visit: www.the-gtc.co.uk

ENGLAND





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