GC2030 | STRI

Golf Course 2030

Integrated Turf Management of Parkland Greens in GB&I

Best Practice Handbook

Contents.

Who is the handbook for?

This handbook intends to provide an informative resource which is accessible to everyone involved with parkland golf courses:

- Golf course owners
- Golfers and club members
- Committees
- Course managers and club owners
- Greenkeepers
- Industry media
- Companies serving the industry

How to use the handbook

The handbook will guide the reader through the chapters to provide a broad understanding of how to apply good practice management techniques more relevant to parkland annual meadow-grass/bent greens.

The R&A facilitates and funds an international research programme, Golf Course 2030, over a three-year cycle. It focuses on key sustainability priorities including – sustainable agronomy; resource management; biodiversity; and climate – to create evidence-based best practices and solutions within the golf industry.

Project conducted by:

STRI

Look out for a golf ball symbol marking a principle statement:

Technical discussion and research information is accessible for higher level understanding of the key statements made.

A guide to managing parkland greens.

This handbook offers practical guidance on managing parkland golf greens in GB&I in a sustainable manner using Integrated Turf Management practices.

This guide has been produced as a part of Golf Course 2030.

The following sections are a guide for understanding, inspiring and influencing behavioural and cultural change as the game embraces a sustainable future.

Integrated Turf Management (ITM) aims to minimise the stresses, disease, pest and weed issues which can be damaging to playing surfaces. The principles for ITM focus on sustainable and best practice methods of greenkeeping. The aim is to consider and identify the pressures of a changing climate and regulation, as well as resource constraints on golf green management.

This information enables us to be better informed about where we are now and where we are heading, as well as providing best practice solutions for those managing parkland golf greens. The following sections are a guide for understanding, inspiring and influencing behavioural and cultural change as the game embraces a sustainable future. This is the very start of the GC2030 journey.

Introduction.

The pressures of increased play, changing climate, and reduced resources need to be better understood if courses are to adapt and prepare for the future.

The publication of this handbook comes at a time of unprecedented challenges.

Increasing pressures and expectations

The publication of this handbook comes following a time of unprecedented challenges dealing with the global coronavirus pandemic, and increasing economic pressures.

There have been inevitable interruptions to the usual golf course operations, although leisure activities including golf experienced an upturn in participation. Courses reported increased membership and higher footfall for the first time in years.

The upturn in play is very welcome and good for the game but it comes with the golfer anticipating year-round play and high expectations, often with little appreciation of the impact of climate change pressures coinciding with changes in environmental legislation.

The pressures of increased play, changing climate and reduced resources need to be better understood if courses are to adapt and prepare for the future.

Climate Change

The impact of climate change is a significant factor.

All of the UK's ten warmest years on record have occurred since 2002 whilst since 1998 the UK has seen seven of the ten wettest years on record. UK winters are projected to become warmer and wetter on average, whereas summers are projected to become hotter and drier.

These statistics are playing out in front of us with the summer drought stress of 2018 followed by the very wet autumn and winter of 2019 and 2020 contributing to greater challenges in keeping golf greens, and golf courses as a whole, open and in good condition for year-round play.

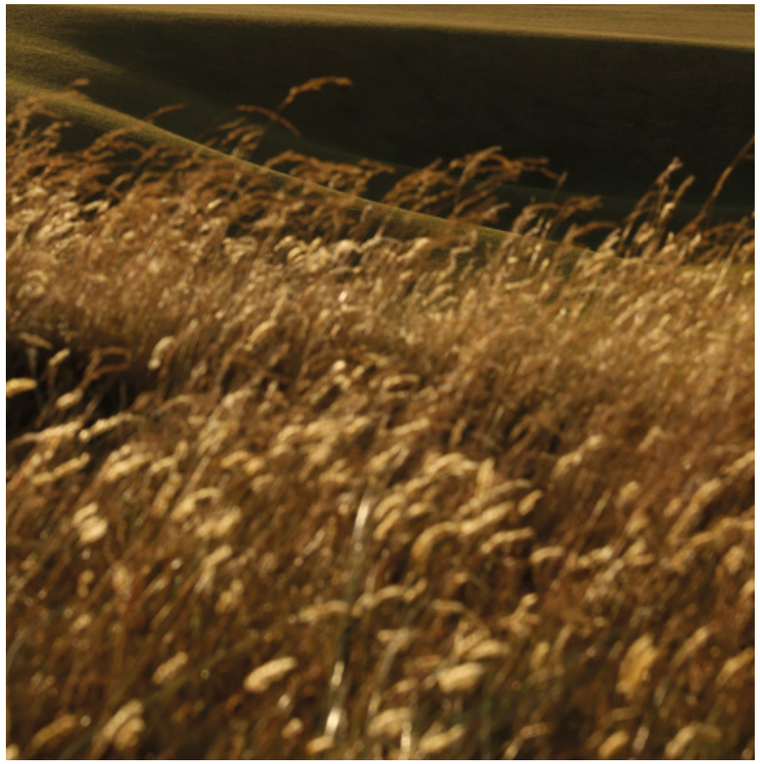
Further information on climate change and its implications for disease incidence is discussed in Chapter 4.

Environmental and legislative change

In recent years there has been significant legislative change around Synthetic Plant Protection Products, known commonly as pesticides, including the withdrawal of some key products making it far more challenging to maintain the same standards of playing quality on greens than was achievable previously. There are fewer pesticide products available for use in the amenity industry now than have been available in recent decades and this trend seems likely to continue. Chapter 2 discusses this issue in greater detail and the role pesticides play in maintaining golf greens.

The need to embrace Integrated Turf Management (ITM) practices

This changing landscape does however offer opportunities to adapt and manage golf greens more sustainably with less chemical input. Advances in research and development are leading to an increased understanding of Integrated Turf Management (ITM) practices and their role in delivering a more biologically diverse environment for the future of golf, whilst at the same time enabling better management of pests, weeds and diseases. This ITM approach is underpinned primarily by developing stronger turf health which is better able to cope with these outside forces.



One key area of management is the need to improve sward grass species composition. This typically means increasing the amount of bentgrass and reducing the amount of annual meadow-grass present and developing stronger, more resilient, sustainable playing surfaces better able to cope with the challenges being faced.

The withdrawal of some key pesticide products in recent years makes it far more challenging to maintain the same standards of playing quality on greens than was previously achievable.

Pesticides and their role in maintaining golf greens.

The availability and application of pesticides have enabled playing standards to be raised and the benchmark set for expected standards of putting surface quality on parkland courses.

For many years there has been an increasing groundswell of public opinion around pesticide use.

Image of damage caused by earthworm casting. Not only does worm casting cause soil structural problems and reduce drainage, but they can also dramatically reduce grass cover to the point where casting numbers damage winter games playing surfaces more than the games themselves.

The role of pesticides in golf green management

Commercially available plant protection products contain one or a combination of chemicals known as active substances that prevent, control or destroy unwanted insects, fungi, plants or weeds.

Pesticides authorised for use in managed amenity turf may be used to keep potentially damaging turfgrass diseases such as microdochium patch or fusarium under control or to eradicate insect pests such as leatherjackets. The availability and application of pesticides have enabled playing standards to be raised and the benchmark set for expected standards of putting surface quality on parkland courses.

What is the problem with pesticides?

For many years there has been an increasing groundswell of public opinion around problems with pesticide use and the detrimental effect these chemical substances have on the wider environment. Studies demonstrating collapses in the number of pollinating insects in Europe have provided compelling evidence of a need for change.

The role of insects has a cascading effect on food webs, ecosystems and biodiversity as a whole through their role as pollinators and a food source. Preserving insect abundance and species diversity has to be a conservation priority, driving the need to look after our environment in a more sustainable way. This has already resulted in some tightening of legislation, changes in the active substances available for use on golf courses and a reduction in the number of products available for sale. These changes are resulting in reduced chemical sales within the UK and as a direct result make it more challenging for greenkeepers to control pests and diseases.

It is too early to be able to determine the full impact of leaving the EU in January 2021 on our pesticide legislation.

Recent trends and changes

Data in The R&A GC2030 Resources Action Plan written by Dr Paul Miller, shows the downward trend of pesticide use in GB&I and it seems likely that this trend will continue. Other European countries including Denmark are already having to manage golf courses without any pesticides, therefore being reliant on pesticides is not an option and steps have to be taken to address this. A deliberate choice needs to be made to reduce pesticide use ahead of enforced changes, developing more sustainable putting surfaces that are in a better place to cope with any further tightening of controls around chemical use.

Since 2016 there have been three critical changes in the greenkeeping industry triggered by the tightening of pesticide legislation. The first happened when stocks of the insecticide chlorpyrifos for leatherjacket control had to be used up by October 2016. Chlorpyrifos was used widely around the world as it was effective, relatively inexpensive, and had a broad spectrum of activity against a wide range of insects. However, concerns about the impact of this organophosphate pesticide known for its damaging effects on the human nervous system, especially in children, saw application banned in the UK following an EU review. The effect has been a significant increase in leatherjacket damage to greens, resulting in turf weakness and sometimes turf dieback as the grubs eat turf roots and leaves, as well as surface damage as birds hunt and peck out the grubs as food. Whilst there is an insecticide Acelepryn that has been licenced on emergency approval for control of leatherjackets, problems around timing of application to maximise efficacy mean leatherjacket issues are ongoing.

The second change happened when the earthworm control products containing the last remaining lumbricide – carbendazim – had to be used up by August 2017 Earthworms themselves are not the problem but their surface casts are – causing muddy turf surfaces especially on inland courses where soils tend to be heavier. Casting rates have increased and turf surfaces are muddier. Sand application, organic matter reduction and lowering of soil pH are options to help reduce casting rates but these methods do not bring casting rates down to those achieved with applications of carbendazim.

It is interesting to look at the table of pesticides that were available to greenkeepers in 2002 and compare this to a comparable list for 2020.

2002	2020
In 2002 there were nine fungicide active substances available for use through GB&I, some used as a single chemical product with others a combination of more than one.	**By 2020** all of these active substances had been removed and replaced with a different set of eight active substances containing significantly reduced quantities of modern active substances.
In 2002 there were four active substances for insecticides.	**In 2020** this was reduced to zero – with just one that has been available for leatherjacket control for the past three years (2018-2020) for limited application under emergency approval.

The most recent significant change was in June 2018 when any remaining stocks of the contact fungicide containing iprodione had to be used up. The loss of this final contact acting fungicide has completely altered the way in which autumn/winter turfgrass disease activity caused by microdochium (fusarium) patch can be managed. Once there is visible disease scarring it is too late to apply one of the remaining fungicides and expect some reasonable level of control. Preventative application of modern fungicides are required for them to be effective and so judging the timing of applications, alongside the environmental and financial expense of repeated applications, makes it very difficult for greenkeepers to rely on fungicides for turf protection. Disease management has become more difficult without the 'go-to' iprodione to check and stop winter disease in its tracks.

The impact of tightening legislation needs to be contextualised within climate change. The trend for milder, wetter winter weather has replaced the previously expected cold, frosty winters when a period of snow cover could usually be relied upon to close and rest the course for a few weeks. Cold, dry weather naturally reduces the likelihood of microdochium patch disease whereas mild, wet conditions will aggravate it. The impact of milder winters with higher rainfall gives this disease greater opportunities, extending the period

of time in which it is most active at the same time as there are less fungicide solutions available.

It is becoming critical to adopt a fully Integrated Turf Management (ITM) approach using cultural techniques in addition to correctly selected turf health products and appropriate nutrition management alongside maintaining well drained turf surfaces, reduced organic matter levels and leaf moisture removal.

Advances in biostimulant technologies is one of the main areas which will strengthen ITM strategies but biostimulant sales literature can be complex and hard to understand, especially if a product is blended with fertiliser such as nitrogen. From July 2022 new legislation will require soil or plant biostimulants to be classed as a fertiliser. Products will need to prove any stated claim of plant health benefit, 'Product Function Categories (PFCs)', independently from the stated nutrient content of the product. This legislative change should improve our understanding of the use of biostimulants within ITM.

Changes have already made a mark on the golf industry with increased pest and disease levels making it more expensive, more time consuming, more difficult and at times impossible to maintain previous turf surface standards on golf greens.

Reduced chemical availability is demanding turf managers throughout the UK & Ireland to approach greens management with less reliance on chemical products. Golfers will sometimes be playing on golf greens that are not as good as they would have been if chlorpyrifos or iprodione for example were still available, but these changes are a direct consequence of better environmental stewardship of our natural landscapes. It is important that these restrictions are understood by everyone within the golf industry so that the accepted benchmark for putting green standards can be realigned with what is now and what will be possible in the future, using a combination of ITM practices and sustainable use of remaining pesticide products.

Green playing standards and agronomic conditions.

The previous chapters have set the scene, describing the challenges of maintaining parkland greens. However it is also important to understand the performance of golf greens and the criteria we can employ to measure this performance.

6,945

Over a 12-year period, **6,945 parkland greens** have been measured as a part of the STRI agronomy team delivering STRI Programme testing to golf clients.

A study of the performance of golf greens

On-site measurements of surface performance (firmness, smoothness, trueness, speed) and soil conditions (moisture content and organic matter) enable an objective assessment of green conditions to be provided to clients, benchmarking current conditions and offering the opportunity to objectively measure long-term performance and progress.

The STRI Programme data recorded between 2009-2020 give an insight into how the physical condition of a green and maintenance practices influence not only the performance of the green but the grass species present in the putting surface.

Some of the key findings from this extensive data set are outlined over the next pages.

The interaction of the organic matter content (OM), moisture content and surface firmness is one of the most important relationships we need to understand.

All major reviews of the STRI Programme data conducted in 2013, 2016 and 2020 repeatedly recorded a positive correlation between wetter soils, softer surfaces and dominance of annual meadow-grass in the sward.

The influence of organic matter content

Organic matter (OM) or thatch is a layer of dead and decaying grass roots, leaves and stems that accumulates just beneath the putting surface in the soil profile. A small amount of OM is desirable for surface resiliency. However, too much OM and the surfaces will be water retentive, soft and susceptible to disease. Rates of OM build up can most easily be accelerated by over-application of irrigation and nitrogen. Annual meadow-grass is by nature a more prolific producer of moisture retentive organic matter and consequently requires more intensive maintenance to compensate for this.

Study data from 2014-2019 found dominant greens were by average 0.7% higher in OM levels in the top 0–20mm of the soil profile than bent dominant swards (7.1% annual meadow-grass – 7.8% bent). It should be noted that the average for both sward types was above the routine STRI target range of 3-6% in the 0–20mm zone to deliver reliable playing surface performance. In light of the outcomes from this data set, a more refined target of 3.5–5% is now increasingly becoming the preferred target range.

STRI's 12-year study suggests that over this time there has been better control of and an overall reduction in OM levels. The data also identified that improvements in green performance were not widely achieved until OM levels were reduced to less than 8% in the top 0–20mm.

Parkland annual meadow-grass

More control of organic matter is not a sole guarantee for year-round improvements. It needs to be underpinned by good soil drainage characteristics. Soils which stay too wet for too long will encourage more rapid organic matter production and lower rates of natural microbial digestion of organic matter.

Green speed and impact on grass species

Analysis of over 7,500 green speed measurements taken using a stimpmeter under routine playing conditions (as opposed to tournament conditions) between the months of June and September recorded average speeds between 9ft–9ft 8in, with the majority of greens measuring between 8ft 6in–10ft.

A study of data from 2019 showed differences in the way grass species (recorded as the most dominant grass type within a green) are managed with variable heights of cut to achieve the required surface performance, as shown in the following table.

Height of cut	Count of all courses	amg	Bent	Creeping bent	Fescue
0-2mm	3	3	0	0	0
2.1-2.5mm	20	6	0	14	0
2.6-3mm	132	120	5	7	0
3.1-3.5mm	154	92	32	17	13
3.6-4mm	167	90	41	12	24
4.1-4.5mm	56	22	24	0	10
>4.5mm	0	0	0	0	
Total	**532**	**333**	**102**	**50**	**47**

2019 STRI Programme Height of Cut

Annual meadow-grass dominant greens (largely 100% annual meadow-grass) cut at 2–3mm recorded the fastest green speeds of 10ft–12ft but this comes with the cost of increased inputs, pesticide reliance and the associated lack of reliable performance (higher OM and reduced firmness under the influence of increased moisture). The use of a Turf Iron or Vibro-roller is commonly used to increase green speed whilst easing the pressure on mowing heights. This sounds simple but there are other factors which need to be considered, as explained under the subject of Rolling.

It is no coincidence that annual meadow-grass is very much the dominant species at heights of cut less than 3mm. The merit of preparing green speed above 10ft for routine play is questioned, not just in terms of the negative impact on the grass species, with risks for managing with increasing legislative restraints and environmental pressures, but also on pace of play.

The role that nutrition plays also comes into the equation when considering how to manage growth and consistency.

Balance OM management and maintain appropriate cutting heights

In summary, green performance will be unreliable if there is an excess accumulation of organic matter. However, excess organic matter may not be the main reason determining which grass species dominate. The height of cut is a primary influence determining the speed of the green. It is also a main disturbance pressure which will promote the dominance of annual meadow-grass if excessively low heights are maintained for prolonged periods.

Ball roll consistency and quality over speed

Whilst heights of cut at 3mm or below on annual meadow-grass dominated parkland surfaces increased green speed, there is no guarantee of this maintenance strategy improving the consistency of surface trueness, especially if greens contain excess organic matter and hold moisture. Surface smoothness and trueness will be impaired if swards are marked with disease and stress scars, foot marks and ball pitch marks in overly soft surfaces dominated by disease susceptible grass species.

The role that nutrition plays also comes into the equation when considering how to manage growth and consistency. The use of plant growth regulators, commonly known as PGRs (trinexapac-ethyl and prohexadione) are registered Plant Protection Products that can be used to gain more consistency or control of growth rates and surface performance. PGR products are not necessarily a key component of an ITM strategy, and the primary controls of turf health and growth would still focus on nutritional and cultural management practices.

There is evidence that PGRs can be used to assist with overseeding strategies, therefore showing a benefit in other areas of ITM.

A higher percentage of bent and fescue grass species in the sward improves the consistency of surface smoothness and trueness characteristics, in combination with drier and firmer turf base conditions.

The data confirm that ideal smoothness and trueness values, as measured with the STRI Trueness Meter, can be achieved in annual meadow-grass dominant parkland greens but that more of these greens fall outside of the target performance range than observed in bent/annual meadow-grass or bent/fescue blended swards.

Setting manageable and measurable targets for parkland greens

The data verify that annual meadow-grass/bent parkland greens can perform consistently well as long as they drain well and support good soil structure. The analysis of the data concludes that the following targets are considered best practice for routine play:

STRI Programme targets for main season routine play						
Performance characteristics						
HoC	**Speed**	**Firmness**	**Moisture**	**Smoothness**	**Trueness**	**OM 0–20mm**
3.25-4.0mm *	8ft-9ft 6in	85-120 gravities	20-25% **	19-25mm	7-10mm	3-6%

* 3.5–4.0mm is the preferred range for the promotion of bentgrass. Mowing at 3.25–3.5mm should only be applied during periods of strong growth and kept for sward refinement and competition set up.

** 15–30% would be the widest range allowing for fluctuations in weather but not recommended as the target to be managed for.

Common turfgrass diseases and ITM controls.

The previous chapter discussed golf green performance and set measurable targets for objective assessments which may help to meet the golfer's expectations.

Surface presentation and performance will inevitably be distorted when the turf is under attack from a disease.

The following sections describe the common diseases, the impact they can have and the controls available when applying ITM strategies.

What is a turfgrass disease?

The majority of turfgrass diseases on parkland golf greens in GB&I are caused by soil fungi. Not all fungi present in the soil or on the turf will cause disease. They are deemed diseases of turf when they attack the turfgrass plant.

Reducing the number of disease outbreaks and the severity of any disease is aligned with creating conditions for a healthy sward. This approach will become increasingly important over the coming years as access to effective pesticide products is set to become more difficult, while at the same time changing climatic conditions are more likely to cause diseases to occur.

As discussed, pathogenic fungi are invariably present, but disease can only develop when suitable environmental conditions (e.g. shade, leaf wetness) that favour the disease prevail.

Their interaction is conceptually presented as the disease triangle. Many of the environmental conditions can be altered to discourage activity even when one of those conditions is uncontrollable, i.e. the weather.

Pathogenic fungi that attack the grass plant are usually present, but it is only when the environmental conditions are favourable to them that they cause disease of turf. They rely on a weakened grass plant to be able to take hold and cause visible damage.

Disease control strategies are mainly focused on an integrated approach of:

a) Enhancement of plant health/ plant defences
b) Alteration of the environmental conditions (microclimate and cultural practices) to favour the turfgrass and discourage the pathogen

Chemical controls using synthetic plant protection products (SPPP) are instigated when available if other measures alone are insufficient.

What damage can turfgrass diseases cause to putting surfaces on parkland golf greens?

Turfgrass diseases weaken the turf and usually result in turf discolouration, turf surface thinning and, ultimately, to dieback of the affected grass species. Turfgrass diseases commonly affect the visual presentation of the turf and lead to a detrimental impact on play where the interaction between the roll of the golf ball and the turf surface is so critical.

What are the most common turfgrass diseases?

It is widely acknowledged that Microdochium patch is the most common and damaging turfgrass disease of parkland golf greens. This has been confirmed by surveys completed in 2002, 2003 and 2004 by STRI summarised in an article in 2005 and more recently in the GC2030 Survey of 655 greens completed over summer 2020. The data confirm Microdochium patch (commonly known as Fusarium patch) continues to be the turfgrass disease of most concern, with Anthracnose ranked the second disease of concern. Red thread was a concern in the earlier surveys but this has been replaced in the top five by Dollar spot which was not mentioned previously. Dollar spot is a disease influenced by warmer weather patterns. Fairy rings and Take-all patch complete the top five diseases of most concern.

Not all turf damage is caused by disease.

Under certain conditions, turf damage which may be symptomatically similar to disease can be caused by issues described throughout the handbook.

Common examples include:
- **Waterlogging or drought stress**
- **Turf dieback due to pest activity such as leatherjackets**
- **Over or under application of fertiliser**
- **Inappropriate mowing, brushing or rolling practices**
- **Soil nutrient deficiencies**

It is important that turf damage is correctly identified to enable the right steps to be taken to improve the health of the sward and check and minimise further surface damage.

Turfgrass diseases ranked in order of concern (1 = most concern, 5 = least)	2002, 2003 and 2004 data from STRI annual surveys	2020 data from STRI GC2030 ITM survey
1	Microdochium patch (Fusarium patch)	Microdochium patch (Fusarium patch)
2	Anthracnose	Anthracnose
3	Fairy ring	Take-all patch
4	Red thread	Fairy ring
5	Take-all patch	Dollar spot

Image showing Microdochium (Fusarium) patch present

The UK Met Office has generated some key headlines based on their modelling for future climate change. They are to be found within The UK Climate Projections 2018 (UKCP18).

What are the climatic change implications for disease incidence?

These findings are based on scenarios of varying emission levels. Key headlines from the study that have the potential to impact turfgrass diseases are included in the following pages:

Rainfall

- Despite overall drying summer trends in the future, new data from UKCP Local (2.2km)suggest a future increase in the intensity of heavy summer rainfall events. Data suggest increases in hourly precipitation in the future, although the trend for drier summers is projected.
- UKCP Global (60km), Regional (12km) and Local (2.2km) all project a decrease in soil moisture during summers in the future, consistent with the projected reduction in summer rainfall. Locally, this could lead to an expansion in the severity of hot spells.
- The strongest signals of change in Ireland mirror the UK and are seen in the summer (decrease) and winter (increase) with the largest impacts for the higher emissions. Winter values typically show increases of 0-8% (medium-low emissions) rising to mostly between 4 and 14% for high emissions. In the summers, the reductions are typically 4-16% (medium-low emissions) and up to 20% for high emissions.

Temperature

By the end of the 21st century, all areas of the UK are projected to be warmer, seasonally more so in the summer than in winter.

Hot summers are expected to become more common. The summer of 2018 was the equal-warmest summer for the UK along with 2006, 2003 and 1976.

Climate change modelling suggests that there is a 12-25% increased chance of seeing a summer as hot as 2018 again. With future warming, hot summers by mid-century could become 50% more common.

- The temperatures of hot summer days, by the 2070s, show increases of 3.7°C to 6.8°C under a high emissions scenario, along with an increase in the frequency of hot spells.
- In line with the global view, projections for Ireland, by Met Eireann, also foresee increases in the summer and winter mean temperatures.
- Seasonal change for Ireland is expected to see an increase in temperature of around 1 degree for both the high and medium-low emission scenarios for spring under the same period as above.

Autumn projections show greater warming of up to 1.5/1.4 degrees for the high/medium-low emission scenario. The patterns are different for summer and winter.

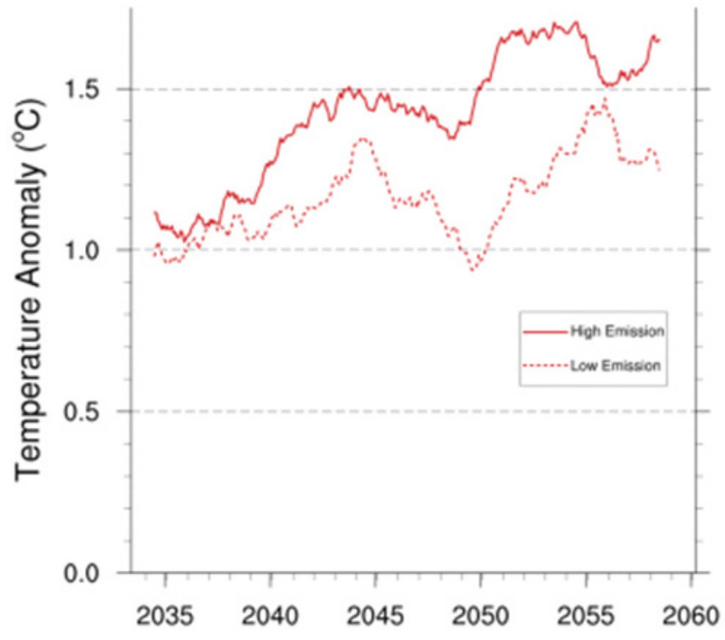
- Summer temperatures show increases from 1 degree in the northwest to 1.5 degrees in the southeast (0.8 and 1.3 degrees respectively for the medium-low scenario). Winter temperatures, on the other hand, show increases ranging from 1.2 degrees in the southwest to 1.7 degrees in the northeast (0.8 to 1.2 degrees respectively for the medium-low scenario).

Frost days

- The latest State of the UK Climate report shows that in the most recent decade (2008–2017) there have been 5% fewer days of air frost (when daily minimum temperature falls below 0°C) and 9% fewer days of ground frost compared to the 1981–2010 average, and 15%/14% fewer respectively compared to 1961–1990.
- The number of icing days (when the daily maximum temperature falls below 0°C) has been decreasing since the 1960s. During the most recent decade (2008-2017) a significant area of the UK has had less than one icing day per year on average, compared to the long-term average of about five.
- Colder than average winters and summers will still occur but will become less likely the further we go into the 21st century.

In the most recent decade (2008–2017) there have been 5% fewer days of air frost

With 9% fewer days of ground frost compared to the 1981–2010 average



Mean of average monthly temperature anomaly for Ireland for the years 2035-2060 for the high and medium-low emission scenarios relative to the average temperature over the period 1981-2000. **Source met.ie**

How will climatic changes influence disease occurrence?

Microdochium patch

- **Prolonged milder and wetter winter periods are likely to increase disease risk and incidence for a disease that favours leaf wetness and mild temperatures of 5-14°C to spread. A continuation of the downward trend in the number of frost days is another climatic condition which will favour the disease.**

Anthracnose disease

- **Wetter winters encourage basal rot anthracnose. Predicted warmer summers together with an increase in the maximum temperature days (hotter spells) increase stress levels for both foliar and basal rot anthracnose disease.**

Dollar spot

- **The risk of infection for this summer disease increases when temperatures range from 15°C to 35°C with a maximum risk when temperatures range between 25°C and 30°C and humidity is greater than 80% for a short number of days.**
- **With rising temperatures expected, disease incidence is likely to increase in line with continental conditions. Risk is greatest in locations where relative humidity and dew formation is already intense. Predicted short sudden bursts of rainfall under higher summer temperatures may increase infection levels in areas that are considered drier and normally not affected.**
- **As warmer conditions extend into the autumn, longer periods of disease pressure together with damper conditions increase risk.**

Fairy ring

- **Disease activity is favoured by warmer periods with fluctuating wet and dry spells of weather, both of which are predicted as part of future climatic changes.**

Insects and insect pest control options.

Chapter Four discussed turf diseases and controls. This section of the handbook looks at the common turf pests. This subject has become more of a concern in recent years due to legislative change and a subsequent withdrawal of insecticides.

27,000

There are thought to be 27,000 species of insects within GB&I

90%

Scientists estimate that insects make up to 90% of all species of animals on the planet

1.4B

There are approximately 1.4 billion insects for every person on the earth

Introduction

With appropriate management, golf courses are valuable landscapes which are able to provide increasingly scarce habitat for insect life. The 3,000 or so golf courses in GB&I cover around 200,000 hectares and, although this is only 1% of the land mass, they are increasingly being recognised as important environmental areas that have a role to play in improving and supporting biodiversity.

As the population of GB&I is expected to reach 75 million by 2030 there are increasing pressures on land for housing and food production.

Consequently, as we look to the future, golf courses have the opportunity to play an important role in supporting all forms of insect life through appropriate habitat provision alongside sustainable pesticide use.

More than 1 million different types of insect have been identified in the world so far, of which there are thought to be 27,000 species within GB&I. Scientists estimate that insects make up to 90% of all species of animals on the planet and that there are approximately 1.4 billion insects for every person on earth.

The incredible variety and number of insects create the biological foundation for all the different ecosystems in the world.

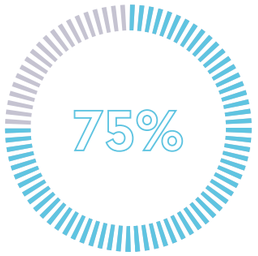
Insects pollinate many of our fruits, flowers and vegetables.

Insects feed on an endless variety of food such as plants, fungi, dead animals and decaying organic matter including that found within golf greens and on golf courses, breaking these materials down and recycling them back into the soil. Insects are also a critical part of the food web, being the sole food source for many amphibians, reptiles, birds and mammals.

Insects and our courses

When it comes to managing golf courses, and greens in particular, insects often get negative press. Greenkeepers encounter problems in presenting good quality putting surfaces and therefore require Integrated Turf Management controls for:
Leatherjackets
Earthworm casts
Chafer grubs
Nematodes

Clockwise from top left: Leatherjackets Crane Fly Larvae, Earthworm, Chafer Grub, Golf green turf weakness caused by nematode activity



Research published in 2017 indicated a 75% reduction in insect biomass had occurred over 27 years.

A 52% decline in bee numbers between 1980 and 2019 has been due to a combination of factors including climate change and loss of suitable habitat, as well as the use of pesticides and intensification of agriculture.

Pesticide legislation and insecticides

There has been a tightening of pesticide legislation and removal of insecticide products in response to research indicating significant reductions in insect numbers across the UK and Europe. Research published in 2017 indicated a 75% reduction in insect biomass had occurred over 27 years. As an important pollinator, bee numbers have also been studied throughout the UK and it seems likely that a 52% decline in numbers between 1980 and 2019 has been due to a combination of factors including climate change and loss of suitable habitat, as well as the use of pesticides and intensification of agriculture.

Although work is being completed to address this, including schemes such as the Healthy Bees Plan 2030, launched by DEFRA in 2020, it is not surprising that there are **no longer any** insecticides with full approval for use on golf courses in the UK.

The golf industry is participating in the movement to encourage pollinators with initiatives such as Syngenta Operation Pollinator and Golf Environment Awards Operation Pollinator.

Leatherjackets are the main insect pest affecting golf greens in GB&I.

Leatherjackets

These are able to cause widespread damage beneath the surface of a golf green, eating away turf roots and compromising the turf's ability to survive. Damage often comes to light in spring when greens fail to start growing uniformly in response to spring weather and applications of fertiliser due to a damaged root system. This damage can extend well into the summer months, particularly if spring growth and recovery potential is poor. The secondary damage of birds pecking for leatherjackets can also cause significant surface damage, with holes in the green impacting ball roll.

The insecticide Acelepryn (chlorantraniliprole) was given Emergency Approval for use on golf greens, with emergency authorisation licences granted for four summers (2018-2021) offering preventative control of leatherjackets and chafer grubs where these were found to be problematic, as advised by a suitably qualified and BASIS registered advisor.

The annual renewal of an Emergency Approval authorisation is not guaranteed. Cultural methods are gaining traction, including black plastic overnight sheeting to bring grubs to the surface. Installing starling bird boxes near to affected greens has been shown to be effective in reducing grub numbers and minimising turf damage – starling beak holes being smaller and cleaner than those caused by crows etc. Biological control methods using parasitic nematodes are already available and likely to become more popular once there is a better understanding of how to use these products most effectively.

Left image; close up scale of Leatherjacket and damage. Right image; Leatherjacket damage extending into early summer

Earthworms

All chemical products for earthworm control have been removed from authorised use. Consequently, earthworm casts are causing increasing problems especially on parkland golf courses under warm, wet conditions.

Casting rates tend to be highest on green surrounds, tees and fairways – it is unusual to find a serious earthworm casting issue on a putting surface.

Prolific casting is particularly problematic on areas within the playing lines and where there will be a high volume of foot traffic as the casts will smear and cap the surface, causing muddy conditions and reduced surface infiltration.

It is not currently legal to apply these materials with the intention of impacting earthworm populations. Saponins are known to be an irritant to earthworms and toxic to aquatic life and their full impact on soil biology is as yet not fully understood. These materials remain unregulated in spite of being harmful to earthworms and wildlife because they are labelled and sold for another use. Some may see this as a grey area and choose to exploit it but the reality is that this is not a legal method for controlling earthworm numbers.

Cultural control measures to lower earthworm activity include reducing organic matter, soil acidification, sand dressing and grass clippings removal. These all tend to be completed routinely as a part of good management. However, at best, these techniques will lower casting rates rather than prevent them completely.

With climate change and the present weather patterns trending to milder, wetter winters, the impact of earthworms is greater for longer than expected. It is therefore necessary for turf managers and golfers to realign expectations of what is achievable and understand that at certain times of the year there will be earthworm casts on golf courses causing muddier, weedier surfaces.

At best, it is unfortunate that the removal of earthworm control chemicals has led to the use of 'soil conditioners' on golf courses containing plant-derived saponins.

These materials are similar to the mowrah meal expellant products used by turf managers in the 1920s and 1930s prior to the introduction of chlordane and other synthetic pesticides. The demand for and supply of these products is driven by the knowledge that saponins irritate earthworms, driving them to the surface where they can be collected up and disposed of.

There are no longer any products with full approval for the chemical control of chafer grubs.

Chafer grubs

Chafer grubs are the larvae of the chafer beetle and the most problematic species in GB&I are the garden chafer, cockchafer and summer chafer. Whilst chafer grubs are usually found on golf fairways and roughs, as well as on sports pitches, lawns and parks they rarely cause problems on golf greens unless from associated damage by foraging mammals searching for the pest as a food.

There are no longer any products with full approval for the chemical control of chafer grubs, although the insecticide Acelepryn has been granted Emergency Approval for use on specific turf areas including golf greens for the last three summers (2018-2020).

Biological control methods using parasitic nematodes are also available and are becoming a more acceptable option than continued use of chemical products.

Nematodes

Most nematodes are beneficial in that they contribute to the decomposition of organic matter or attack and kill pest insects. However, there are a few species which are problematic in terms of damaging turfgrass.

Golf greens and particularly sand based green constructions can provide perfect conditions for nematodes with pore spaces for oxygen, water and nematode mobility and irrigation in periods of dry weather. Nematodes are aquatic animals and need moisture to survive and for mobility.

Close-up image of Chafer Grubs

They are microscopic in size and are capable of only limited movement in soil.

Nematodes feed on all parts of the turfgrass plant depending on the nematode species, with the most frequently attacked portion being the root system. Many injury symptoms caused by nematodes are those typically associated with a shortened root system. Depending on the host and the nematode involved, symptoms on roots include the inhibition of root elongation, swollen tips, galls, lesions and shortened stubby roots. In most cases root symptoms are not obvious. One of the first symptoms is an increased tendency for the grass plant to wilt.

Subsequently, the shoots may become stunted in irregular patches and appear yellowish or chlorotic and eventually symptoms progress to general thinning of the turf. These symptoms can also be attributed to numerous other environmental and pest stresses making identification difficult.

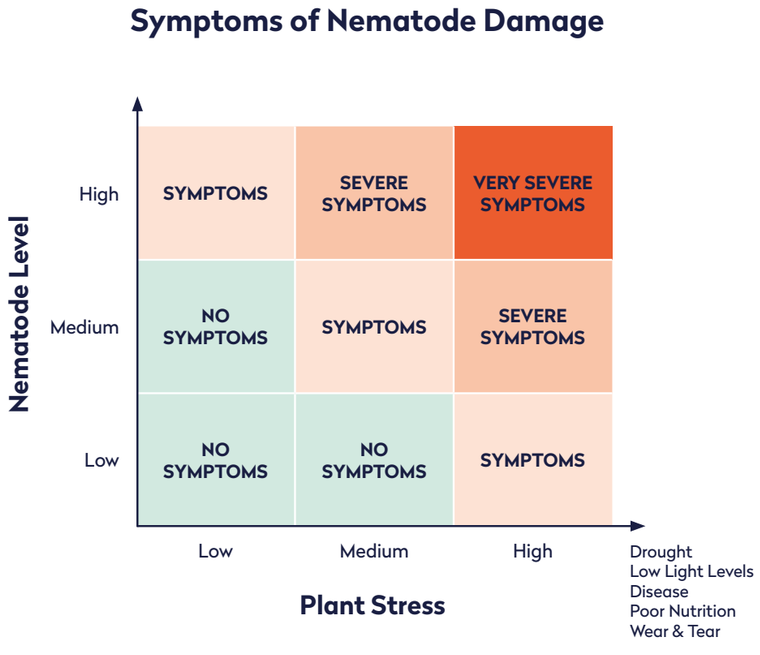
Typically, nematodes are associated with a disease complex in which significant turfgrass injury is the result of a combination of stresses, such as disease, environmental and/or parasitic nematodes. Correction of the other environmental or pest stresses frequently lessens the problem. It is likely that as the impact of climate change is predicted to result in hotter summers, so the effects of nematodes may become more problematic.

Nematicide garlic extract products are currently available in the UK but the full benefit and possible negative effects are not clearly understood, especially if not dealing with the primary cause of the stress induced nematode activity.

Summary

Insect species are under increasing pressure and numbers are declining. Insecticides that were available to turf managers have been withdrawn to minimise further damage. There are only a few insect pests found on golf courses (leatherjackets, earthworms, chafer grubs and nematodes), however it is typically only leatherjackets that can cause a significant issue on greens.

Cultural techniques need to be adopted and used as effectively as possible to mitigate the damage to the playing surface caused by these insects. As custodians of our golf courses, we should be providing surfaces for golf but also developing these landscapes to offer valuable, sustainably managed habitats to support as diverse a range of insect species as possible.



Weeds and control options.

This chapter, following on from damage and disturbance of diseases and pests, looks at issues with weeds and the ITM practices needed for their control and management.

Weeds are regarded as ‘plants that are growing in the wrong place, somewhere that they are not wanted’.

What are weeds?

These plants are typically very good competitors that take advantage of any opportunities to colonise weakened turf and bare areas. Weeds sometimes detract from the smoothness of the putting surface but are mainly seen as a concern when affecting overall presentation or outcompeting the preferred grass species. In respect of golf greens, weeds fall into three main categories – broad-leaved weeds, moss and algae, and weed grasses. The control and management techniques available to tackle these weeds vary widely depending on the weed in question.

Silvery thread moss

Integrated moss control measures centre around promoting a strong, healthy turf cover.

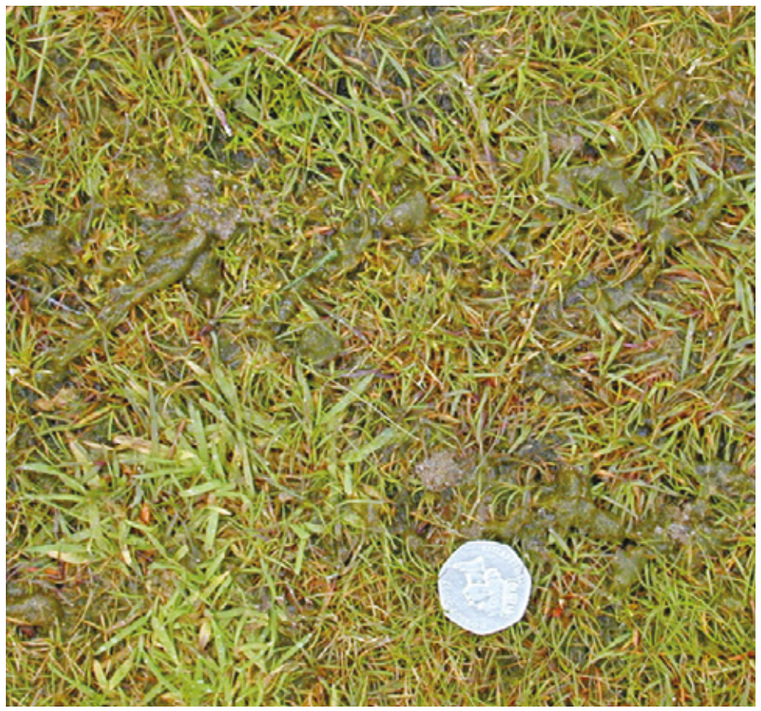
Mosses

There are two types of moss more commonly found on golf greens, silvery thread moss and trailing moss. These opportunistic plants take advantage of weakened turf and gaps in the turf caused by disease. Carried on the wind, moss spores require a damp or moist surface and a lack of competition for space and resources. Mosses are generally confined to damp environments or at the very least require moisture to complete their life cycle. Mosses also succeed in prominent dry and stressed areas where grass density is thinned, allowing moss to colonise gaps when moisture returns.

They are able to survive drought conditions, dehydrate and remain dormant for long periods before rehydration allows photosynthesis to recommence. Integrated moss control measures centre around promoting a strong, healthy turf cover and optimising growing conditions for the grass species.

Algae

Algae can develop on poorly draining surfaces, especially where grass cover is thin or bare. The algae known as "squidge" sometimes coats the turf surface with a slippery green slime. The protonemal stage of moss development is the dark juvenile stage that is often confused with algal growth on the surface of greens. Integrated algae control measures focus on maintaining dry, free-draining turf surfaces and improving grass cover and density.



Broad-leaved weeds

Daisy, mouse-ear chickweed, pearlwort, toad rush, white clover and yellow suckling clover are the most commonly found broad-leaved weeds in golf greens. They usually establish in areas of weaker turf cover where the seedling weed is able to establish itself amongst the grass plants. Although these weeds thrive best under certain soil and climate conditions, they are all able to grow successfully under less than ideal conditions. Maintaining a strong turf cover through appropriate nutrition and irrigation is an effective way to reduce rates of weed establishment and the need for weed control measures, however in many situations hand weeding tends to be a practical option although very occasionally a selective herbicide application may be required.

Weed Grasses

These are able to persist at putting surface heights of cut but are considered undesirable due to their differing growth rates and textures to the preferred sward. Yorkshire fog, perennial ryegrass and coarse textured bentgrasses can be considered the most common weed grasses although it is usual to find these as a low percentage of the botanical composition of a parkland sward. Annual meadow-grass is also considered an undesirable or weed grass but is not included within this chapter as it is covered elsewhere within the handbook.

Image group, clockwise from the left: Daisy and clover, algae, mouse-ear chickweed and yellow suckling clover

Image to right: Yorkshire Fog

Grass sward species management.

This chapter underpins much of the detail covered in the Integrated Turf Management principles discussed.

The buy-in of golfers and club decision-makers is needed when setting out on a path of grass species improvement.

The aim of this section is to present a guide for managing the conditions which will favour a blending of grass species, bentgrass and annual meadow-grass, with a view to promoting bentgrass as a more sustainable species better equipped to deal with the anticipated turf stress and disease issues discussed throughout this GC2030 handbook. Readers should also reference the GC2030 'Grass selection guide'.

Introduction

The buy-in of golfers and club decision-makers is needed when setting out on a path of grass species improvement. This can, and must, be done without sacrificing the annual meadowgrass component whilst it remains integral to delivering a presentable playing surface.

Creating the environmental conditions, i.e. micro-climate/ rootzone, which will encourage the spread and establishment of bentgrass will have a twofold benefit.

1. Reduce disease and stress risk incidence across all grasses in the blend.

2. Improve year-round surface performance with less invasive maintenance practices and fewer inputs.

Image of Browntop bentgrass sward

Bentgrass vulnerability to Microdochium patch disease incidence is less and the recovery rate is faster than the susceptible annual meadow-grass, while bentgrasses are rarely affected by anthracnose disease in GB&I.

Whilst this section comes towards the end of the handbook, the following points of discussion are pivotal to the success of sustainably managing Parkland greens. The importance of responsible tree management is paramount.

Why promote the development of bentgrass?

Bentgrasses are an essential component of the holistic approach to managing our Parkland putting surfaces which will come under increasing pressure through climate change and the restricted use of Synthetic Plant Protection Products such as fungicides.

Both browntop bentgrass and creeping bentgrass species, particularly the modern bentgrass cultivars, are preferred choices not only because of their better ball roll quality characteristics over annual meadow-grass, but also because of their reduced vulnerability to diseases.

Importantly, bentgrass cultivars, unlike annual meadow-grass, are increasingly being bred for better performance traits and specifically for better disease tolerance. Annual meadow-grass swards devoid of bentgrass can produce good surfaces but they require higher inputs and vigilance to help overcome their fragility.

Velvet bentgrass offers good tolerance against dollar spot disease and competes well against annual meadow-grass due to its high density. A large drawback in establishing velvet bent, however, is its tendency to create more organic matter and soft surface conditions. Velvet bent is hard to manage and is more vulnerable to Microdochium patch than other bentgrasses. Velvet bentgrass doesn't blend as well due to its low growing characteristic and dense nature. It is rarely used today.

Image of Browntop bentgrass sward

The establishment of bentgrass will best succeed in situations where there is good access to light, whilst the risk of disease incidence will be reduced on both the bentgrasses and annual meadow-grass species. Bentgrasses are likely to fail under dense shade and high traffic.

Setting the conditions for improved grass blends

Managing the micro-climate, inputs and maintenance

a) Shade
Browntop bentgrass and creeping bentgrass both require good levels of sunlight for growth and spread, more so than annual meadow-grass. In addition, bentgrass leaves are more succulent in shade with the result that they are more vulnerable to injury from wear and tear, e.g. damage from intensive play and other disturbance pressures such as mechanical damage from equipment. Not only is growth and recovery restricted in shaded microenvironments but because the plant is weaker in shade there is an increase in the disease risk to all grasses.

The impact of shade is currently looked at in terms of total shade hours per day, as opposed to the quantity of morning versus afternoon shade. The more sunlight that reaches the surface the better. Where dew formation occurs, the removal of shade on the morning path of the sun helps reduce the vulnerability to disease.

The most common shade culprits are trees. The more that trees are responsibly removed or pruned to increase sunlight levels in highly shaded situations the better.

Tree management needs to be responsibly planned and carried out correctly. Tree compensation schemes should always be considered. This may include replanting to encourage age and species diversity in areas away from the course and the playing lines, particularly in the south facing sunlight or westerly facing prevailing air flow, or biodiversity net gains with the development of ecology rough or wetland).

b) Air Movement
Restricted air movement caused by trees and shrubs increases the risk of disease and adds to the turf stress levels during warmer periods because surface moisture cannot be dispersed and the grasses natural cooling function, evapotranspiration, will be diminished.

Improving air movement over the putting surface requires removing obstructions and alleviating barrier density to both sides of the green complex in relation to the prevailing wind as a priority. Barriers preventing air to move away from green complexes will hamper air movement and often cause stagnation.

Promoting air movement is essential to encourage the bentgrasses, particularly in lower lying pockets of a course or adjacent to water bodies. Some shelter should be retained in very exposed locations for better bentgrass growth where wind can otherwise cause a chilling or suppressive effect.

A lack of air movement favours disease activity on all grasses and restricts bentgrass growth.

Irrigate adequately to retain a regular moisture content of 20-30% in the upper 60mm of the green's profile, using a soil moisture meter to monitor this, with moisture available beyond rooting depth.

c) Rootzone Moisture Management
Bentgrasses need moderate levels of rootzone moisture if they are to establish and spread. In fact, they do very well in damper conditions, which is especially the case for creeping bentgrass, but only where disturbance pressures are low to very low.

Restricting the water supply during dry and warmer periods will limit the spread of bentgrass and favour diseases such as fairy ring as well as the stress diseases of anthracnose and dollar spot. Anthracnose is particular to annual meadow-grass while dollar spot will affect both grasses if the air humidity is high and the rootzone is dry. Allowing greens to excessively dry out for periods might be considered a control strategy against annual meadow-grass but unless very carefully managed and timed to ensure there is good bentgrass spread to fill gaps, then annual meadow-grass and moss entry will be enabled at later stages when more prolonged rainfall returns.

Excessive moisture application or retention on the other hand will favour annual meadowgrass in more disturbed environments when there is sufficient nutrient for its growth and where oxygen levels are diminished. Consequently, an effective, reliable, and accurate means of applying irrigation water uniformly and ensuring it penetrates evenly into the rootzone is a prerequisite for healthy grass growth, with bentgrass being no exception.

Along with intermittent aeration, surfactants (commonly known as wetting agents) are deployed to supplement watering effectiveness to within a defined target range, as well as being a water conservation tool. Localised application of granular wetting agents, applied in addition to spray application, will help retain target moisture on high parts of undulating greens prone to runoff. Undulating greens present extremes of moisture and make for difficult management, and it is here that weeds such as silver thread moss can outcompete the grass.

Higher rainfall levels demand better drainage capacity to favour bentgrass growth unless disturbance pressures are very low.

d) Rainfall levels and drainage

To compensate for higher rainfall, either drainage capacity needs to improve or disturbance pressures need to be alleviated. Smaller greens in high rainfall areas with moderate to high levels of traffic will remain annual meadow-grass dominant unless changes are made. Courses located in drier locations are likely to be more successful in promoting bentgrass under the same disturbance pressures.

Good drainage levels are a basic requirement for surface performance (playability and turf health). The drainage rate is influenced primarily by the make-up of the greens soil profile together with status and management of organic matter.

Bentgrass promotion requires good drainage capacity unless play levels are very light. Wet greens with moderate to high levels of traffic will favour annual meadow-grass but also anthracnose disease on the meadow-grass.

Drainage can be enhanced using the following techniques:

1. Reconstruction to a sand-based profile
2. Installation of pipe drainage
3. The drainage potential is improved or restored more slowly over time through increased deep aeration and the build-up of a higher sand content at the top of the profile of older soil-based 'push-up' greens through topdressing.

Reconstruction to a sand-based profile specification only guarantees good drainage rates if correctly maintained and does not guarantee successful bentgrass cover unless management is correctly tailored to the bentgrasses.

Organic matter accumulates at the base of the grass cover as the turf grows and if present at too great a depth or density, it will impede drainage of water from the surface. The faster grass grows the greater the rate of organic matter accumulation. If left to accumulate unchecked drainage rates drop and surfaces become softer (reference Chapter 3).

Management of organic matter tends to be achieved by controlling growth rates to satisfy sufficient ball roll quality/bentgrass vigour on the one hand, and by physically removing it or diluting it with sand on the other.

Applying adequate rates of sand topdressing regularly to match growth rates and achieve a target organic matter content of the more refined 3.5-5.0% in the upper profile is required to keep organic matter in check. Sand-based dressings are abrasive and can weaken grass, particularly if rigorously worked in from the surface. Regular light amounts of topdressing are more forgiving for bentgrasses.

The management of organic matter needs to achieve the lower end of the researched target range (Chapter 3) on soil-based greens versus sand-based greens if drainage is to improve at a faster rate. It can be a critical issue too if basal rot anthracnose disease of annual meadowgrass is of concern. The opportunity to apply sand is more challenging for shaded and poor draining greens in wetter areas than it is on sand-based greens. In addition, sand integration is more difficult with lower heights of cut.

The optimal nitrogen level that produces sufficient density, ball roll and visual quality, while at the same time minimising competition from annual meadow-grass is site specific. Do not continually restrict nitrogen to a level compromising overall turf health and playing quality.

To develop a nutrition plan, it is imperative to understand all of the environmental, management and usage points discussed in this section of the handbook. A nutrition plan cannot be solely guided by soil analysis. Even then, plans are only guidelines and should be flexible adjusting to the changes in growth potential which will be seen as the weather and ground conditions change.

The promotion of a uniform rich green colour favours annual meadow-grass in a mixed sward. A deep green colour is not always good!

e) Nutrition

The level of nutrition, primarily nitrogen, applied is a major determinant of the botanical composition and population dynamics of a sward.

Bentgrasses gain a competitive advantage with annual meadow-grass at lower levels of nitrogen input. The current bentgrass varieties of both species (browntop and creeping bents) have similar nitrogen demands. The challenge is in restricting the nitrogen level to enable bentgrass to grow at that competitive advantage, but at the same time not being so low that the annual meadow-grass weakens to a point where surface performance suffers and playing level cannot be sustained. A rough gauge is that significantly paler, but not stressed, annual meadow-grass gives a growth advantage to the bentgrasses. A lush uniform dark green colour, often considered attractive by the golfer, is not a good indicator. However, it should be noted that during periods when nutrition levels are low and meadow-grass turns a paler yellow, it is the bentgrasses that retain a natural greenness.

Any sustained higher levels of nitrogen feeding, overly applied in the search of anthracnose and dollar spot suppression on annual meadow-grass, can stifle the spread of bentgrass by allowing annual meadow-grass to be too competitive. Managing these diseases in a full ITM programme as described is required and a balance to meet performance must be maintained. Sufficient growth must still be delivered to achieve good overall sward density, ball roll quality, bentgrass growth and prevent moss entry. If you fail here, you will lose the buy-in of the golfer and key decision-makers.

Short periods of greater disturbance will sometimes be necessary in a mixed sward to satisfy playing demands.

In a mixed sward, typical annual nitrogen inputs should range from 55-110 kg/hectare. This is a wide range and suggested from experience depending on the soil profile (physical features), traffic levels, latitude and rainfall. Lower levels are more typical for soil-based greens with higher levels probably required for sand-based greens and more southern locations which enjoy a longer growing season. Other nutrients will be required generally in significantly lower amounts, except perhaps for potassium.

f) Golf traffic, mowing and other disturbance pressures

Annual meadow-grass, unlike bentgrass, tolerates highly disturbed environments. This is explained in principle in STRI Disturbance Theory research.

A disturbance pressure is one that injures the grass blade to the point that regrowth is affected. Disturbance pressures include foot traffic, mowing regime, verticutting, grooming, sand topdressing incorporation, aeration and rolling.

The demand for prolonged periods of competition play, or tournament green speeds for day-to-day routine play, hampers the development and spread of bentgrass because of the greater disturbance pressures required to achieve it. Chapter 3, including STRI Programme data research, discusses the impact of close mowing having a negative influence on the finer grass species.

Even with optimum management, and the demand for greater green speed, it is the concentration of golfer traffic that is a major constraint to bentgrass growth.

Determining which bentgrass to introduce is largely a feature of geographical location but also of the diseases and disturbances faced.

Short periods of greater disturbance will be necessary at times in a mixed sward to satisfy playing demands. For example, sward refinement of annual meadow-grass will often be required, particularly during flowering periods, and to enhance trueness. However, one should be cognisant of the suppressing effect this can have on bentgrass spread/growth depending upon the intensity of these practices; it is often a balancing act for turf managers, having to weigh up short-term versus longer term needs.

Those higher disturbances suppress bentgrass and result in a demand for more nitrogen, all of which favours meadow-grass. Ideally, maximum levels of play should be identified and based on pinnable putting areas, rainfall levels, profile drainage and geographical location. Where play levels exceed the threshold deemed tolerable for the site then winter greens, rest periods, green rotation and green extensions are options to consider, even if they are hard to digest.

Reduction or elimination of as many of these disturbance pressures is essential to bentgrass promotion. Their reduction becomes more critical when other variables such as drainage and environmental conditions are compromised.

High levels of winter traffic, at a time of year when growth and recovery is often dramatically slowed, is particularly damaging to bentgrasses and more so to creeping bentgrasses in many locations. Damage bentgrass as little as possible for it to thrive. Let it grow!

Annual meadow-grass

Browntop bentgrass versus Creeping bentgrass

Within these islands, creeping bentgrass is the first grass to slow down its growth as temperatures drop in the autumn, to the point of semi-dormancy during cold periods, especially when easterly winds prevail. It can be slow to get going in the spring until decent temperatures arrive. It is at that point, under moderate to high traffic, that annual meadow-grass can be competitive and gain a foothold. Browntop bentgrass cultivars grow and compete better under the same conditions.

In general, creeping bentgrass promotion is likely to be more successful when confined to southern, warmer locations if it is to have a chance to persist and compete well when interseeded into an annual meadow-grass dominant or blended sward.

The modern cultivars of both bentgrass species are better placed to compete with annual meadow-grass, helped by their superior density when compared with older cultivars.

The species and cultivar choice for bentgrass grasses brought to the market will be fluid, but likely to widen in years ahead as cultivar breeding for better traits brings new cultivar selections. This is a slow process which requires years of research, cross-breeding and testing.

Grass cultivar selection will be dependent on experience, availability, as well as reference to industry cultivar trials from BSPB/STRI, STERF/NIBIO, NTEP and Rutgers University.

Currently, there is limited data on ratings for Microdochium patch, which is a key disease in GB&I. More widespread data for dollar spot disease is available, as many cultivars are bred in the USA to address dollar spot, where it is their main disease of concern.

What about the inclusion of fine red fescue?

Fine red fescue can co-exist in a blend where very good environmental conditions (airy microclimate and good profile drainage) together with better dispersal of golf traffic are found. Fescue brings another level of disease tolerance and enhanced trueness.

Fescue establishment is extremely challenging in higher rainfall areas. Its inclusion within an overseeding programme can be justified though to help reduce the symptoms of Take-all patch disease, if problematic, and where bentgrasses struggle to establish in drier parts of a green.

Browntop bentgrass

Browntop bentgrass is adapted best to a cool temperate and oceanic climate. It is more wear and drought tolerant than creeping bent. It is the preferred researched general UK climate bentgrass species.

Creeping bentgrass

Creeping bentgrass is most suitable for continental climates being able to survive very low regional temperatures in that environment while at the same time enjoying warmth. Under warmer climatic conditions creeping bentgrass, if allowed to grow, competes very favourably with annual meadow-grass. In a mixed sward creeping bent will outcompete browntop bentgrass in the warmest of locations.

The appearance of fescue within a sward is a good indicator that disturbance pressures are lower which would give confidence for bentgrass promotion, if that is your main target grass. Creeping bentgrass is likely to choke it out where elevated temperatures are common. Retaining a small amount of Red fescue in the sward, even if only to drier high spots and bunker sand-splash areas, can be a good biological indicator that you have achieved the right balance with your nutrition programme. Having distinct patches of fescue rather than a blend with bentgrass would suggest the nitrogen level is lower and that conditions are too dry.

Grassing and seeding methods

Establishment of bentgrass can be achieved either in a gradual way through overseeding, by seeding into a bare surface, inter-seeding into a current blend, or more immediately through turfing.

Whichever method of grassing is chosen; the conditions and management approach must be adjusted to favour bentgrass growth. This is particularly valid if the more costly option of turfing using imported bentgrass turf is chosen in an attempt to buy instant success. Experience would suggest that success with this solution is far from guaranteed as issues are commonly encountered when the same environment and management is continued. There are a number of overseeding techniques to consider. These, generally, involve opening up the turf surface, but whichever is chosen should ensure that there is good seed to soil contact. A lack of seed to soil contact compromises seed establishment. The seed depth placement, together with temperature, is critical to the germination of bentgrass species, together with provision of enough moisture. Seed should generally be placed at 2-3mm depth and when traffic levels are on the higher end of the preferred range, creating larger gaps in the surface will assist seedling emergence.

Development of a reasonably sized bentgrass nursery as a source for turfing repairs, and for propagation as smaller plugs, can supplement overseeding well. It offers a supply of known material more specific to the situation when imported turf choice may be limited. Typically plugs of 50-100mm diameter are inserted to replace disease scarred turf. The spread of bentgrass, or not, from plugs inserted into the putting green will offer an insight into whether favourable conditions for bentgrass growth are being met.

Whichever method of grassing is chosen; the conditions and management approach must be adjusted to favour bentgrass growth. This is particularly valid if the more costly option of turfing using imported bentgrass turf is chosen in an attempt to buy instant success. Experience would suggest that success with this solution is far from guaranteed as issues are commonly encountered when the same environment and management is continued.

The story so far.

The R&A has recognised a changing landscape with regard to resource availability and the future use of chemical plant protection products.

This is the very start of the GC2030 journey towards meeting the change and delivering a sustainable future.

The R&A has recognised a changing landscape with regard to resource availability and the future use of chemical plant protection products. The worst case scenario set out from a plant protection point of view is a total ban on usage. At the same time climate change predictions expect increased disease and insect pressure due to milder, wetter winters and drier, hotter summers.

This handbook has discussed the need for a better understanding of the challenges encountered and the drive required for behavioural and cultural change, particularly for golf clubs. As suggested, this is the very start of the GC2030 journey towards meeting the change and delivering a sustainable future.

The opening chapters have highlighted the challenges from changes in climate pressures and legislative restraints most relevant to the management of parkland greens. In chapter 3, the understanding and need to manage the expectations for playing standards and how to accurately assess the current situation was discussed. These initial chapters are important to digest and incorporate into future golf course policies.

Whether involved at a stakeholder level or simply as a golfer, by reading this handbook you are already invested as a custodian of the courses you play and will have a better understanding of how to encourage and embrace sustainable change.

Evidence has been presented which emphasises the crucial influence of environmental conditions to disease and grass species performance.

The handbook progressed to discuss current disease, insect and weed traits, as well as outlining management controls from a future focused holistic integrated turf management (ITM) perspective. Guidance for best practice of key areas of maintenance are given also knowing that the management of parkland annual meadow-grass and bentgrass greens will come under greater pressure in the future. For those of a technical mind, a series of literature and technical reviews are available within each turf management section to further assist decision making.

Evidence has been presented which emphasises the crucial influence of environmental conditions to disease and grass species performance. It supports the need to encourage improvement of the green microclimatic conditions together with drainage rates, even if the botanical composition cannot be altered to desired levels, i.e. increased dominance of bentgrass within the blend. Managing the microclimate is the starting point to a better future. It will be difficult to side-step this despite probable resistance to the change that will require tree management.

Every effort should be taken to promote better grass species within greens for it is the bred grasses that will see renewed advances in selection for disease tolerance. We will see developments in cultural practices that strengthen the plant which will include biostimulants as well as plant defence inducers. A crossover from horticulture will see biological control agents play an increasing role, while a better understanding of the influence of the soil ecosystem will gain pace. New plant protection chemistries may yet come, although they will face ever-tougher registration hurdles. No matter what, these future advances will have a greater impact where better environmental conditions are presented.

The R&A group of companies was formed in 2004 to take on The Royal and Ancient Golf Club of St Andrews' responsibilities for governing the Rules of Golf, staging The Open, golf's original championship, and developing the sport. The World Golf Museum in St Andrews is part of The R&A group.

Together The R&A and the USGA govern the sport of golf worldwide, operating in separate jurisdictions with a commitment to a single code for the Rules of Golf, Rules of Amateur Status and Equipment Standards. The R&A, through R&A Rules Ltd, governs the sport worldwide, outside of the United States and Mexico, on behalf of over 41 million golfers in 144 countries and with the consent of 159 organisations from amateur and professional golf.

The R&A has responsibility for running a series of world class amateur events and international matches in women's and girls' as well as men's and boys' golf. The R&A stages the AIG Women's Open and works with the DP World Tour to stage the Senior Open presented by Rolex.

The R&A is committed to investing £200 million over ten years in developing golf and supports the growth of the sport internationally, including the development and management of sustainable golf facilities. For more information, visit www.randa.org.

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