Integrated Pest Management Strategies for Dollar Spot - a practical Case Study 2022-2024

Findings from a three-year applied field survey of Best Management Practices on 12 golf courses aimed at reducing dollar spot damage on greens



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FOREWORD

Dear Reader,

Here is the outcome of a three-year field-based study into the most effective maintenance strategies to minimise dollar spot damage on putting greens. The study has generated an extensive dataset, but at least as many new questions about this devastating fungal disease affecting fine turf greens. These questions are equally relevant to many other researchers, consultants, superintendents, and turfgrass practitioners. We therefore consider this study a foundation for further, more focused investigation into the complexities of dollar spot management.

Over the past three years, we conducted a minimum of 36 visits across all participating golf courses, collecting data and practical insights. In addition, the greens were sampled eight times for soil analyses and fungal diagnostics. Alongside pitch marks and disease scars, a new phenomenon has now emerged: “dollar spot research damage.” To all superintendents — our sincere apologies for that ;-) .

The strength of this study lies in the integration of practical field experience and applied turfgrass knowledge with established scientific insights into dollar spot, the fundamentals of putting green agronomy, and emerging Best Management Practices (BMP) for sustainable dollar spot control.

This English-language version of the report, originally published in Dutch in April 2025, is a fairly literal rendering of the results obtained between 2022 and end of 2024. We apologise if some Dutch technical jargon has inadvertently remained in the tables and graphs.

We extend our sincere gratitude to all Course Managers and their teams for their cooperation, hospitality during site visits, operational support, and above all, their valuable technical contributions to the project. Thanks to your data and field experience, we have moved a step further. Frank, Tido, Bas, Jannes, Kees, Arjen, Jan, Lennard, Eric, Richard, Maurice, Mark, Harry, Jan Hein, André, and Marco — thank you all. We also wish to thank Professors Pierre de Wit and Gert Kema, both phytopathologists and fungal disease experts affiliated with Wageningen University. It was a pleasure to exchange knowledge and discuss fungal pathology throughout the project. Our appreciation also goes to Barenbrug Research for conducting fungal disease analyses on the collected samples.

Special thanks as well to NGA, DGB (Flip Wirth), Valentine Godin (Belgian Golf Wallonia), Dirk Kauter (Swiss Golf), and all others who provided inspiration and input during the course of this study.Finally, we thank the Royal Netherlands Golf Federation (NGF), represented by Alexander de Vries, Alexander Renders — and until 2024, Niels Dokkuma — for their input, feedback, and for making this project possible. As commissioning body of this research, the NGF gratefully acknowledges the financial contributions of the following co-funders: the Ministry of Infrastructure and Water Management, SportInnovator (Ministry of Health, Welfare and Sport), NOC*NSF, and Golf Course 2030 (The R&A).

The Authors
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SUMMARY

Background of the Project

The most common fungal diseases on golf greens are *Clarireedia bennetti* (dollar spot) and *Microdochium nivale* (Microdochium patch/snow mould). Of these two, dollar spot is the most persistent and directly affects the playability of the green. Timely prevention or appropriate control is therefore essential.

In light of the ongoing reduction in the use of chemical plant protection products, the golf sector is seeking efficient and sustainable measures to prevent damage caused by these fungal diseases. This requires knowledge development and dissemination, translated into practical solutions for the golf industry in the form of so-called **Best Management Practices (BMPs)**. In other words: what is the most appropriate practical management approach to reduce dollar spot damage to an acceptable level?

Project Objective

To further implement Integrated Pest Management (IPM) within the Dutch golf sector in practice.

The intended outcome is a measurable reduction in damage caused by Dollar Spot and Microdochium patch on golf greens in the Netherlands, achieved with significantly reduced reliance on chemical plant protection products, based on the results of applied field research.

Approach

The project involved establishing, activating, and monitoring a practice-based measurement system at selected leading golf courses in the Netherlands.

Parameters measured on three monitored greens per golf course included:

- Soil moisture
- Water infiltration rate
- Organic matter content
- Rooting depth
- Thatch thickness
- Turfgrass species composition
- Meteorological data (relative humidity, soil and air temperature)
- Cultural practices (rolling, aeration, topdressing, fertilisation)

Playability parameters were also included:

- Ball roll consistency (trueness)
- Green firmness (Clegg)
- Stimp (green speed)

Multi-year data were translated into practical recommendations and shared with the sector.

For the three-year study, 12 golf courses were selected to represent a broad cross-section of Dutch golf course conditions. In accordance with the DGB monitoring protocol, three greens per course were selected:

- Best (B)
- Average (G)
- Worst (S)

Participating golf courses:

- Utrechtse Golfclub Amelisweerd
- Golfclub Amsterdam
- Golfbaan Bentwoud
- Domburgsche Golf Links
- Edese Golfclub Papendal
- Golf- en Countryclub Geijsteren
- Golf- en Countryclub Lauswolt
- The Links Valley Golf
- Utrechtse Golfclub “de Pan”
- Sallandse Golfclub “de Hoek”
- Veluwse Golfclub
- Golfclub ’t Zelle

Working Method

Over a three-year monitoring period, researchers visited each course four times per year.

This resulted in:

- 48 visits per year
- 144 visits in total

Soil samples were taken frequently for chemical and physical analysis of the top 0–6 cm layer.

Weekly dollar spot infection assessments were carried out in cooperation with the course managers, using a standardised evaluation form. At the end of each season, participating courses submitted detailed reports of all maintenance activities.

Results (Section 3)

Field data were analysed in relation to potential BMP “control levers” including:

- Water management
- Organic matter content
- C/N ratio
- pH
- Turfgrass composition
- Nutrient inputs
- Iron (iron sulphate) applications
- Cultural practices (rolling, aeration, topdressing)
- Green firmness (Clegg)

Dollar spot progression over three seasons was compared against these parameters to identify correlations and practical relationships.

Because the study covers only three seasons, with highly variable weather conditions and a non-continuous dataset, statistically robust conclusions cannot be drawn in all cases. Additional monitoring years would be required for that.

Nevertheless, the findings provide valuable practical insights and direction.

Section 4 presents a specific management profile for each of the 12 courses based on these BMP levers. A broader classification is then proposed:

- Intensive systems
- Extensive (“less is more”) systems
- Transitional systems

Conclusions (Section 5)

The conclusions are based on both field findings and scientific literature. They are not statistically validated due to the limited scope (12 courses, 36 greens, incomplete datasets). Indications are based on specific field observations and require further validation.

Cultural (Agronomic) Conclusions

1. Maintenance practices may be identical across greens, yet their response to dollar spot varies considerably.
2. Green history and construction profile are key determinants of disease susceptibility.
3. Preventive use of iron sulphate reduces dollar spot activity. Frequency of application is more important than total annual iron input. U.S. research confirms this.
4. After moderate to severe infection, increasing iron sulphate applications may worsen damage. Curative applications dry the leaf surface but may further weaken the plant.

5. Rolling reduces dollar spot activity, provided that sand particle size and porosity are not excessive. Surface compressibility is required for rolling to be effective.
6. The Smith-Kerns prediction model is a useful preventive tool. The commonly used 20% threshold should be lowered to approximately 12%.
7. Bentgrass-dominant greens require 70–100 kg N/ha annually (plus Mg and K), divided into at least five applications when organic matter in the top 6 cm is below 2.5%.
8. Organic matter content (2–4–6 cm) should average above 3% to provide buffering capacity. Compost-amended topdressing can help increase OM.
9. Targeted hand watering on susceptible greens prevents drought stress and reduces dollar spot vulnerability. Wetting agents may assist.
10. Shade and shelter are not decisive triggers for dollar spot.
11. Leaf wetness duration correlates directly with dollar spot severity. *Agrostis stolonifera* (creeping bentgrass) forms dense canopies and prolongs leaf wetness; therefore, it increases risk independent of genetic resistance.

Communication & Playability Conclusions

12. Use the Holing Out Tester regularly to determine realistic damage thresholds. Follow R&A guidance: minimum 70% trueness for acceptable playability. Test at four locations at 6 ft (1.83 m).
13. Clear communication with members is essential. Awareness, expectation management, and education about sustainable greenkeeping are key.

Indications

1. Dew irrigation appears to reduce infection pressure. Optimal timing, duration, and green construction interactions require further research.
2. A thicker thatch/mat layer (up to ±3.5 cm) may reduce dollar spot on fescue and velvet bent greens.
    - *Agrostis canina* (velvet bentgrass) builds thicker thatch and may buffer moisture and nutrients better.
3. Oxalic acid may play a role in fungal virulence. Preliminary research suggests *Clarireedia jacksonii* prefers acidic leaf environments. Plant sap analysis may become a diagnostic tool.

Recommendations for Further Research

1. What is the optimal bacteria–fungi ratio in the 0–2 cm layer?
2. Why are fescue greens more tolerant than bentgrass greens? What is the role of C/N ratio?
3. What is the optimal timing of maintenance during the day to minimise mechanical injury and infection risk?
4. Can we better monitor dollar spot spread patterns across courses?
5. What are the natural antagonists of *Clarireedia* spp.?
6. What is the role of oxalic acid production in plant–pathogen interaction?
7. Can plant sap analysis become a practical management tool?

8. Breeding: how do we develop the ideal dollar spot–resistant seed mixture for greens?
9. Does green construction type influence dollar spot severity?

PART 1 – BEST MANAGEMENT PRACTICES FOR DOLLAR SPOT CONTROL

Background and Framework of the Multi-Year Applied Field Study

1. Background of the Problem

The most common and persistent fungal diseases affecting putting greens on golf courses are dollar spot (*Clarireedia bennettii* spp.) and Microdochium patch (*Microdochium nivale* spp.). Because these diseases directly impair turf quality and therefore green playability, timely prevention or appropriate control is essential.

The use of chemical plant protection products on golf courses has been significantly reduced in recent years. Dutch legislation requires the application of Integrated Pest Management (IPM), with only limited and temporary exemptions. Further reduction of fungicide use is strongly desired by the golf sector, provided that playing quality can be maintained.

There is therefore a clear need for effective and sustainable management measures that help prevent damage caused by turfgrass diseases. This requires both knowledge development and knowledge transfer, translated into practical Best Management Practices (BMPs): identifying which cultural, nutritional and environmental management strategies are most effective in reducing dollar spot damage to an acceptable level under practical conditions.

Within Dutch golf, a group of frontrunner courses actively applies the “measure-to-manage” principle, collecting data to steer towards more sustainable and efficient green management. Many of these courses are associated with NGA/DGB initiatives. Head greenkeepers from these courses have expressed a strong need for applied knowledge on preventing and managing dollar spot and Microdochium patch in an environmentally responsible way, while safeguarding playing quality.

To obtain better-substantiated results and to develop a future-proof IPM-based management framework, extensive applied field research on golf courses is required.

2. Turfgrass Fungal Diseases

2.1 Dollar Spot

Dollar spot is one of the most destructive turfgrass diseases affecting putting greens. It is caused by *Clarireedia* species (formerly *Sclerotinia homoeocarpa*). The disease is characterised by small, circular, bleached, straw-coloured depressions approximately the size of a dollar coin, hence the name.

The pathogen does not produce spores. When actively growing under favourable conditions, particularly in the presence of dew, white cobweb-like mycelium can be observed between

leaves and crowns of the turfgrass plant. At the leaf level, lesions appear as hourglass-shaped necrotic constrictions with dark brown margins.



Detailed damage caused by dollar spot on the grass leaf

Seasonal occurrence

In theory, dollar spot activity occurs from April through October. In practice, disease activity may start earlier in spring under favourable conditions and, in recent years, has increasingly been observed well into autumn and even early winter. In 2022, active dollar spot was recorded into December. Changing weather patterns likely contribute to this extended activity window and may indicate increasing variability in disease behaviour.

Favourable conditions

Dollar spot thrives under warm temperatures combined with high relative humidity. Warm summer days followed by cool nights promote prolonged dew formation on greens, particularly in late summer. Extended leaf wetness duration is a key driver of disease development. A dry, sandy rootzone combined with prolonged leaf wetness is a particularly high-risk scenario for dollar spot activation.



High air humidity above hole 7 of the Domburg Golf Links (photo by A. Bosschaart)

2.2 Microdochium Patch (Snow Mold)

Microdochium patch initially presents as circular patches with white mycelial growth, with turf within the affected area turning yellow to orange-brown. The disease primarily occurs during late winter, early spring and autumn, at air temperatures between 0 and 10 °C.



Serious snow mold (photo by Peter Landschoot, Penn State University)

The disease is caused by *Microdochium nivale* and can affect all turfgrass species on putting greens, with *Poa annua* being particularly susceptible. Although historically associated with prolonged snow cover, the disease remains relevant under Dutch winter conditions characterised by cool, wet and overcast weather without persistent frost.

In most cases, turf affected by Microdochium patch recovers once temperatures rise and active growth resumes in spring, provided that appropriate cultural recovery measures such as light fertilisation, brushing and overseeding are applied.

Snow mold begins with the infection of leaf tissues by mycelium of *Microdochium nivale*, which survives on plant debris in the soil. The mycelium spreads from plant to plant beneath the snow cover and causes infections that result in patches of damaged leaves, stems, and crowns. Spores (conidia) formed on infected tissues can initiate new infections and develop into new patches, even after the snow cover has disappeared.

M. nivale survives as dormant mycelium in leaf litter, thatch, and soil throughout spring, summer, and autumn. Snow mould occurs most frequently under prolonged snow cover when the soil is not frozen. Under the mild and variable Dutch winters, the risk of snow mould therefore remains consistently present.

Disease development

Ideal conditions for snow mould development are temperatures slightly above freezing at the interface between snow and turf, combined with prolonged leaf wetness. Once the snow melts and the turf is no longer covered, disease activity usually declines, but it may become active again if cold, wet, and overcast conditions persist.

This disease is generally most severe on putting greens and tees, particularly where turf is maintained with excessive nitrogen fertilisation or where the rootzone has a high nitrogen-releasing capacity. Recently seeded turf that has not fully matured before winter is also especially vulnerable. In most cases, turf affected by snow mould recovers once temperatures rise and active leaf growth resumes in spring.

Management

Cultural practices that can reduce the severity of snow mould include preventing prolonged snow cover on greens, applying only moderate amounts of nitrogen fertiliser in autumn, and avoiding mechanical operations such as deep aeration from October onwards.

When snow mould occurs in March, recovery can be supported after removing dead leaf material by applying small, frequent inputs of nitrogen, either sprayed or granular. Although all turfgrass species are susceptible to snow mould, annual meadow grass (*Poa annua*) and creeping bentgrass (*Agrostis stolonifera*) are among the most sensitive to damage (3).



Scattered snow mold patches – Green 18, Golfclub 't Zelle, March 2023 (photo: A. Wolleswinkel).

2.3 Control Versus Prevention

This study is grounded in two key theoretical frameworks:

1. the **Plant Disease Triangle**, and
2. the **Disturbance Theory** developed by the R&A and STRI.

The Plant Disease Triangle

A turfgrass disease can only develop when three components are present simultaneously:

1. **Host** – the turfgrass plant must be susceptible. Not all species or cultivars are equally vulnerable. While *Poa annua* is particularly sensitive to Microdochium patch, virtually all turfgrass species used on greens are susceptible to dollar spot to some degree.
2. **Pathogen** – the disease-causing organism must be present, observable as mycelium or characteristic turf damage.
3. **Environment** – conditions must favour infection and disease development. Key environmental factors include temperature, moisture, nutrition status and pH, as well as the overall maintenance regime.

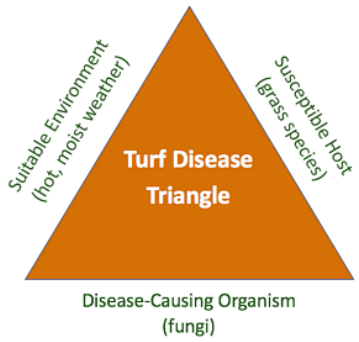


Figure 1: Schematic representation of the 'Turf Disease Trainagle' (source: Joshua Tree experts)

Leaf wetness duration is the most critical environmental driver for both dollar spot and Microdochium patch. Nitrogen nutrition also plays a dual role: excessive nitrogen can increase Microdochium patch risk, while insufficient nitrogen increases susceptibility to dollar spot.

The Disturbance Theory

According to the Disturbance Theory, putting greens are continuously disrupted by maintenance operations such as mowing, rolling, irrigation, aeration, topdressing and verticutting, as well as by play, weather and seasonal influences. While these practices are essential for maintaining playability, they also prevent the turf ecosystem from reaching full equilibrium.

Turfgrass species dominance on greens is largely determined by their ability to tolerate disturbance. *Poa annua*, for example, is highly adaptive and thrives under frequent disturbance.

The core challenge of greenkeeping lies in balancing playing quality, management intensity and turfgrass resilience. This study focuses primarily on those environmental and management factors that can be actively steered through Best Management Practices.

2.4 Importance of Meteorological Data

Accurate meteorological data and forecasts are essential for effective disease management. Hourly data are particularly valuable for understanding temperature fluctuations, relative humidity and leaf wetness duration. Tools such as Meteoblue provide accessible weather data, while local weather stations and soil moisture sensors offer valuable site-specific insights.

This study utilised meteorological data to support disease forecasting models, including the Smith-Kerns Dollar Spot Prediction Model, which uses five-day moving averages of relative humidity and mean air temperature to estimate dollar spot infection probability. Findings from this study indicate that under Dutch conditions, disease activity frequently occurs at lower probability thresholds than those commonly cited in international literature.

The Smith-Kerns Dollar Spot Prediction Model is a logistic-based model that uses a 5-day moving average of daily relative humidity and daily average air temperature to create a probability that dollar spot will occur on a given day. The model was created by Dr. Damon Smith and Dr. Jim Kerns and has been validated by years of additional field research conducted primarily in Wisconsin, but also in Oklahoma, Pennsylvania, Mississippi, Tennessee, Connecticut, and New Jersey. The model can be used by golf course managers to more accurately time control measures to control dollar spot."

3. Practice-Oriented Inventory Study

3.1 Objective

The objective of this study is to further implement the Integrated Pest Management (IPM) framework in a practical manner within the Dutch golf sector. More specifically, the study aims to provide greenkeepers with concrete tools and management strategies to reduce damage caused by dollar spot and Microdochium patch on golf putting greens in the Netherlands, without the (direct) use of chemical plant protection products.

Given the applied nature of the study design, this research does not seek to provide a strictly scientific validation. Instead, it focuses on gathering evidence based on practical field results. The knowledge developed through this approach is subsequently intended to be disseminated widely throughout the golf sector.

3.2 Approach and Methodology

The study consisted of the following components:

- **Literature review**
  An inventory was conducted of validated scientific and applied knowledge relating to both fungal diseases, their environmental conditions, and turfgrass species and

cultivars. This included a review of IPM-related studies from, among others, the United Kingdom, Scandinavia, Germany and the United States.

- **Development and implementation of a monitoring system**
  A monitoring system was established, activated and evaluated at leading golf courses in the Netherlands. Twelve golf courses were monitored over a three-year period (2022, 2023 and 2024), with four site visits per year (March–May, June, September, October–November). In total, 144 site visits were conducted.
  The selected courses provide national coverage and represent a range of soil types (clay and sand-based) and course typologies, including parkland, woodland and links-style courses. Final selection was made jointly by the commissioning body and the contractor.
- **Measurement of disease-related parameters on monitored greens**
  Measurements were carried out on selected monitoring greens and included, where available:
    - leaf wetness duration (meteorological data)
    - relative air humidity (meteorological data)
    - soil temperature (meteorological data)
    - night-time air temperature (meteorological data)
    - shading and shelter
    - turfgrass species composition
    - rooting depth and thatch thickness
    - mowing height
    - rolling frequency and time of day
    - dew removal (yes/no) and/or dew irrigation
    - use of iron sulphate or iron-containing fertilisers, including application rates
    - use of chemical plant protection products (yes/no), including product, dosage and frequency
    - organic matter content at depths of 0–2, 2–4 and 4–6 cm
    - unsaturated hydraulic conductivity (double-ring infiltrometer method)
    - pH of the rootzone (0–6 cm)
    - nitrogen regime (kg/ha), timing and application frequency
    - volumetric water content (%) in the top 0–6 cm
    - volumetric water content (%) at depth (6–12 cm)
    - irrigation regime (daily / wet–dry cycle / soil moisture-based)
    - soil water tension (using soil sensor systems where available)
- **Visual assessments and disease monitoring**
  In addition to quantitative measurements, visual assessments were conducted to record the general condition of the monitored greens. Disease development was scouted and documented, including the date of occurrence, photographic records and severity scoring based on a standardised protocol developed by the researchers. Playing intensity (traffic) at the time of assessment was also recorded.
- **Use and evaluation of disease prediction models**
  Existing disease forecasting models, including the Smith-Kerns model, were applied and evaluated using the collected field data. Where possible, model parameters were adjusted to better reflect Dutch climatic conditions. Improved prediction of dollar spot (and Microdochium patch) outbreaks enables timely implementation of preventive management measures.

- **Translation of multi-year data into preventive management strategies**
  The multi-year field data were translated into a structured management framework aimed at preventing fungal disease damage through preventive, non-chemical measures.
- **Knowledge dissemination**
  The developed knowledge is disseminated widely within the sector following a PDCA (Plan–Do–Check–Act) cycle. Target audiences include greenkeepers, course committees, course managers, scientists and the golf industry. Knowledge transfer also extends beyond the golf sector to educational training programmes, societal organisations and managers of football stadium turf, where similar fungal diseases occur.

4. Selection of Golf Courses and Greens

During the winter of 2022, the Royal Dutch Golf Federation (NGF) conducted a nationwide call for participation in a national monitoring study focusing on the most common fungal diseases affecting golf greens: dollar spot (*Clarireedia bennettii* spp.) and Microdochium patch (*Microdochium nivale* spp.). More than 50 golf courses responded positively to this call.

To obtain a representative overview of fungal disease management practices in daily greenkeeping operations, a minimum of 20 participating courses was initially considered desirable. For practical reasons, the final number of participating courses was set at 12, selected from the original pool of 50 applicants.

4.1 Selection Criteria

In consultation with the NGF, golf courses were selected based on the following criteria:

a. Pesticide use policy
Preference was given to courses that make limited or no use of fungicides and that operate under a clearly defined sustainability policy in which Integrated Turf Management (ITM) and Integrated Pest Management (IPM) are integral components of green management. Selection was not limited to members of the Duurzaam Golfbaan Beheer (DGB) group.

b. Dollar spot and Microdochium patch pressure
Disease pressure over the three seasons preceding the project was considered. The selection aimed to include both courses experiencing significant fungal disease pressure and courses with limited or no disease-related problems.

c. Green construction type (USGA, Dutch, push-up)
Rootzone construction was considered a potentially important factor influencing disease susceptibility. Over the past four decades, many sand-based greens have been constructed in the Netherlands. Collinge (1997) reported that 54% of Dutch greens follow this construction method (NGF Greenkeeping Handbook, 2006).

Three main green construction types are distinguished:

- **Push-up greens**: constructed on the native soil profile, gradually amended through intensive topdressing.
- **USGA greens**: constructed according to USGA guidelines, consisting of a 30 cm sand-based rootzone over a highly permeable drainage layer, with infiltration rates of 150–300 mm per hour and an ideal organic matter content of 2–4%.
- **Dutch greens**: derived from Californian/USGA construction principles but typically leaner and extending to a depth of approximately 40 cm.



From left to right: 'push up', USGA and Dutch green – Sallandse Golf Club (photo: C. Paulussen)

d. Course type (parkland, links, polder and forest golf courses)
Course typology influences green exposure to wind, shade and microclimate. Greens may be sheltered, heavily shaded or fully exposed to wind, affecting drying potential after rainfall or persistent dew. A balanced distribution of course types was therefore considered desirable.

e. Existing monitoring and data collection
Courses already engaged in data collection were preferred, as this increases the availability of management and maintenance data. While DGB courses initially appeared to have an advantage, incomplete datasets meant this was not decisive.

f. Turfgrass composition and sustainable management focus
Courses were selected that aim for a lower proportion of *Poa annua*, which typically requires high inputs of water, fertilisers and plant protection products. Preference was given to courses with a higher proportion of *Festuca rubra* spp. and/or *Agrostis capillaris* or *Agrostis stolonifera* spp., or with an active policy to move in that direction.

g. Geographical situation
Courses were selected to provide national geographical coverage, capturing macro-climatic differences while remaining logistically feasible for site visits.

h. Head greenkeeper qualifications
Selection considered the level of engagement, proactivity and technical expertise of the head greenkeeper.

i. Age of the golf course
Both younger courses (<15 years) and older courses (>30 years) were included to explore potential relationships between course age and fungal disease occurrence.

4.2 Monitoring Greens

In accordance with the DGB monitoring system and measurement protocol, monitoring greens were selected for each golf course. Per course, three greens were designated as **Best (B)**, **Average (G)** and **Worst (S)**. This classification was made by the head greenkeepers themselves, based on disease pressure, playing quality, turf composition and related factors.

Although this is a subjective classification, it was adopted as the initial objective reference point for the study. In Part 4, *BMP Strategies*, this classification will be reassessed for each course, as greens may have transitioned from S to B over the course of the study.

PART 2 – CHARACTERISATION OF GOLF COURSES: BASELINE SITUATION IN 2022



This part describes the characterisation of green management (*cultural practices*) per course and outlines the baseline quality of the monitored greens at the start of the study. It also states the target quality levels as formulated by the greenkeepers themselves.

The assessment is based on the questionnaire completed by the greenkeepers (Appendix 1) and the first measurement round in April/May 2022.

Table 2 summarises, per golf course and per monitoring green, a number of key cultural practice indicators as recorded, analysed (Eurofins) and measured during the first two baseline inventory rounds. The infiltration rate is presented as an average of measurements taken across the full three-year study period.

Table 2: Cultural practice characteristics of golf courses and monitoring greens, April/May/June 2022 (in DUTCH).

					(toplaag)		Profiel		
Baan		**green**	**Toplaag**	**type**	**M50**	**D60/D10**	**Infiltratie**	**Org. Stof %**	**Ondergrond**
1	UGC Amelisweerd (Utrecht)	4	Zand	80:20	317	1,8	1500	2,8	Klei
1	UGC Amelisweerd (Utrecht)	11	Zand	80:20	316	1,8	900	2,4	Klei
1	UGC Amelisweerd (Utrecht)	18	Zand	80:20	315	1,9	1020	2,5	Klei
2	Amsterdamse GC (N-Holland)	3	Zand	80:20	327	1,9	432	2,4	Zware klei
2	Amsterdamse GC (N-Holland)	6	Zand	80:20	332	1,9	900	2,4	Zware klei
2	Amsterdamse GC (N-Holland)	18	Zand	80:20	336	1,9	1044	1,9	Zware klei
3	GB Bentwoud (Z-Holland)	4A	Zand	80:20	293	2,1	2400	3,8	Zware klei
3	GB Bentwoud (Z-Holland)	4B	Zand	80:20	277	2	2850	3,7	Zware klei
3	GB Bentwoud (Z-Holland)	4C	Zand	80:20	276	2,1	1650	4,2	Zware klei
4	Domburgsche GC (Zeeland)	9	Zand	90:10	307	2,2	520	2,4	Zand
4	Domburgsche GC (Zeeland)	8	Zand	90:10	292	2	600	1,6	Zand
4	Domburgsche GC (Zeeland)	7	Zand	90:10	308	2,1	780	2,1	Zand
5	Edese GC Papendal (Gld)	14	Zand(fijn)	90:10	331	1,9	840		Zand
5	Edese GC Papendal (Gld)	9	Zand(fijn)	90:10	328	1,8	504	3,7	Zand
5	Edese GC Papendal (Gld)	5	Zand(fijn)	90:10	321	2,2	1200	4,2	Zand
6	G&CC Geijsteren (Limburg)	8	Zand	push up	290	2	840	2,2	Zand
6	G&CC Geijsteren (Limburg)	6	Zand	push up	294	2	960	2,3	Zand
6	G&CC Geijsteren (Limburg)	17	Zand	push up	298	1,9	900	2,3	Zand
7	G&CC Lauswolt Beetsterzwaag (Fryslan)	11	Zand	push up	284	21,1	720	2,8	Zand
7	G&CC Lauswolt Beetsterzwaag (Fryslan)	17	Zand	push up	258	2,4	480	2,6	Zand
7	G&CC Lauswolt Beetsterzwaag (Fryslan)	4	Zand	90:10	290	1,9	920	3,7	Zand
8	UGC De Pan Zeist (Utrecht)	17	Zand	push up	348	2,5	288	3,7	Zand
8	UGC De Pan Zeist (Utrecht)	2	Zand	push up	331	2,7	180	3,1	Zand
8	UGC De Pan Zeist (Utrecht)	16	Zand	push up	350	2,5	336	3,1	Zand
9	Sallandsche GC De Hoek Diepenveen (Ov)	1	Zand	push up	294	2,3	1320	3	Zand
9	Sallandsche GC De Hoek Diepenveen (Ov)	5	Zand	USGA	305	2	540	4	Zand
9	Sallandsche GC De Hoek Diepenveen (Ov)	17	Zand	Dutch	301	2	1020	2,7	Zand
10	The Links Valley - Ermelo (Gld)	2	Zand	80:20	322	2,1	4200	2,5	Zand
10	The Links Valley - Ermelo (Gld)	6	Zand	80:20	350	2	5100	2,3	Zand
10	The Links Valley - Ermelo (Gld)	9	Zand	80:20	330	1,9	4200	2,4	Zand
11	Veluwse GC - Hoog Soeren (Gld)	1	Zand	push up	297	1,8	900	4,2	Zand
11	Veluwse GC - Hoog Soeren (Gld)	3	Zand	push up	288	2,4	768	4,1	Zand
11	Veluwse GC - Hoog Soeren (Gld)	7	Zand	push up	295	1,8	240	4,1	Zand
12	GC 't Zelle - Hengelo (Gld)	8	Zand	80:20	301	2	2400	3	zand
12	GC 't Zelle - Hengelo (Gld)	9	Zand	80:20	314	1,8	2190	2,9	zand
12	GC 't Zelle - Hengelo (Gld)	18	Zand	80:20	308	1,8	2100	2,7	zand

1. Utrechtse Golfclub Amelisweerd



(Hole 4 photographed from the green, April 2022)

Characterisation and quality

Utrechtse Golfclub Amelisweerd has an 18-hole course and a 9-hole par-3 course. It is located on the outskirts of Utrecht, confined between railway lines and motorways. The course contains the typical landscape elements of the region: orchards, many water features, and far roughs grazed by sheep.

Amelisweerd is a typical clay-based course, where drainage and water management are essential for year-round playability. The greenkeeping team aims for high green quality without the need to use fungicides. From a playing-quality perspective, the greens should score at least 75% on trueness, reach at least Stimpmeter 8 (minimum 9 for competitions), and have a firmness of >90 measured with a Clegg hammer.

Green construction and management

The greens are constructed according to the “Dutch green” principle. This means the construction is fully sand-based, with organic matter (heather compost) blended into the rootzone. The average M50 -the so-called sand median- value lies between 280 and 300 µm.



Left to right: rootzone greens 4, 11 and 18 (photo: C. Paulussen)

Amelisweerd is relatively open with scattered solitary plantings at some distance from the greens. The greens are generally favourably positioned, i.e., not significantly sheltered or shaded.

An intensive topdressing regime on a clay course such as Amelisweerd supports favourable growing conditions. Although fine fescue (*Festuca rubra*) is desired, browntop bentgrass (Agrostis capillaris) is the dominant turfgrass species on the greens. Overseeding is carried out 4–5 times per year with 100% Agrostis capillaris (BAR All Bent mix), 45–50 kg/ha per application.

Topdressing is done with pure sand with an M50 of 360 µm. Shallow aeration takes place every six weeks during the growing season. In spring and autumn, deeper aeration is carried out using thicker tines to a maximum depth of 15 cm.

The greens are rolled 2–3 times per week, alternating with mowing. To keep diseases under control, frequent preventive applications of iron sulphate are used. Amelisweerd is slightly below the overall average across the 12 courses (44 kg pure Fe/ha per green per year).

The target nitrogen input at the start is just over 40 kg pure N/ha, split across 12 applications per year. The main nitrogen sources are ammonium sulphate during summer, supplemented with urea.



Green 4

The monitoring greens

On 25 April 2022, the baseline (T0) measurements were taken. Table 3 summarises the monitoring green characteristics.

Table 3: Characteristics of Amelisweerd monitoring greens at project start.

	18	**4**	**11**	**Notes**
Greenkeeper classification	good	average	poor	
Estimated % Festuca rubra spp.	3	5	1	
Estimated % Agrostis capillaris spp.	60	42	47	
Estimated % Poa annua	37	53	52	
Weeds	yes	yes	yes	Yorkshire fog and plantain (grn 11)
Pests	no	yes	yes	leatherjackets on grn 11 and 4
Disease susceptibility	yes	yes	yes	
Infiltration capacity (mm/hour)	150	240	120	

2. Amsterdamse Golfclub



Monitor green 3 shortly after iron sulphate application (photo by A. Wolleswinkel)

Characterisation and target quality

Amsterdamse Golf Club has been the “true” Amsterdamse Golf Club since 1934, although the club has relocated over time. Since 1990, the 18-hole parkland course has been situated at Bauduinlaan in the Houtrakpolder. It is a varied clay-based course with many water features and **USGA-spec greens**.

Green management focuses on maintaining **browntop bentgrass** and promoting more **fine fescues** within the greens. At the start of the study, the club and greenkeeping team were satisfied with the prevailing quality. The guiding principle is to maintain playable greens. Dollar spot is acceptable as long as it does not affect playing quality. No quantitative thresholds are provided for green speed, trueness and/or firmness.

Green construction and management



Left to right: root zone of the greens 3, 6 and 18 (photo by C. Paulussen)

The greens are sand-based and managed with a frequent topdressing/iron regime: every 2–3 weeks, a small amount of sand (M50 360 µm) is applied in combination with an iron sulphate treatment. Total annual topdressing volume is approx. 100 m³ spread across 15–20 applications.

Surface aeration is performed once every six weeks. Deeper aeration (8 mm tines to 15 cm) is done in both spring and autumn.

The nitrogen regime is moderate at approx. 80 kg pure N/ha, using alternating applications of ammonium sulphate and urea.

The turfgrass composition consists mainly of Agrostis capillaris, with a substantial proportion of Poa annua and a smaller share of Festuca rubra. Each September, overseeding is carried out in two passes with fine fescue and browntop bentgrass.

To control dollar spot, multiple small iron sulphate applications are used annually. However, the damage threshold is sometimes exceeded, making fungicide use (Signum) necessary; it is applied at 1,9 kg/ha when required. In the baseline year 2022, application of Signum was not needed.

The greens are not rolled, but dew removal (dew sweeping) is performed during the growing season every morning at 06:00. No anti-dew products are used.

The monitoring greens

On 19 April 2022, baseline measurements were taken. Table 4 summarises the monitoring green characteristics.



Green 3

Table 4: Monitoring green characteristics at project start.

	18	**6**	**3**
Greenkeeper classification	good	average	poor
Estimated % Festuca rubra spp.	30	15	20
Estimated % Agrostis capillaris spp.	35	55	40
Estimated % Poa annua	35	30	40
Weeds	no	no	no
Pests	yes	yes	yes
Disease susceptibility	no	yes	yes
Infiltration capacity (mm/hour)	188	216	90



Green 6 (left) and green 18 (right)

3. Golf course Bentwoud



C loop golf course Bentwoud, green 4

Characterisation and target quality

Golfbaan Bentwoud is a relatively young 36-hole golf facility (including a qualifying par-3/4), located in the Green Heart of the Randstad. The four 9-hole loops are heavily played year-round. The greens are sand-based and, despite intensive use, have had fine red fescue (*Festuca rubra commutata* and *litoralis*)as the dominant species since construction in 2012.

Most maintenance is performed early in the morning, as the course becomes too busy later in the day. As a result, the target quality set by the greenkeeping team is not always fully achieved.

Green construction and management



from left to right: rootzone greens 4A, 4B and 4C

The fescue-dominant greens have a very sandy profile with a “cap” consisting of 15–25 mm thatch and below that 20–30 mm of mat. Although this organic layer is generally undesirable, it does not (yet) appear to negatively affect playing quality. To manage thatch accumulation, an annual hollow-tine operation (10 mm) is conducted.

During the year, monthly light topdressings are applied (M50 300 µm, 0.5 m³ per green) combined with deep (25 cm) and shallow (7 cm) aeration.

Nitrogen input is typically around 60 kg pure N/ha, split across 12–15 applications of ammonium sulphate.

Iron sulphate is sprayed monthly from early spring to year-end at 10 kg/ha in 400 L water. Greens are rolled once per week. Preventive dew control measures and dew sweeping are not applied.



Fine fescue turf on green 4C, early spring (left) and looking out on the fairway (right)

The monitoring greens

Baseline measurements took place on **26 April 2022**. Table 5 summarises the monitoring green characteristics.

Table 5: Monitoring green characteristics at project start.

	4C	4B	4A	Notes
Greenkeeper classification	good	average	poor	
Estimated % Festuca rubra spp.	83	77	55	
Estimated % Agrostis capillaris spp.	12	15	30	
Estimated % Poa annua	5	8	15	
Weeds	no	no	no	clover
Pests	yes	yes	yes	leatherjackets
Disease susceptibility	yes	yes	yes	take-all patch
Infiltration capacity (mm/hour)	258	90	66	



Greens 4A (left) and 4B (right)

4. Domburgse Golf Links



Panoramic view from first tee

Characterisation and target quality

Domburgsche Golf Links was established in 1941 and is the Netherlands' only 9-hole links course located so close to the sea. The course lies directly behind the dunes and has an open character. Although wind exposure is generally high, micro-scale sheltered areas exist and may influence turf quality.

The greens have been renovated in multiple years but still consist primarily of fine fescue, fully consistent with the course's links character and coastal location. Domburg positions itself as a competitive course within a nature area and aligns management accordingly. Playing criteria typical for a links course are pursued, including a target Stimpmeter speed of at least 8,5.

Green construction and management

All greens are built on native soil, but were renovated in the 1990s–2000s. To prevent layering in the profile due to continual input of fine blown dune sand, progressively coarser topdressing sands have been used over the years. The topdressing sand has an M50 of 390 µm.

Approx. 70 tonnes of topdressing sand is applied annually, sometimes combined with shallow aeration (Maredo 3 mm, 4x/year) and deeper hollow-tining (1x/year with 8 mm tines). This deeper aeration is combined with overseeding, adding approx. 300 kg fine fescue (BAR Fescue) per ha to the greens.

Annual nitrogen input is 40 kg N/ha, using TX 10 5-0-8 and Terralift, typically applied in spring. Seaweed products and wetting agents are used regularly (every 6 weeks) to optimise water infiltration and distribution.

Iron sulphate is also used: approx. 160 kg/ha in 400 L water, split across 8 applications. Preventive dew control and dew sweeping are not applied.



Left to right: rootzone profiles greens 9, 8 and 7

The monitoring greens

Baseline measurements were taken on **2 May 2022**. Table 6 summarises monitoring green characteristics.

Table 6: Monitoring green characteristics at project start.

	7	9	8	Notes
Greenkeeper classification	good	average	poor	
Estimated % Festuca rubra spp.	90	82	71	
Estimated % Agrostis capillaris spp.	6	10	15	
Estimated % Poa annua	4	8	14	
Weeds	yes	yes	yes	Sagina, Yorkshire fog, buck's-horn plantain
Pests	no	no	no	
Disease susceptibility	yes	no	yes	dollar spot in low sheltered areas; green 8: fairy ring damage
Infiltration capacity (mm/hour)	600	360	540	



From left to right: overview greens 7, 8 and 9



Damage caused by dollar spot at hole 9

5. Edese Golfclub Papendal



Panoramic view on the 10th hole

Characterisation and target quality

Edese Golfclub Papendal is an 18-hole woodland course in the hilly landscape of the southern Veluwe ridge between Arnhem, Oosterbeek and Ede. The course is surrounded by forests, lanes and meadows and is naturally integrated into the landscape. Greens are partly open but also partly sheltered and shaded. Nature and environmental considerations are key priorities for the club.

The objective is to achieve the highest possible quality with as few inputs as possible, according to the greenkeeping team of AHA de Man at the start of the dollar spot study (from 2024 onwards, maintenance was contracted to Enk Golf en Groen).

Green construction and management

The greens are native-soil based with a fine sand texture (M50 < 300 µm). Topdressing is carried out every two weeks using M50 330 µm sand, approx. 1 m³ per green. Due to the fine sand fraction and potential compaction risk, rolling is avoided.



From left to right: rootzone profiles greens 5, 9 and 14

Aeration is performed at least 4x/year, mainly 15–20 cm deep using 12 mm tines (3x) and once in May shallow aeration to 6 cm with 8 mm tines.

Annual nitrogen input is approx. 70 kg N/ha, with roughly 75% applied during the growing season, mostly granular (Sierraform). Seaweed products and wetting agents are also used.

To keep dollar spot pressure low, dew is brushed/swept in the morning and iron sulphate is used throughout the year.

Notable is the presence of **Agrostis canina** in several greens. Some greens were seeded/overseeded with this species in the past. Annual overseeding is performed twice with Agrostis capillaris cultivars Manor and Arrowtown. Historically, Villa I (*Agrostis canina*) was also used.

The monitoring greens

Baseline measurements were taken on 19 April 2022. Table 7 summarises monitoring green characteristics.

Table 7: Monitoring green characteristics at project start.

	5	9	14	Notes
Greenkeeper classification	good	average	poor	
Estimated % Festuca rubra spp.	2	5	2	
Estimated % Agrostis capillaris spp.	68	65	75	Overseeding: Arrowtown/Manor & Villa I (*A. canina*)
Estimated % Poa annua	30	30	23	
Weeds	no	no	no	

	5	9	14	Notes
Pests	no	no	no	
Disease susceptibility	yes	yes	yes	
Infiltration capacity (mm/hour)	60	30	150	



Green 14 (l) and green 9 (r)



Green 5

6. Golf- en Countryclub Geijsteren



View of the 17th hole from the green

Characterisation and target quality

Golf- en Countryclub Geijsteren is an active golf club located on the Geijsteren estate in northern Limburg. It is a typical parkland course with both push-up greens and sand-constructed greens. Several greens are moderately to heavily shaded.

Target playing quality is described in the green management plan: the highest possible quality with a strong “less is more” philosophy. Chemical plant protection is postponed for as long as possible, provided play does not suffer from disease damage such as dollar spot. No hard criteria are specified for Stimp or trueness, although these are managed more actively ahead of important competitions/tournaments.

Green construction and management

The native-soil greens are lightly topdressed every two weeks with M50 320 µm sand. Shallow aeration (5–10 cm) is performed during the growing season, and verti-draining to 40 cm is conducted once per year in late February–early March. The “schudfrees” (deep cultivation) is also used on greens to a maximum depth of 25 cm, followed by rolling.



Root zone profiles greens 6 (left), 8 (middle) and 17 (right)

Annual nitrogen input is usually just under 100 kg N/ha, applied via a Marathon fertiliser programme, supplemented with seaweed and trace elements such as Mn, Si, Mg and Fe. Small iron sulphate applications are applied as needed only.

Rolling is used frequently: from April at least once per week, and in summer and ahead of tournaments even daily. Regular vertical mowing is applied, combined with topdressing and brushing/rolling-in of the sand.

Turf composition is predominantly a mix of Agrostis capillaris and Agrostis stolonifera. Geijsteren follows an intensive overseeding regime: in (early) spring 2x with 100% browntop bentgrass (BAR All Bent), in summer 2x with 100% creeping bentgrass (BAR Trio Bent), and in autumn again with browntop bentgrass. Each overseeding uses 30–35 kg seed/ha.



Greens 4 (left) and 8 (right)



Green 17

The monitoring greens

Baseline measurements were taken on 22 April 2022. Table 8 summarises monitoring green characteristics.

Table 8: Monitoring green characteristics at project start.

	17	**6**	**8**
Greenkeeper classification	good	average	poor
Estimated % Festuca rubra spp.	2	0	0
Estimated % Agrostis capillaris spp.	79	49	45
Estimated % Poa annua	19	51	55
Weeds	no	no	no
Pests	no	no	no
Disease susceptibility	yes	yes	yes
Infiltration capacity (mm/hour)	96	192	222

7. Golf- en Countryclub Lauswolt



The edge of the woodland in springtime splendour along the 11th hole

Characterisation and target quality

Golf- en Countryclub Lauswolt is a beautifully situated woodland course, hidden in the Frisian forests near Beetsterzwaag. The course includes several surprising “outside holes” adjacent to a large nature area along the Koningsdiep. The greens are native-soil based (push-up) and are mostly shaded in the woodland area, while the outside holes are fully open.

The greenkeeper and club have a clear quality ambition: reduce turf stress by aerating and topdressing less under stress conditions (drought/heat) and instead rolling greens more and more frequently. To keep turf drier in autumn and winter, more iron-containing **lawnsand** will be applied. Parameters such as OM 2-4-6 (organic matter at 2, 4 and 6 cm), pH and infiltration capacity are monitored. Longer term (2025 and beyond), the head greenkeeper aims to increase and maintain Festuca rubra in greens (minimum 60%) and reduce Poa annua to below 15%, within the playing-quality framework set by the club.

Green construction and management

The renovated greens (1993) generally have a fine sand texture. The M50 value is low, between 210 and 230 µm. Topdressing is performed with M50 300 µm sand, 7x per year, at 8–15 m^3/ha per application. Aeration is done every five weeks with solid tines (6 mm) to 12 cm depth.



From left to right: root zone profiles greens 4, 11 and 17

Nitrogen fertilisation uses ammonium sulphate and urea, with granular fertiliser applied in spring. Annual input is 60–70 kg pure N/ha (of which 30 kg granular), split across 8–10 applications. Seaweed and wetting agents are also used.

Iron sulphate is part of the programme, with annual dosage varying depending on disease pressure; the average is 100–120 kg, plus 10% Fe delivered via granular fertiliser. Rolling is performed after aeration and additionally once per week, and in the early morning (daily/regularly as described).

Turf composition is a mix of Festuca rubra and Agrostis capillaris in varying proportions, sometimes accompanied by more or less Poa annua. In spring/summer, overseeding is performed twice with 100% bentgrass (20 kg/ha per application) and in autumn once with 100% fescue at 100 kg/ha.

In 2023, less iron sulphate was used; this was replaced by lawn sand applied in autumn.

The monitoring greens

Baseline measurements were taken on 25 April 2022. Table 9 summarises monitoring green characteristics.

Table 9: Monitoring green characteristics at project start.

Green	4	17	11	Notes
Greenkeeper classification	good	average	poor	
Estimated % Festuca rubra spp.	87	50	72	
Estimated % Agrostis capillaris spp.	12	35	24	
Estimated % Poa annua	1	15	4	
Weeds	yes	yes	no	chickweed
Pests	yes	yes	yes	
Disease susceptibility	no	yes	yes	17: dollar spot; 11: fusarium
Infiltration capacity (mm/hour)	240	108	168	



Hole 4 (seen from the green)



Greens 11 (left) and 17 (right)

8. Utrechtse Golfclub De Pan



View of the 17the hole from the green

Characterisation and target quality

De Pan is among the best-ranked golf courses in the Netherlands. Designed in 1927 by renowned architect Harry S. Colt, it is highly varied and challenging for low-handicap golfers, with surprising contours and elevation changes.

De Pan is a heathland course rich in nature, flora and fauna, with heather as a defining feature maintained through responsible sustainable management. The greens are largely positioned in shade and shelter. Club and greenkeeping aim for the highest possible playing quality under a “less is more” philosophy. Fungal diseases are acceptable as long as the (visual and playing-quality) damage threshold is not exceeded.

Green construction and management

The push-up greens have a high organic matter content in the surface layer. Topdressing is performed 4–5 times per year with pure sand (M50 330 µm), 0.5 m³ per green per application. In addition to an annual “Graden Sand Injector” operation, the greens receive 6 verti-drain treatments: five times with 8 mm solid tines to 15 cm, and once with 12 mm solid tines to 20 cm.



From left to right: root zone profiles greens 2, 16 and 17

De Pan targets a total annual nitrogen application of approx. 70 kg N/ha (urea and ammonium, 100% ICL granular), depending on weather and plant demand. No additional fertilisation is applied. Iron is supplied as part of the fertilisation programme and in autumn via lawnsand; no iron sulphate spraying is done.

Until shortly before the start of the dollar spot study, rolling was not part of the management programme (apart from daily use of pedestrian mowers). With the arrival of a new roller in 2022, this changed.

The turfgrass sward is almost 100% Agrostis capillaris; on some greens older bentgrass cultivars are still visible. Overseeding is done twice per year with 100% Agrostis capillaris cultivars (Manor and Arrowtown).

The monitoring greens

Baseline measurements were taken on 26 April 2022. Table 10 summarises monitoring green characteristics.

Table 10: Monitoring green characteristics at project start.

Green	16	17	2	Notes
Greenkeeper classification	good	average	poor	
Estimated % Festuca rubra spp.	6	2	1	
Estimated % Agrostis capillaris spp.	93	97	98	
Estimated % Poa annua	<1	1	1	
Weeds	no	no	no	moss
Pests	yes	yes	yes	leatherjackets
Disease susceptibility	no	no	yes	green 17 also dollar spot-prone
Infiltration capacity (mm/hour)	256	192	252	



Hole 2 (from the green)



Hole 16 (from the green)



Hole 17 (from the green)

9. Sallandse Golfclub De Hoek



View of the 1st hole from the green

Characterisation and target quality

Sallandse Golfclub is located near Diepenveen (north of Deventer) and dates back to 1934, with expansion to 18 holes in 1990. The course has greens of different construction types, many of which are situated in varying degrees of shelter and shade. Maintenance is carried out by De Enk Golf en Groen.

In consultation with the club, the greenkeeping team aims for improved cultural practice quality and playing quality, with faster greens (higher Stimp) as a goal. To achieve this, mowing is carried out daily and rolling frequency is intended to increase.



From left to right: root zone profiles greens 1, 5 and 17

Green construction and management

Sallandse has USGA, Dutch and push-up greens. All greens are managed in the same way.

Topdressing is intensive: 6–7 times per year, applying a total of 18–20 m^3/ha of pure sand (M50 300 µm). Topdressing is always combined with aeration (6–7 times per year, 8 mm solid tines to 10 cm depth).

Total annual nitrogen input is over 100 kg pure N/ha, split across 8–10 applications. The main fertilisers used are 15-10-10 (Greenmaster Start) and 6-5-10 + 6Fe (Greenmaster Autumn). Iron is supplied via Autumn and through 4–5 iron sulphate spray applications. In addition, Sallandse applies fungicides structurally (both preventive and curative).

Rolling, dew sweeping and anti-dew products are also part of the programme but—according to the team—too infrequently and inconsistently.

The overseeding programme is intensive on greens dominated by Poa annua plus common and creeping bentgrass. Overseeding occurs up to 6 times per year: in (early) spring with 100% browntop bentgrass (BAR All Bent), in summer with 100% creeping bentgrass (BAR Trio Bent), and in autumn again with 100% browntop bentgrass (BAR All Bent).



Green 1 (left) and 5 (right)



Green 17.

The monitoring greens

Baseline measurements were taken on **29 April 2022**. Table 11 summarises monitoring green characteristics.

Table 11: Monitoring green characteristics at project start.

Green	17	5	1	Notes
Greenkeeper classification	good	average	poor	
Construction type	Dutch	USGA	Push-up	
Estimated % Festuca rubra spp.	0	1	1	
Estimated % Agrostis capillaris spp.	65	75	72	
Estimated % Poa annua	33	24	27	
Weeds	yes	yes	yes	hornwort, Sagina
Pests	yes	yes	yes	cockchafer grubs (2020); some leatherjackets
Disease susceptibility	yes	yes	yes	also significant Microdochium + some take-all; grn 5 most dollar spot-prone
Infiltration capacity (mm/hour)	210	70	252	

10. The Links Valley Golf



View of the 2nd hole from the green

Characterisation and target quality

Links Valley is the first reversible 9-hole golf course in the Netherlands. It is beautifully located in the Veluwe near Ermelo, with significant elevation changes and a largely open character. Maintenance is carried out by SBA Golf en Groen, which aims for consistently playable greens with a minimum Stimpmeter speed of 9. SBA measures and monitors extensively and adjusts maintenance based on data.

Green construction and management

This is a young course with newly constructed sand-based greens (2017). Due to their age, the greens are prone to rapid thatch accumulation, and therefore receive frequent topdressing (every two weeks) with M50 330 µm sand, often combined with shallow aeration (5–10 cm) using thin tines (Maredo). Hollow-tining is also performed 1–2 times per year.



From left to right: root zone profiles greens 9, 6 and 2

Total annual nitrogen input averages 120 kg pure N/ha, mainly applied in liquid form (WSF ammonium sulphate and urea, Sierraform). Seaweed and trace elements (including T-mag Elite) are also applied.

Approx. 160 kg/ha iron sulphate is sprayed annually (in 300 L water) split across 8–10 applications. For much of the year, greens are rolled and dew is brushed/swept early in the morning.

Turf composition is a mix of Festuca rubra and Agrostis capillaris, with dominance varying per green and between years. Overseeding is standard: in spring 25 kg/ha 100% browntop bentgrass (BAR All Bent), and in autumn 20 kg/ha browntop bentgrass followed by 30 kg/ha 100% fescue (BAR Fescue), in separate operations.

Links Valley aims to avoid fungicide use for dollar spot, but if the damage threshold is at risk of being exceeded, fungicides may still be used.



Green 9

The monitoring greens

Baseline measurements were taken on **20 April 2022**. Table 12 summarises monitoring green characteristics.

Table 12: Monitoring green characteristics at project start.

Green	9	6	2
Greenkeeper classification	good	average	poor
Estimated % Festuca rubra spp.	46	38	32
Estimated % Agrostis capillaris spp.	50	60	65
Estimated % Poa annua	4	2	3
Weeds	no	no	no
Pests	no	no	no
Disease susceptibility	no	no	yes
Infiltration capacity (mm/hour)	120	168	30



Hole 2 (from green perspective)



Green 6



Links Valley Golf course plan

11. Veluwse Golfclub



Hole 1 from green perspective

Characterisation and target quality

Veluwse Golfclub is a very attractive 9-hole course located in the Veluwe forests, between the so-called 'Kroondomeinen of 't Loo palace' and the village of Hoog Soeren. Nature is a key priority. The greens are almost all in shade and shelter.

The club and greenkeeper aim to apply no plant protection products, and irrigation should be kept to a minimum. Stimpmeter speed should be at least **8**. Maintenance is managed "in the moment," meaning day-to-day decisions are driven by weather and site conditions.



Root zone profiles green 1 (left), green 3 (middle) and green 7 (right)

Green construction and management

All greens are push-up greens with a fine sand texture and M50 between 280 and 300 µm. Topdressing with pure sand is performed 6–10 times per year, with a total of 90–100 m^3/ha applied annually. Aeration is performed monthly with 8 mm solid tines, and hollow-tining is carried out once per year (also in combination with topdressing).

Total annual nitrogen input is capped at 100 kg pure N/ha, applied 2–3 times per year in granular form (16-0-16). Greens may also receive potassium sulphate (occasionally) and seaweed. Iron sulphate is sprayed sparingly (max 30 kg/ha). Rolling is carried out but not according to a fixed pattern.

Greens are overseeded twice per year (spring and autumn) with a mixture of Festuca rubra and Agrostis capillaris (BAR Superb), approx. >1 kg per green.



From left to right: greens 1, 3 and 7

The monitoring greens

Baseline measurements were taken on 20 April 2022. Table 13 summarises monitoring green characteristics.

Table 13: Monitoring green characteristics at project start.

Green	7	1	3	Notes
Greenkeeper classification	good	average	poor	
Estimated % Festuca rubra spp.	10	8	5	
Estimated % Agrostis capillaris spp.	75	80	67	
Estimated % Poa annua	15	12	28	
Weeds	no	no	no	
Pests	no	no	no	
Disease susceptibility	yes	yes	yes	green 7 most dollar spot-prone
Infiltration capacity (mm/hour)	72	150	78	

12. Golfclub ’t Zelle



Green 18.

Characterisation and target quality

Golfclub ’t Zelle consists of an 18-hole championship course (Bosrijk and Waterrijk) and a 9-hole par-3 course (Veldrijk). The club is located in the rural Achterhoek region near Hengelo (Gld) and is part of the ’t Zelle estate. Maintenance is carried out by Agrec Zelle Beheer.

The aim is to achieve vital, resilient, consistently playable greens. Nature and environmental values are emphasised, and chemical plant protection products are not used.

Green construction and management

The greens are push-up (native-soil) and are maintained as naturally as possible: minimal nitrogen, supplemented with seaweed, magnesium sulphate (Epsom salt) and biostimulants. Total annual pure N input is around 40 kg/ha, mostly in liquid form (ammonium sulphate).

Topdressing is carried out regularly (at least 6 times per year) with pure sand (M50 330 µm) combined with deep and shallow aeration: Maredo 6 mm to 4 cm, Procore 10 mm to 5 cm, and 1–2 times per year verti-draining with 8 mm tines to 20 cm.



Root zone profiles green 8 (left), green 9 (middle) and green 18 (right)

Iron sulphate is part of the programme. The team sprays frequent small quantities annually, often combined with wetting agents to improve infiltration.

Dominant turfgrass species are Agrostis capillaris and Festuca rubra in varying proportions by green. Overseeding typically occurs in spring with 100% browntop bentgrass (40 kg/ha Manor) and in summer with 60 kg/ha fine fescue (cultivars Absolom and Gima).

The monitoring greens

Baseline measurements were taken on 29 April 2022. Table 14 summarises monitoring green characteristics.

Table 14: Monitoring green characteristics at project start.

Green	8	9	18	Notes
Greenkeeper classification	good	average	poor	
Estimated % Festuca rubra spp.	60	52	40	
Estimated % Agrostis capillaris spp.	32	40	48	
Estimated % Poa annua	8	8	12	
Weeds	yes	yes	yes	Sagina
Pests	no	no	no	leatherjackets and cockchafer grubs
Disease susceptibility	no	yes	yes	Microdochium, dollar spot and thatch collapse (esp. grn 9)
Infiltration capacity (mm/hour)	324	232	312	



Greens 8 and 9.



’t Zelle course plan.

PART 3 – RESULTS OF THREE SEASONS OF MONITORING PER GOLF COURSE

All 12 golf courses were visited and monitored four times per year for three consecutive years (2022, 2023, 2024) (March–May, June, September, October–November). This resulted in a total of **144 site visits**. Across all 12 courses, a set of approximately **20 key cultural practice parameters** was monitored.

For each green, the most relevant parameters were measured and assessed over three seasons, based on observations during at least **12 site visits** by the project team, supplemented by a dollar spot monitoring programme carried out by the greenkeepers themselves. The development of dollar spot activity is presented in relation to these parameters and, where available, supported by (local) meteorological information.

The monitored parameters included volumetric water content (VWC%) / soil moisture (and soil water tension), organic matter at 2, 4 and 6 cm depth (OM 2-4-6), (un)saturated infiltration, C/N ratio, and turfgrass composition, as well as meteorological variables such as relative humidity, (average) temperature and leaf wetness duration. Chapters 1 through 12 present the measurements, analyses, observations and the head greenkeeper's experiences per golf course.

After three seasons of monitoring **36 greens**, it proved impossible for a number of courses to keep the diseases fully under control without any chemical plant protection products.

Figure 2 provides an overview of whether fungicides were applied at the participating golf courses.

Gebruik fungicides monitorgreens			
	2022	2023	2024
Amsterdamse Golf Club			2 x *
Domburgse golfclub			
Edese Golf Club Papendal			1 x
Golf en Countryclub Geijsteren	3 x **		
Golfbaan Bentwoud			
Golfclub Lauswolt			
Golfclub 't Zelle			
Sallandse Golfclub 'de 'Hoek'	2 x	2 x	2 x
The Links Valley			
Utrechtse Golfclub Amelisweerd			
Utrechtse Golfclub 'De Pan'		1 x	1 x
Veluwse Golf Club		1 x	1 x ***
		GEEN toepassing fungicides	
		1 of meerdere toepassingen fungicide Signum	
	*	Monitorgreens met Signum én Stressguard gespoten	
	**	1 x Signum en 2 x Heritage	
	***	Greens 1 en 3 niet gespoten, van green 7 alleen de helft met Signum	

Figure 2: Use of fungicides at the 12 participating golf courses

In addition, iron (iron sulphate) was frequently used as a supplementary nutrient input to reduce dollar spot pressure (Figure 3). Figure 4 presents the total annual nitrogen inputs (kg N) per course and per green.

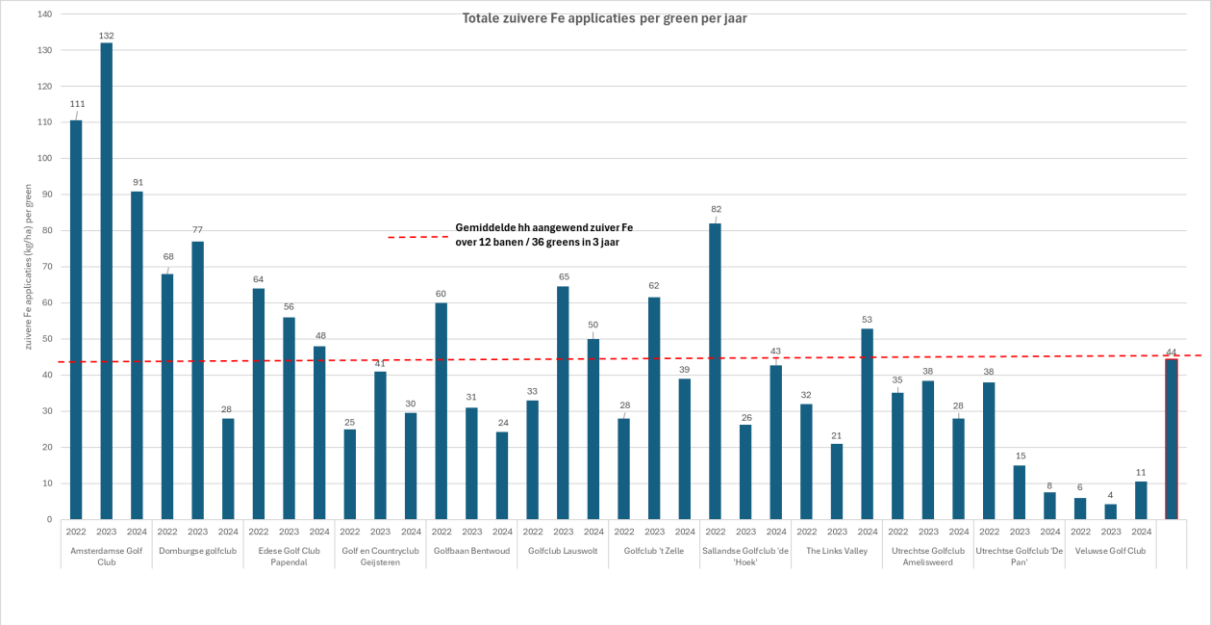


Figure 3: Total overview of pure iron sulphate use across the 12 courses over three monitoring seasons

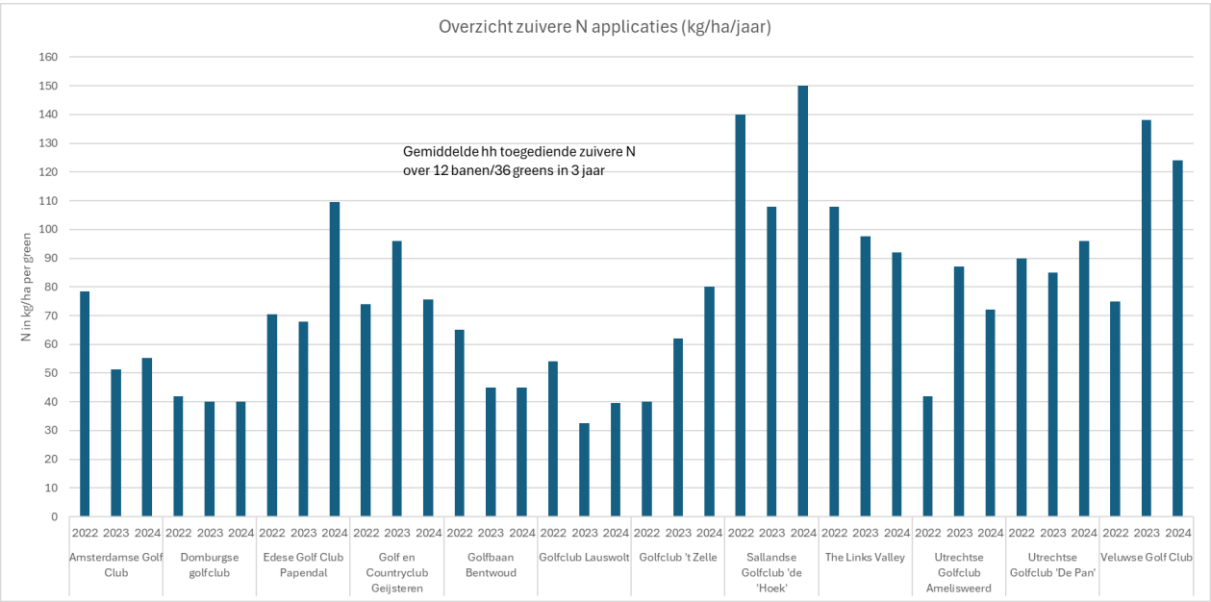


Figure 4: Total overview of pure nitrogen use across the 12 courses over three monitoring seasons

Before detailing specific parameters, each golf course section first presents key indicators related to dollar spot infection levels per monitored green. Infection severity was visually monitored over three seasons using a **0–6 ranking** (Figure 5). (Later in the project, grid-based photo assessments were used; however, as this was not implemented at all courses, those data have not been included in this report.)

0 – no mycelial webs, no dollar spot
1 – a few webs
2 – many webs, no visible damage yet
3 – active mycelium, early symptoms
4 – active dollar spot, moderate symptoms
5 – severe dollar spot, damage across the green

Figure 5: Field-based dollar spot infection score

For all greens, an annual average score is presented and compared against the national average infection level for that monitoring year.

After weighting and averaging, a more detailed scoring methodology was used in the results discussion:

Final score | **Dollar spot severity**
<1 | Very low – at most a few webs
1.0–1.5 | Low – scattered webs, very limited damage
1.5–2.0 | Low to moderate – dispersed webs, light damage
2.0–2.5 | Moderate – increasing damage
2.5–3.0 | Moderate to severe – dispersed and increasing damage
3.0–3.5 | Severe – widespread damage
3.5–4.0 | Severe to very severe – damage affects play
4.0–5.0 | Very severe – extensive damage, major impact on play

5.0 | Disastrous

Figure 6: Final scoring methodology

For each golf course and monitoring green, the following parameters were measured and monitored:

A. Water management: soil moisture (VWC%) and infiltration capacity (mm/hour)

During the four annual visits, soil moisture was measured at two depths: **0–6 cm** and **6–12 cm**. Per green, **six readings per depth** were taken and averaged. By measuring at multiple locations, insight was also gained into within-green variability. In addition, porosity was determined (based on saturated moisture measurement), and an approximate moisture content at wilting point was estimated.

The infiltration capacity (hydraulic conductivity) of the top layer is a measure of the rootzone's ability to drain water. It also indicates drought sensitivity and the ability to retain moisture during periods with little or no rainfall. Infiltration performance may also justify specific management practices (or the decision to avoid them). Infiltration measurements were performed at the start of the project (2022) and at the end (2024).

B. Organic matter, C/N ratio and acidity (pH)

Organic matter buffers water and nutrients, supporting turf growth and recovery. However, excessive accumulation should not lead to reduced infiltration, increased disease pressure (e.g., Microdochium) or poor playing quality. As putting greens continue to become leaner, the need to maintain sufficient organic matter in the upper rootzone appears to be increasing—particularly to keep turf in good condition during periods of (abiotic) stress.

In this study, organic matter was measured multiple times at **0–6 cm**, and at the start and end also at **0–2, 2–4 and 4–6 cm** in line with the methodology described by Micah Woods. Below is an overview from global datasets of analysed putting green profiles. Notably, organic matter percentages are highest in the 0–2 cm zone.

	Mean organic matter by weight (%)				
		STRI		ATC & BRT	
Sample depth (cm)	NZSTI	Parkland	Links	C_3	C_4
0 to 2	8.2	9.6	7.6	8.0	8.6
2 to 4	4.7	6.8	5.7	4.2	3.5
4 to 6	3.3	5.1	4.7	2.7	2.2

Figure 6: Putting green organic matter by depth in the soil | Asian Turfgrass Center Woods, 2020)



Rootzone OM 2-4-6 depth classification (Woods, 2021)

C/N ratio

A high C/N ratio reflects a higher proportion of stable organic matter and reduced mineralisation of organically bound nitrogen by soil biology. The C/N ratio was tracked for all greens over the three seasons. High carbon levels can indicate organic matter accumulation

and potentially increased fungal activity. Conversely, higher nitrogen availability (lower C/N ratio) generally indicates faster mineralisation and a more dynamic, bacteria-driven soil system.

In 2024, data collection began for fungal and bacterial activity (the so-called **fungus:bacteria ratio**) and microbial activity expressed as mg C. At present, there are insufficient data to draw firm conclusions. Appendix 11 provides the first results for fungus:bacteria ratio and microbial activity.

pH
In practice, pH is a useful indicator for steering turfgrass composition. pH may also influence the activity of (pathogenic) fungi. Differences in pH and their relationship with dollar spot are mapped per green.

C. Turfgrass species and cultivars

Over three seasons, the turf composition of each green was recorded, including which cultivars were used for overseeding.

D. Fertilisation programme: nitrogen, iron sulphate and other elements

This includes total pure nitrogen inputs (kg/ha), timing and number of applications per year, as well as the form (urea, nitrate or ammonium).

Iron—applied as iron sulphate (including lawnsand) or as a trace element in standard fertilisers—is also a key component of greenkeeping practices. Application rates (kg/ha) and timing were monitored and related to dollar spot pressure per year.

E. Other preventive BMPs

These include rolling frequency, dew removal (brushing/sweeping), and night-time and/or dew irrigation.

Before discussing parameters in detail, an overview is provided of dollar spot development per season.

F. Playing quality indicators

Ultimately, the objective is consistent playing quality. Although the measurements represent snapshots, each green was assessed for firmness (Clegg), speed (Stimp) and trueness (ball roll consistency). Clegg firmness appears particularly relevant in relation to rolling.

G. Microdochium patch

At the start of the project, it was intended to monitor Microdochium patch (*Microdochium nivale*) intensively. However, already in the first monitoring year it became clear that the impact (damage) caused by this disease was far less extensive than damage caused by

Clarireedia bennettii spp. Damage is generally superficial, and with appropriate recovery measures (topdressing and overseeding) the most severe symptoms can disappear quickly.

Per course, Microdochium susceptibility and observed damage are briefly referenced.

1. Utrechtse Golfclub Amelisweerd



Dollar spot development overview

Table 15 provides an overview of the actual infection levels per green per year. The final column presents the national average dollar spot (DS) level. Appendix 3 includes the actual DS infection curves per year (monthly timeline) plotted against the Smith-Kerns forecast model prediction.

Overall, dollar spot pressure at Amelisweerd can be considered high, with 2022 standing out negatively for all monitored greens. One year later, green 18 improved from a score of **2.7** to **1.8**, possibly attributable to increased management focus on green 18, which is located near the clubhouse.

Table 15: Overview of dollar spot infection severity (0–6) in 2022, 2023 and 2024

Year	Green 4	Green 11	Green 18	National average DS
2022	2.7	2.7	2.7	1.0
2023	2.8	3.2	1.8	1.8
2024	1.8	1.5	1.8	1.5
3-year average	**2.5**	**2.7**	**1.9**	

Dollar spot damage was severe on all greens. The forecast curves in Appendix 3 typically show a “mountain” shape peaking in August—the month in which dollar spot is most damaging due to maximum activity driven by high temperature and relative humidity.

It is also notable that dollar spot at Amelisweerd (and at other courses) tends to occur at a lower probability percentage (the so-called action threshold) than indicated in literature sources (Smith et al., 2017). Literature generally assumes that when the model line exceeds **20%**, it is time to apply preventive fungicides. In all cases at Amelisweerd, the probability was **<15%** when the first damage symptoms appeared.

A. Water management

Water management involves controlling both **rootzone moisture levels (VWC%)** and the **infiltration capacity** of the upper rootzone. The water-holding capacity of the construction influences soil moisture patterns, and the same applies to infiltration speed. As a guideline, a minimum rootzone moisture level of **20% VWC** is maintained on Amelisweerd's sand-constructed greens.

The soil moisture pattern is similar across the three monitored greens, with **green 11** being the wettest at the 0–6 cm depth.

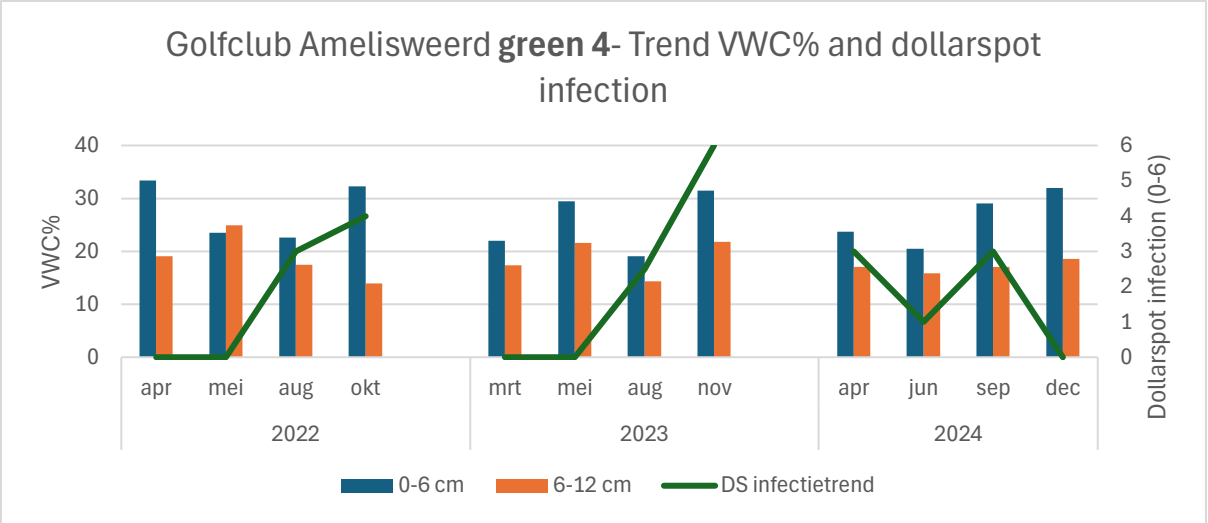


Figure 8: Soil moisture trend vs dollar spot – green 4

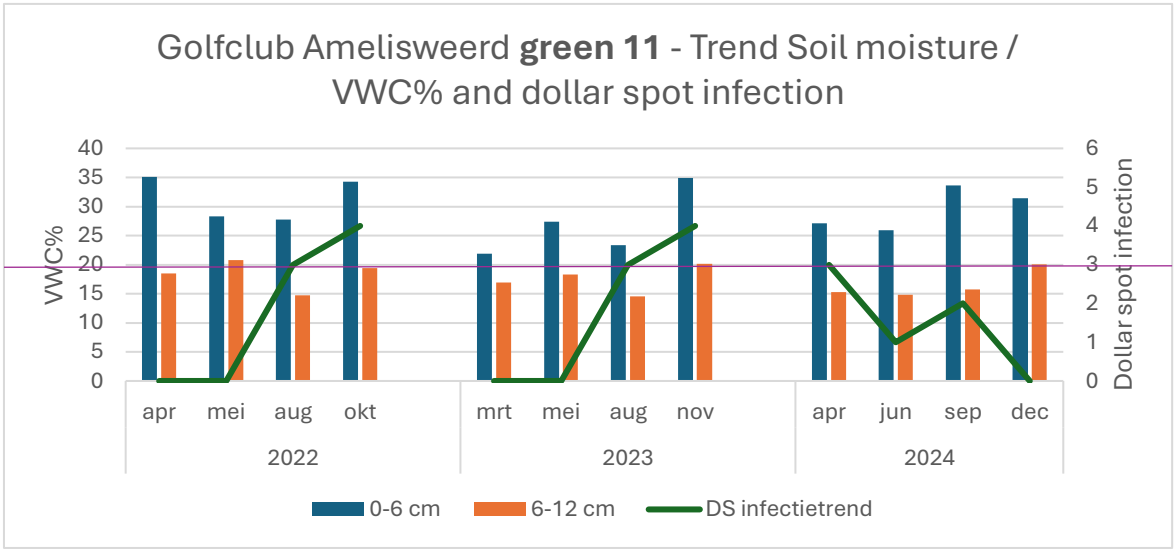


Figure 9: Soil moisture trend vs dollar spot – green 11

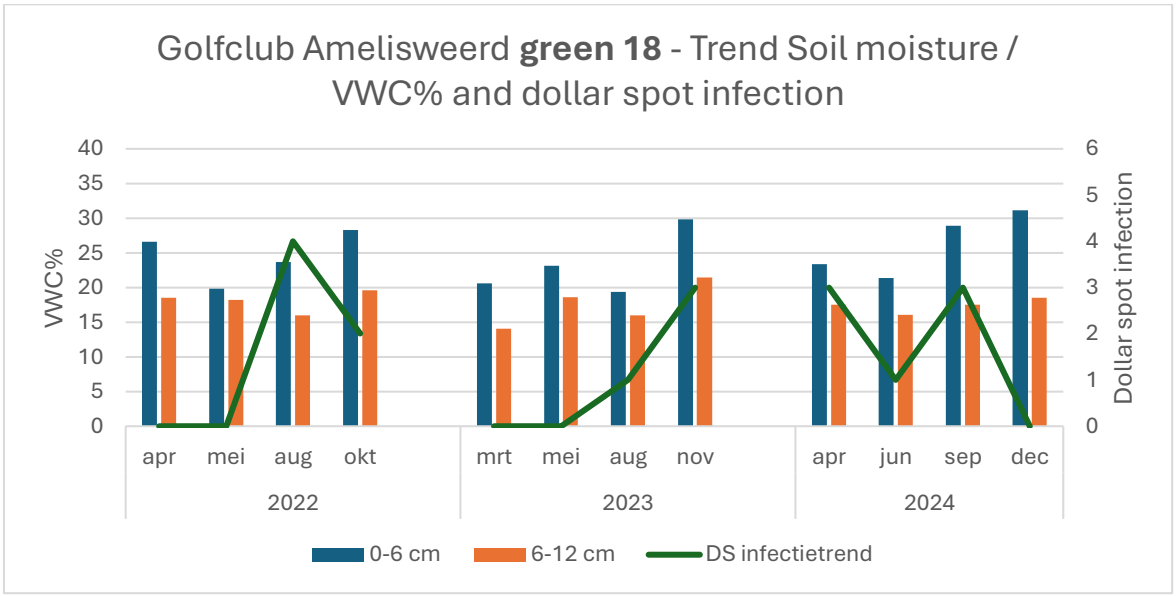


Figure 10: Soil moisture trend vs dollar spot – green 18

Infiltration speed decreased over the three seasons to values just above **50 mm/hour** for the 0–6 cm layer. Below that depth, water movement is not restricted, with infiltration speeds up to **1500 mm/hour**.

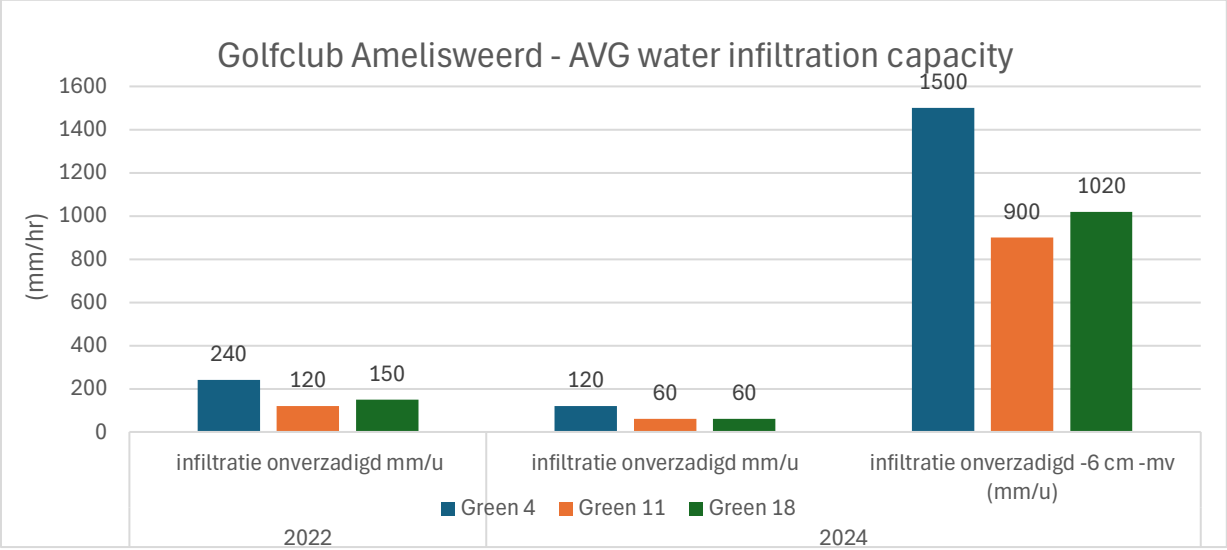


Figure 11: Average infiltration capacity over the three seasons

B. Organic matter, C/N ratio and pH

Clarireedia bennettii spp. is a pathogenic fungus primarily located in the upper rootzone. Koch et al. (2020) showed that dollar spot is most prevalent within the upper 6 cm. To assess the relevance of organic matter in this zone, the layers 0–2, 2–4 and 4–6 cm were distinguished. Organic matter content (loss on ignition) was determined in year 1 (July 2022) and year 3 (September 2024).

Figure 12 presents the OM 2-4-6 results for the monitored greens. Organic matter levels are relatively similar across greens. At 4–6 cm, most values are below 3%, while a minimum of 3% is generally preferred.

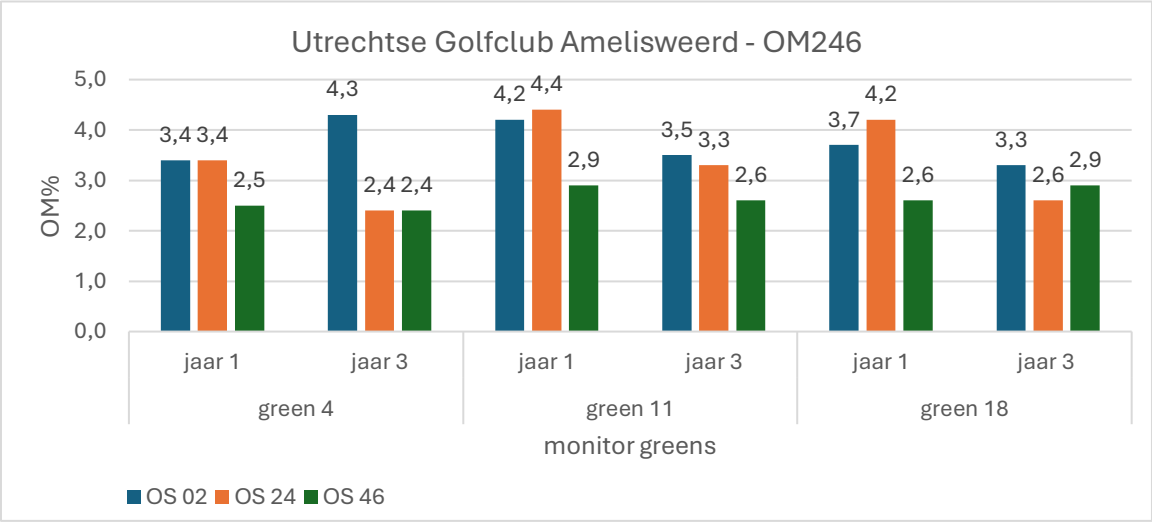


Figure 12: OM 2-4-6 development in years 1 and 3

For greens 11 and 18, the effect of topdressing with sand is visible, with a reduction in OM 0–2. In contrast, OM 0–2 increased on green 4.

The C/N ratio was also determined annually and varied widely between 5 and 12 per green. A low C/N (<10) indicates more bacterial-driven mineralisation but also suggests limited organic matter build-up and potentially higher vulnerability to disease during stress periods.

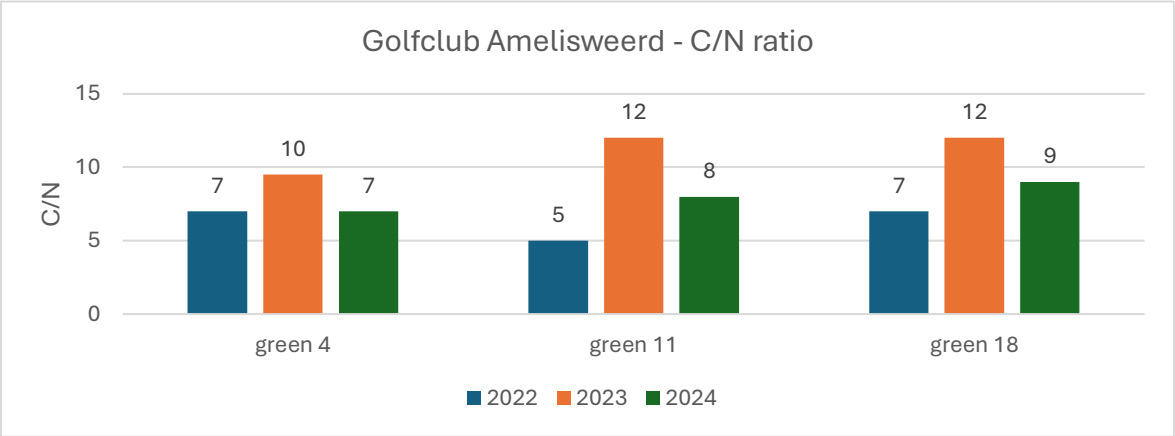


Figure 13: C/N ratio per green

Average pH at Amelisweerd is above **5.5**, with greens 11 and 18 around pH 6.0. Given the dominance of bentgrass and the continuous competitive pressure from *Poa annua*, a lower pH would be advisable.

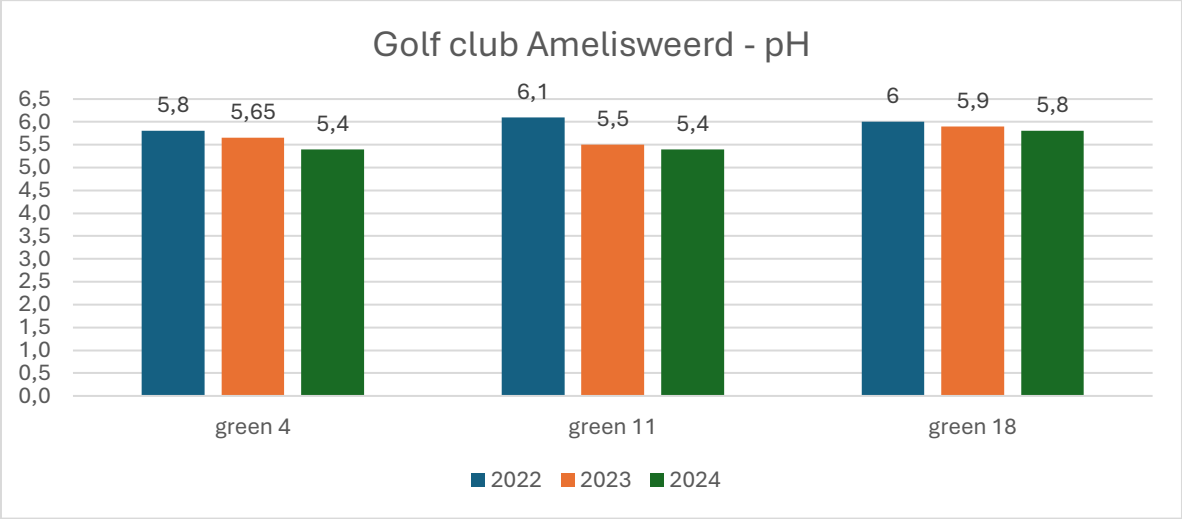


Figure 14: pH development

C. Turf grass composition and overseeding

All greens have turf composed of a mix of *Poa annua* and *Agrostis capillaris*. *Festuca rubra* is present but only up to a maximum share of 8–10%. By the end of the project, the proportion of *Poa annua* appears to have decreased in favour of fine fescue. Figure 15 shows the turf composition trend.

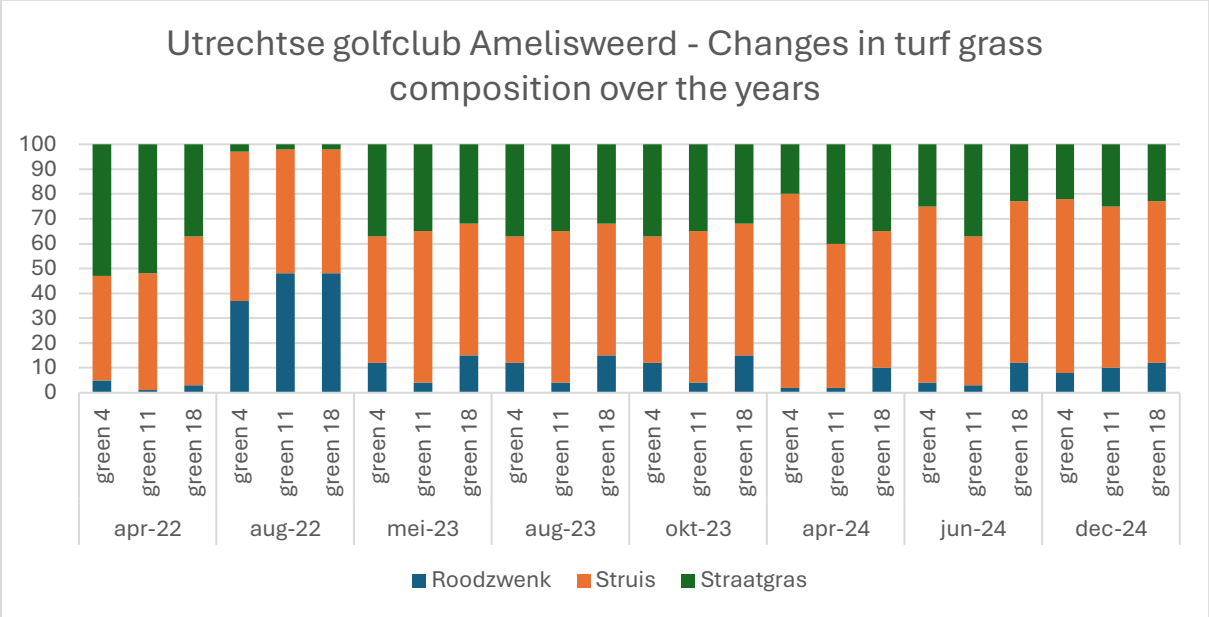


Figure 15: Turf grass composition development

Amelisweerd has an active overseeding policy. In 2022 and 2023, overseeding was conducted four times (3x spring: bentgrass and 1x autumn: fescue). In 2024, overseeding frequency increased to eight times. Appendix 4 provides the overseeding programmes with rates and frequency.

D. Fertilisation programme: nitrogen and iron sulphate

Nitrogen inputs at Amelisweerd are below the national average. Only in 2023 was more nitrogen applied than the average across the other courses.

Table 16: Key facts on nitrogen inputs in relation to dollar spot pressure at Amelisweerd

Year	Total N (kg/ha) Amelisweerd	National average N (kg/ha)	Average DS pressure (0–5) Amelisweerd	National average DS pressure
2022	42	79	2.7	1.0
2023	87	76	2.6	1.8
2024	72	88	1.7	1.5

Small nitrogen applications were made throughout the year in all seasons. Nevertheless, the fungus became active and it appears that the continuously present (or insufficient) nitrogen was not enough to allow the weakened turf to recover.

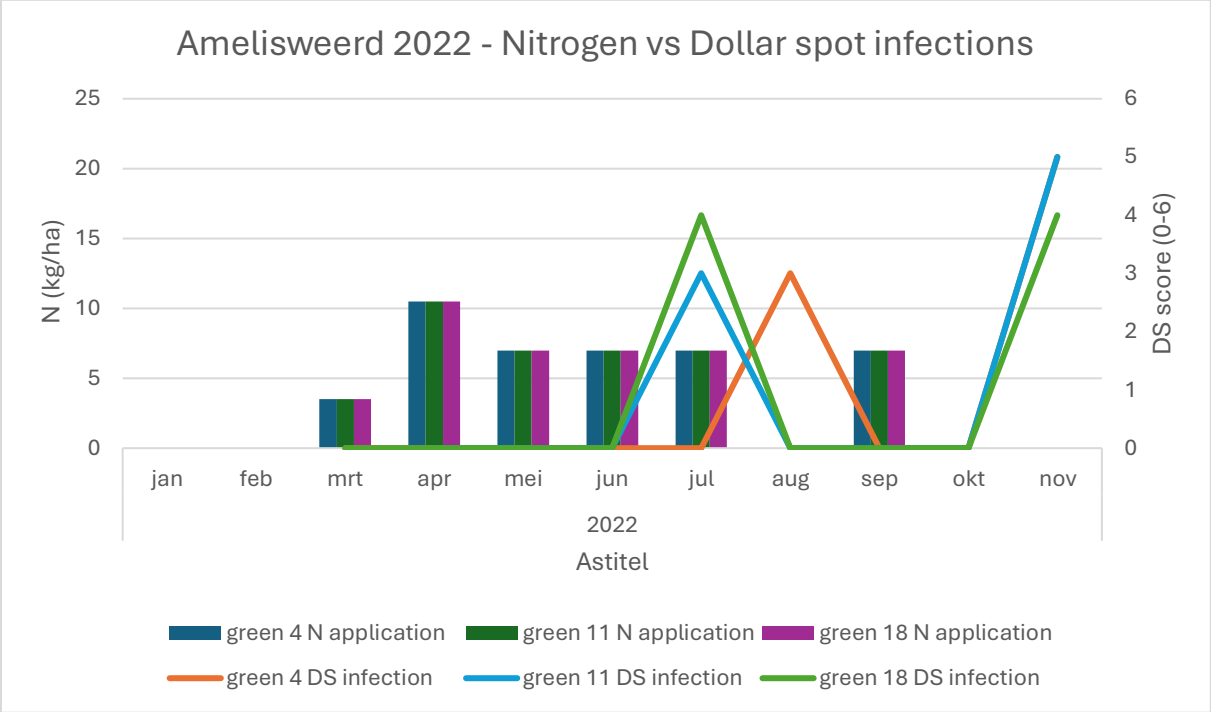


Figure 16: N applications vs dollar spot infection in 2022

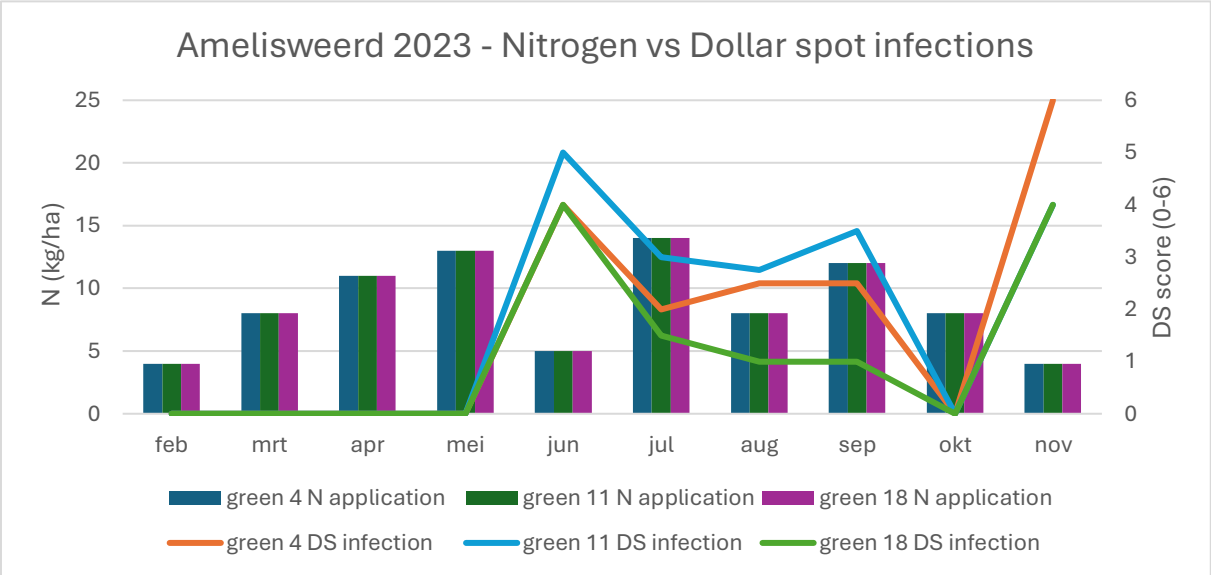


Figure 17: N applications vs dollar spot infection in 2023

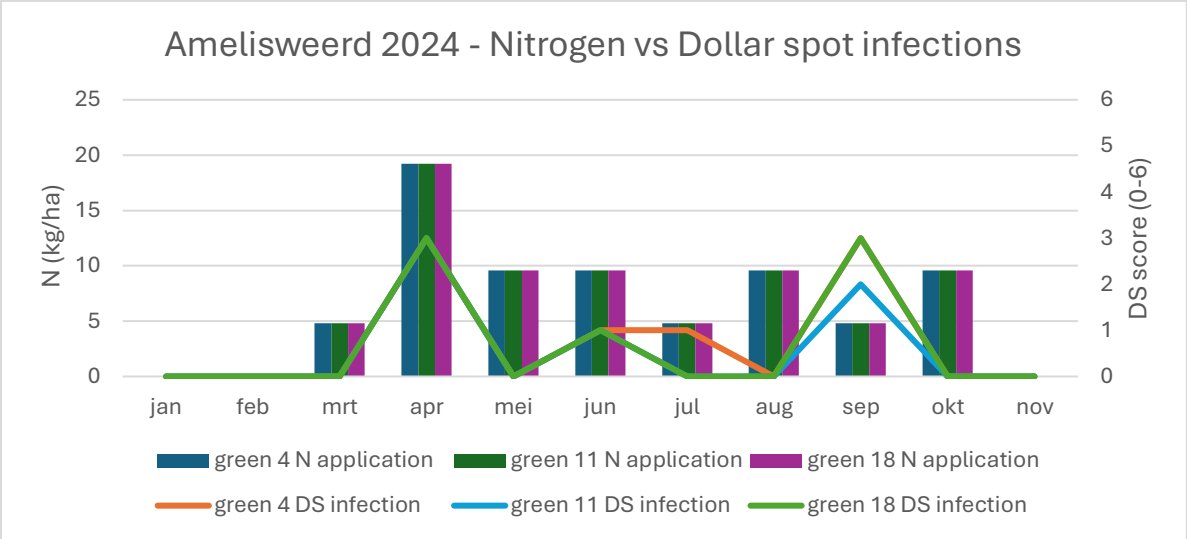


Figure 18: N applications vs dollar spot infection in 2024

Amelisweerd used progressively less pure iron over the years compared to national averages. However, actual dollar spot pressure remained (well) above the 12-course average in all years. Given the damage caused by both dollar spot and mechanical operations, adequate nutrition is essential to support recovery.

Table 17: Key facts on iron sulphate use in relation to dollar spot pressure at Amelisweerd

Year	Total Fe SO4 (kg/ha) Amelisweerd	National average Fe (kg/ha per green)	Average DS pressure (0–5) Amelisweerd	National average DS pressure
2022	35	48	2.7	1.0
2023	38	47	2.6	1.8
2024	28	38	1.7	1.5

Iron was primarily applied as iron sulphate. The dry, cold spring of 2022 showed little dollar spot activity; pressure was kept under control through regular small iron sulphate applications. However, this regularity could not prevent a larger outbreak (with clear damage symptoms) during the summer period.

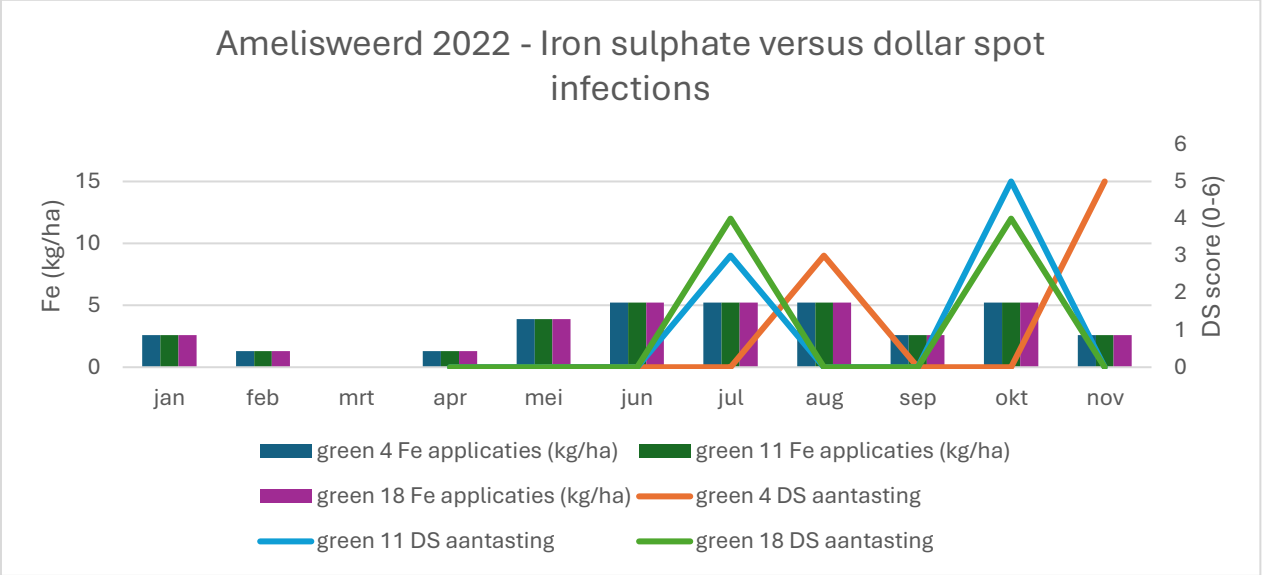


Figure 19: FeSO4 applications vs dollar spot infection in 2022

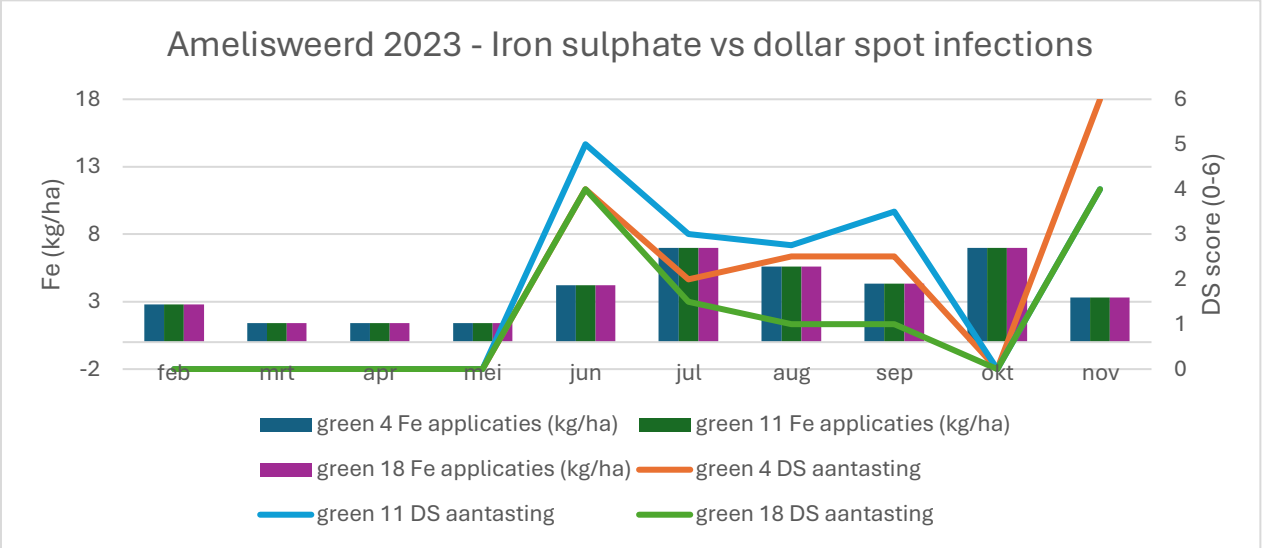


Figure 20: FeSO4 applications vs dollar spot infection in 2023

In the wet year 2023, slightly more iron sulphate was applied than in 2022, but this did not have a favourable effect on dollar spot damage. From May onwards, continuous symptoms were observed throughout the season, and preventive iron sulphate sprays did not provide sufficient control.

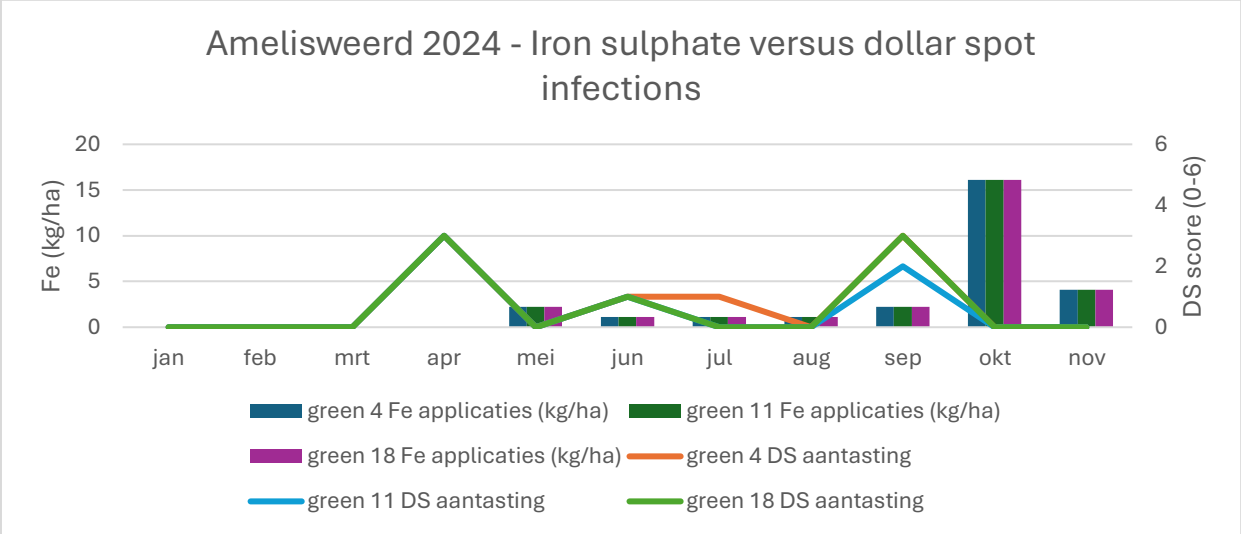


Figure 21: Fe SO4 applications vs dollar spot infection in 2024

Extreme wetness in early 2024 resulted in slow to no turf recovery. Due to the poor, wet conditions, less iron sulphate was applied, and fewer severe dollar spot attacks with extensive damage appear to have occurred.

E. Cultural practices: rolling, topdressing, aeration and other

At Amelisweerd, no additional products with trace elements or seaweed were applied beyond the nitrogen and $FeSO_4$ treatments, as far as is known.

Table 18: Overview of mechanical operations

Practice	Year	Frequency	Notes
Rolling	2022	1–4x per week	28 rolling weeks
	2023	3–6x per week	30 rolling weeks
	2024	2–4x per week	25 rolling weeks
Topdressing	2022	12x per year	4.5 m^3
	2023	9x per year	5.5 m^3
	2024	7x per year	7 m^3
Aeration	2022	1x 18 cm, 3x 6 cm, 3x 3 cm	solid tines
	2023	2x 18 cm, 3x 3–5 cm	
	2024	2x 18 cm, 2x 6 cm, 1x 18 cm	

F. Playing quality indicators

Appendix 5 presents playing-quality indicators (Stimp speed, trueness via holing-out test, and firmness via Clegg) in table form. Below, Clegg firmness values for greens 4, 11 and 18 are shown in a bar chart, with a target range of 80–100 Gm (gravimeters).

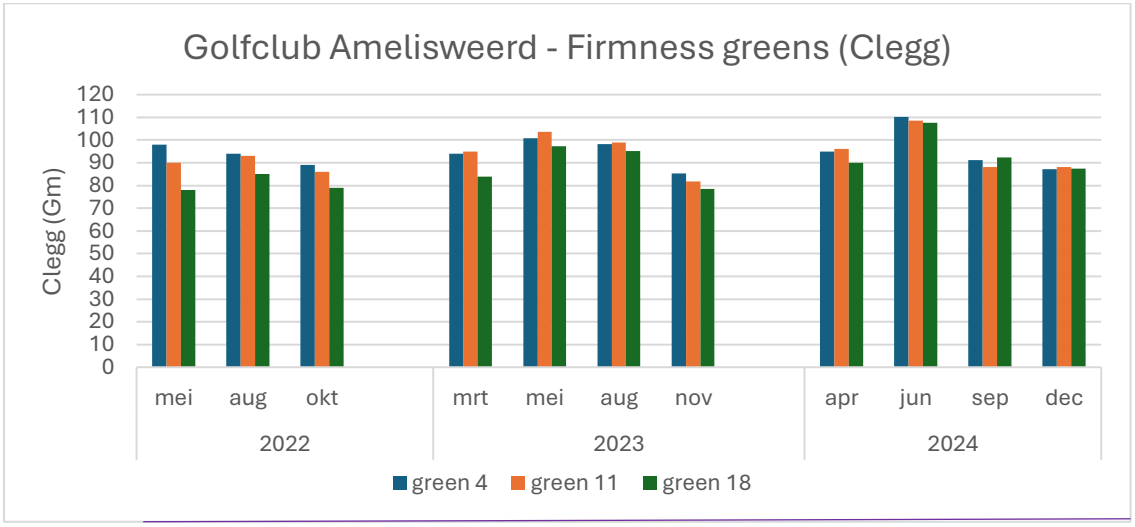


Figure 22: Clegg values over time

Correlation analysis indicates a weak to moderate correlation between firmness and dollar spot susceptibility across the greens: there is an indication that more frequent rolling is associated with less dollar spot—especially for green 4. There are insufficient data for Stimp and trueness to draw conclusions regarding their relationship with dollar spot.

G. *Microdochium patch* (snow mold)

Amelisweerd had limited issues with winter fusarium. Only during the final inventory round in early December 2024 were severe infections recorded on all monitoring greens.

H. Conclusions

Amelisweerd shows moderate dollar spot pressure, with scores of **2.5**, **2.7** and **1.8** for greens 4, 11 and 18 respectively. Damage to greens was caused not only by dollar spot but also by frequent mechanical operations such as rolling and topdressing, which can injure turf or smear/seal the surface layer. In all cases, this increases turf stress and creates leaf wounds, thereby increasing susceptibility to fungal disease. This susceptibility was evident on all three greens, with green 18 showing the best recovery from dollar spot in 2024.

The strategy of frequent topdressing and (deep) aeration is appropriate for a water-rich course such as Amelisweerd but also imposes substantial stress on the greens. Turf recovery appeared insufficient, as reflected by nitrogen inputs that were lower than would typically be required for bentgrass greens. In addition, turf vitality was not actively supported through broader trace element management, and the rootzone lacked the extra organic matter required to buffer the turf during stress.

Dollar spot consistently “ran ahead” of management practices. Here too, proactive use of the Smith-Kerns model can support control—and preferably prevention—of dollar spot damage. Preventive use of iron (iron sulphate) tends to be more effective than curative use: beyond a certain point, more iron sulphate no longer helps and may become counterproductive.

2. Amsterdamse Golfclub





Severe storm, Amsterdamse Golfclub, July 202.)

Dollar spot development overview

All greens showed infection levels ranging between **1.8 and 3.3** (scale 0 = none to 6 = very severe damage) across the seasons. Compared to the national picture, this is an above-

average score. When looking across the three monitoring seasons, visible dollar spot damage was greatest in 2024.

Table 19 shows that, on average across the three seasons, all monitoring greens experienced more or less the same level of dollar spot severity. Noteworthy is the progression from the relatively “mild” year 2022 to the severe dollar spot season 2024, in which Amsterdamse ultimately decided to apply fungicides.

Table 19: Average level of dollar spot severity at Amsterdamse Golfclub in 2022, 2023 and 2024

Year	Green 3	Green 6	Green 18	National average DS
2022	1.9	2.1	1.8	1.0
2023	2.1	2.2	2.6	1.8
2024	3.3	2.9	2.9	1.5
3-year average	**2.4**	**2.3**	**2.4**	

Fungal activity started early in the year (April) and persisted through to the end of the season. The figures in Appendix 3 present, for each year, the actual infection levels plotted against Smith-Kerns model probability (%) forecasts.

In 2022 and 2023, the first dollar spot symptoms became visible from a probability of approximately 15%, in July. In 2024, however, dollar spot activity was already observed in May. Just before the May infections, the Smith-Kerns probability curve rises steeply from <10% to >20%, as a result of a weather shift from cool, wet conditions to drier, slightly unsettled weather with higher temperatures.

The early dollar spot outbreak can be attributed not only to changing weather but also to unrecovered damage scars from dollar spot in 2023.

A. Water management: soil moisture and infiltration capacity

Figures 23–25 show, for greens 3, 6 and 18, the trend in measured soil moisture (VWC%) and the corresponding trend in dollar spot (increasing or decreasing) per year.

Amsterdamse Golfclub is the only one of the 12 courses where soil moisture at 0–6 cm is lower than at 6–12 cm. Average VWC nevertheless remains around or above 20%, including in the severe dollar spot year 2024. Soil moisture does not appear to influence the occurrence of dollar spot.

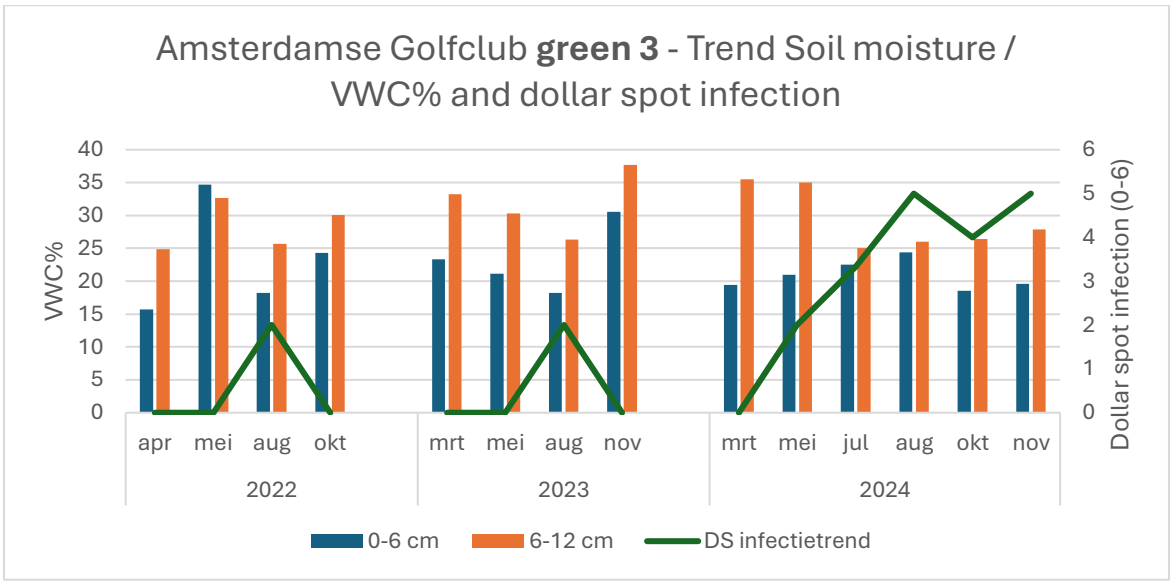


Figure 23: Soil moisture trend vs dollar spot severity – green 3

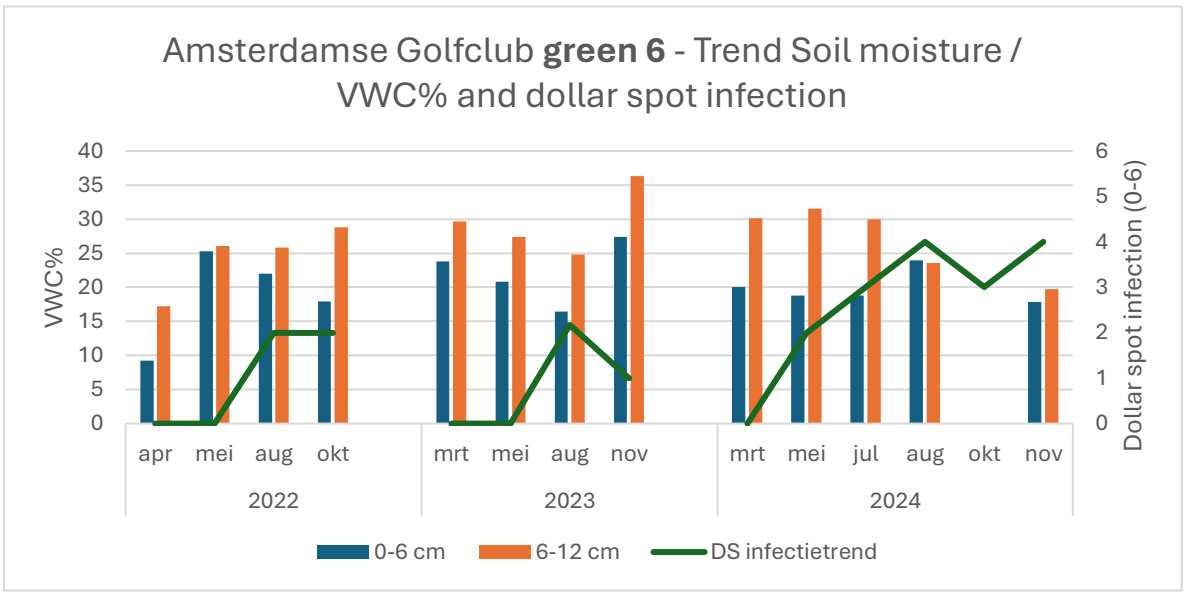


Figure 24: Soil moisture trend vs dollar spot severity – green 6

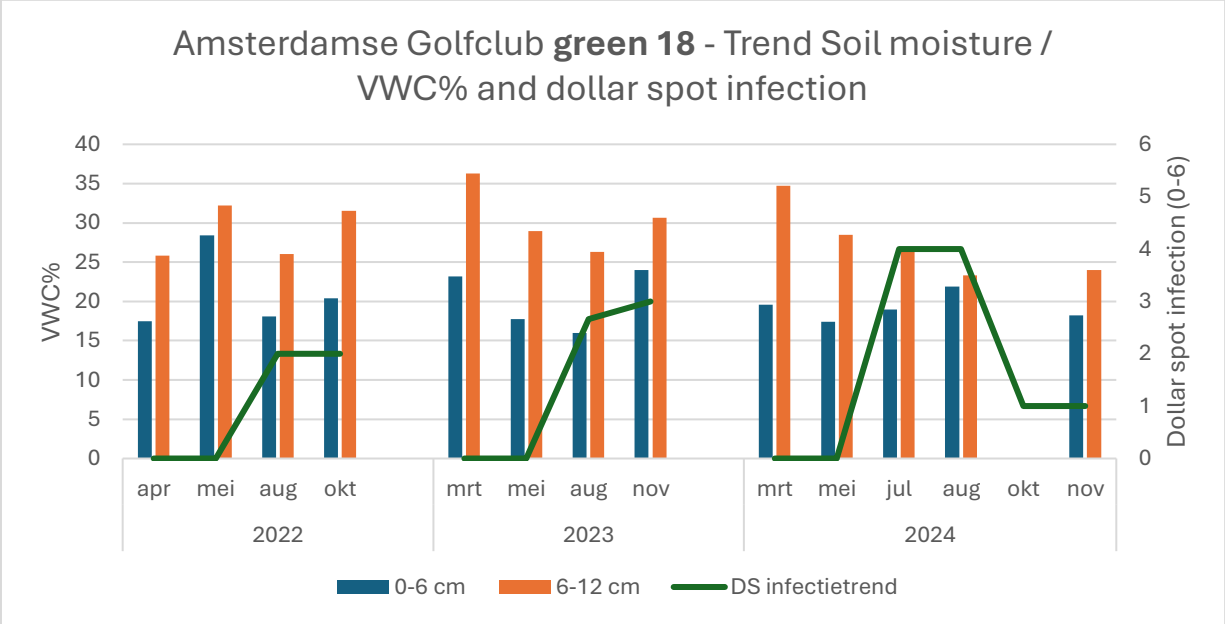


Figure 25: Soil moisture trend vs dollar spot severity – green 18

Infiltration capacity improved over the course of the study. Topdressing and aeration contributed to this improvement. A notably high infiltration rate was measured especially on greens 6 and 18 below 6 cm below surface level.

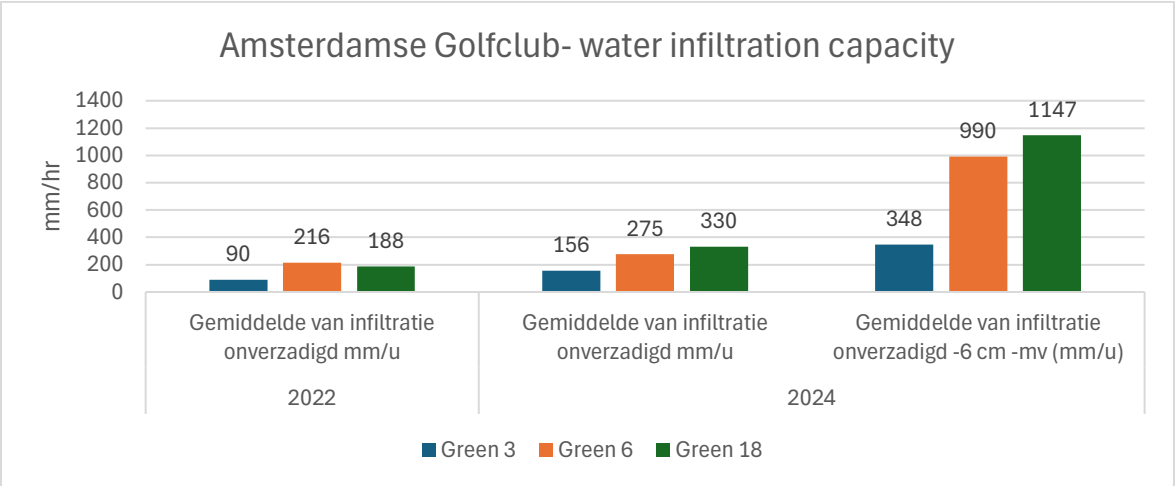


Figure 26: Average infiltration capacity over three years

B. Organic matter, C/N ratio and pH

At the start in 2022, the highest organic matter levels were observed in the 4–6 cm layer rather than near the surface. By year 3 (2024), this pattern reversed, with organic matter in 0–2 cm higher than in the 2–4 and 4–6 cm layers.

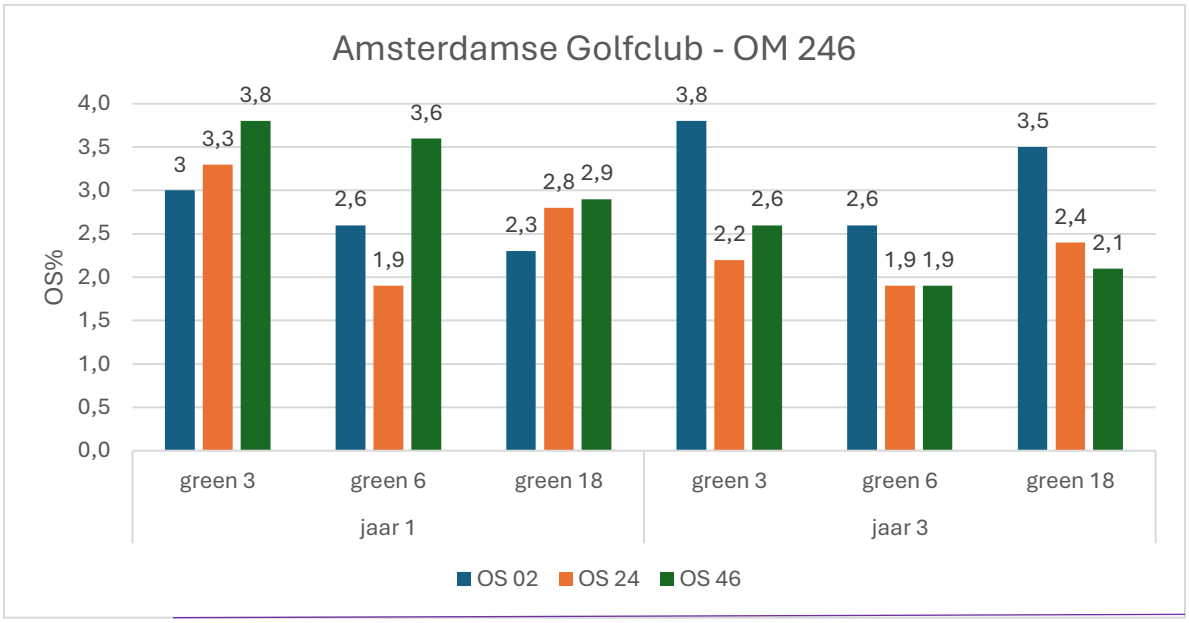


Figure 27: OM 2-4-6 development in years 1 and 3

Using a target value of **3.0% OM**, green 6 falls below this threshold in both years 1 and 3. Greens 3 and 18 are only slightly higher, with OM 0–2 values of 3.8% and 3.5% respectively. Nevertheless, the rootzone appears to lack sufficient buffering capacity for strong turf recovery and vitality.

pH remained stable across the three seasons. With average values between **5.3 and 5.5**, the top 0–6 cm provides suitable conditions for a sufficiently active soil biology. This is reflected in the C/N ratio, which is around **10** for greens 3 and 18. On green 6, the C/N ratio drops to **7** in year 3, indicating increased bacterial activity and therefore higher mineralisation of organically bound nitrogen.

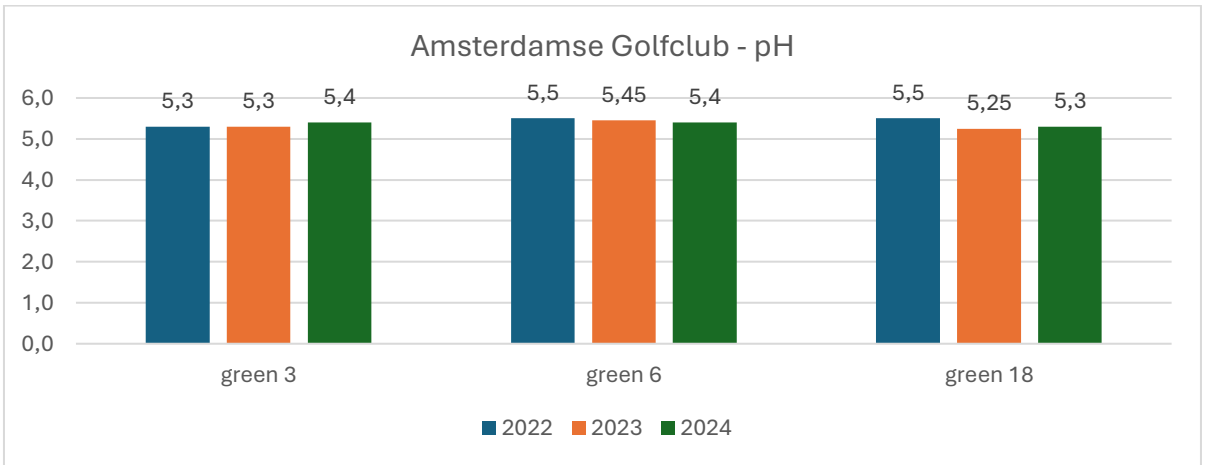


Figure 28: pH development

C. Turf composition and overseeding

All greens have a turfgrass composition consisting of a mix of **Poa annua** and **Agrostis capillaris**. **Festuca rubra** is present in the sward but is under competitive pressure from the dominant bentgrass. Figure 29 shows the development of turf composition over time.

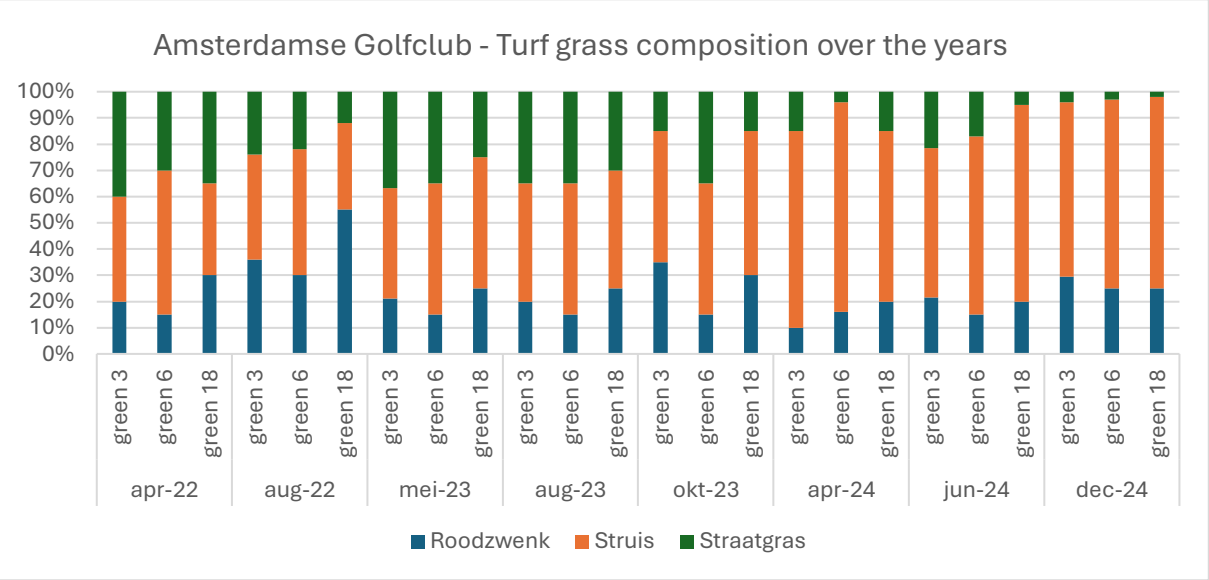


Figure 29: Turf composition development

The club overseeds multiple times per year with browntop bentgrass, and typically once in autumn with fine fescue. Appendix 4 provides an overview of overseeding programmes and seed mixtures.

D. Fertilisation programme: nitrogen and iron sulphate

Total nitrogen inputs at Amsterdamse are below the national average across all seasons, while dollar spot pressure is moderate to severe.

Table 20: Key facts on nitrogen inputs in relation to dollar spot pressure at Amsterdamse Golfclub

Year	Total N (kg/ha) Amsterdamse	National average N (kg/ha)	Average DS pressure (0–5) Amsterdamse	National average DS pressure
2022	79	73	2.4	1.0
2023	51	76	2.3	1.8
2024	55	88	2.4	1.5

Nitrogen was applied mainly as **ammonium sulphate** and **urea**. Applications were split across the year in small doses. Only in April 2024 was a larger single nitrogen application

made (**18 kg pure N**) to stimulate rapid recovery growth following extreme wetness in preceding months.

Dollar spot infection levels increased over the study years, resulting in higher turf stress and a greater need for nutritional buffering to support recovery growth. This requires nitrogen, but Amsterdamse's nitrogen inputs did not increase accordingly.

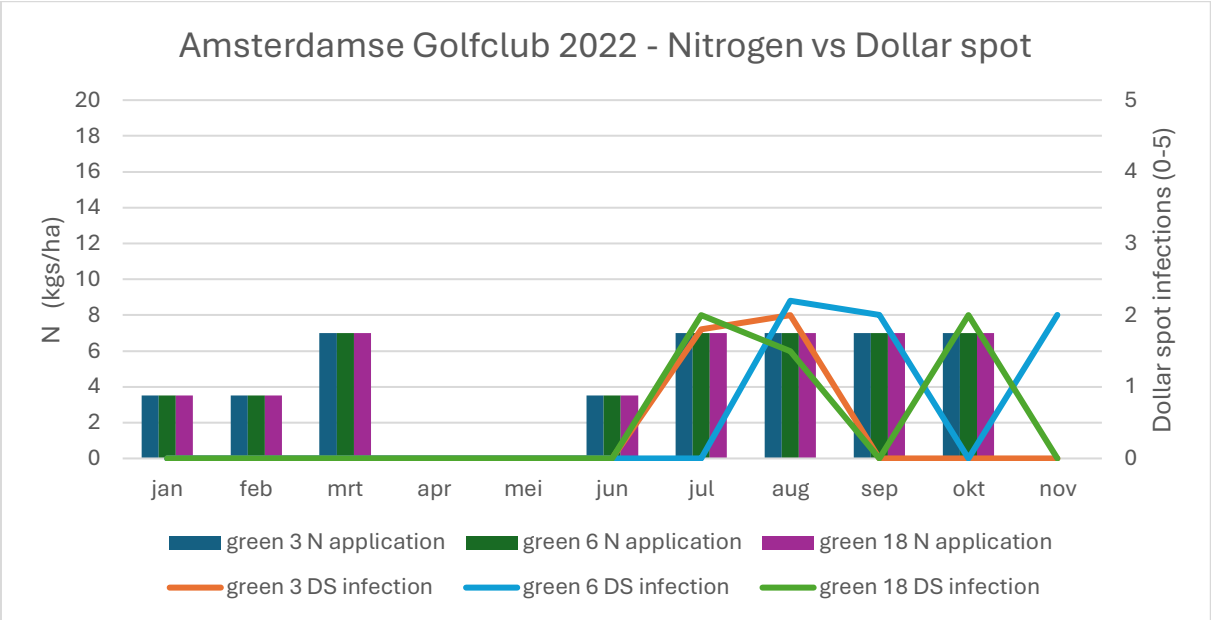


Figure 30: N applications vs dollar spot infections in 2022

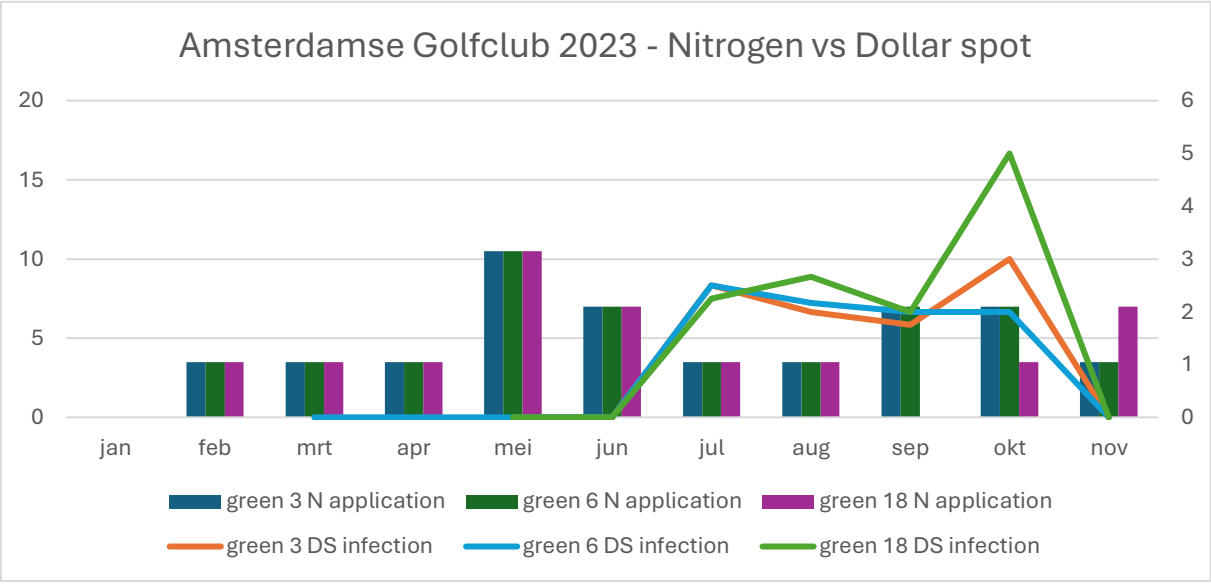


Figure 31: N applications vs dollar spot infections in 2023

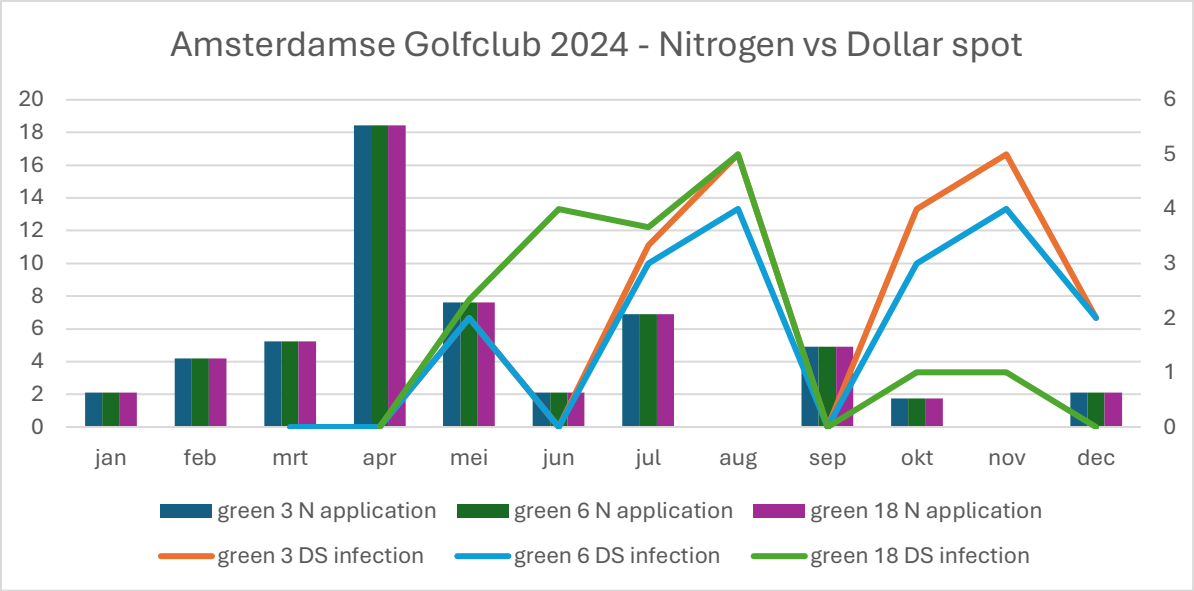


Figure 32: N applications vs dollar spot infections in 2024

In contrast to nitrogen, Amsterdamse Golfclub applied substantial quantities of **iron sulphate** throughout all monitoring seasons—well above the average across the 12 courses. Despite frequent iron sulphate applications, dollar spot pressure did not decrease over the years and remained above the national average throughout the study period.

Table 21: Key facts on iron sulphate use in relation to dollar spot pressure at Amsterdamse Golfclub

Year	Total Fe (kg/ha) Amsterdamse	National average Fe (kg/ha per green)	Average DS pressure (0–5) Amsterdamse	National average DS pressure
2022	111	48	2.4	1.0
2023	132	47	2.3	1.8
2024	91	38	2.4	1.5

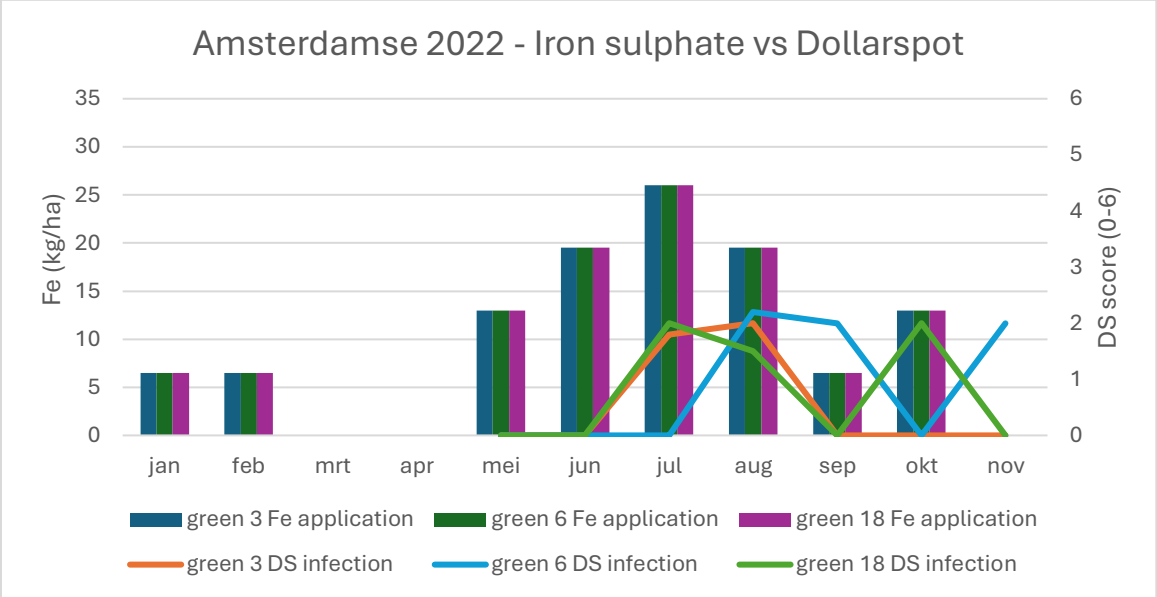


Figure 33: FeSO4 applications vs dollar spot infections

In 2022, iron (iron sulphate) applications appear to have had a short-term effect. In June/July, dollar spot still developed, though damage remained limited. In autumn, the pathogen became active again, but on green 3 it did not cause visible damage.

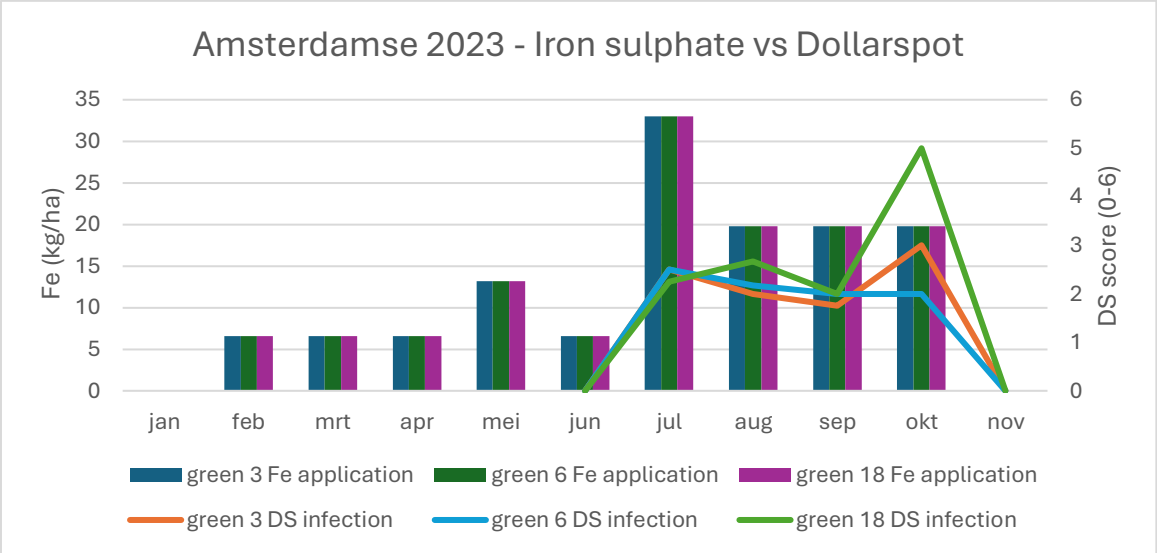


Figure 34: FeSO4 applications vs dollar spot infections

In 2023, more iron sulphate was required in spring than in the year before. Conditions were considerably wetter. Dollar spot remained absent until drier and warmer weather arrived in June. The outbreak was severe, and greenkeeping responded immediately by applying a large quantity of iron sulphate. However, iron sulphate did not succeed in pushing the pathogen “back” for the remainder of the season, as reflected by the infection curve and the spike between August and October. Green 18 was most affected that year.

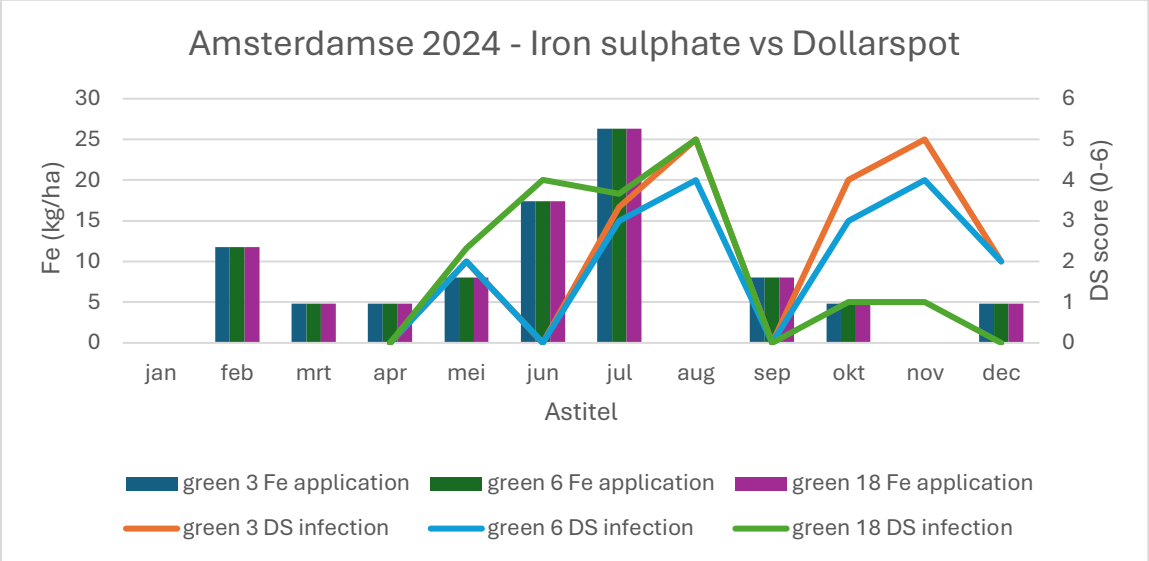


Figure 35: FeSO4 applications vs dollar spot infection

In 2024, spring was again wet and dollar spot could not be prevented. Once conditions dried in May, the pathogen caused severe infection on all greens (and again later in July). Iron inputs in spring proved insufficient to keep dollar spot under control. As in previous years, management response was reactive rather than proactive.

Because no recovery occurred after September 2024 and the damage threshold for the club, players and greenkeepers had been exceeded, it was decided to apply fungicides (**Stressguard** and **Signum**).

E. Cultural practices: rolling, topdressing, aeration and other

Amsterdamse applies a frequent topdressing regime in combination with iron sulphate spraying. Topdressing is carried out with 360 µm green sand. Since 2023, rolling has also been introduced, although opinions are divided regarding its effectiveness (more on this in Parts 4 and 5).

In addition, the greens are aerated three times per year, including one operation to **15 cm** depth.

Table 22: Overview of mechanical operations

Practice	Year	Frequency	Notes
Rolling	2022	0	0 weeks
	2023	1.9x per week	17 weeks
	2024	1.8x per week	33 weeks
Topdressing	2022	19x	3 m^3
	2023	14x	4.2 m^3
	2024	10x	3.8 m^3
Aeration	2022	3x solid 8 mm, 15 cm	
	2023	2x solid ProCore, 1x solid 8 mm Verti-Drain	
	2024	2x solid 8 mm	

F. Playing quality indicators

Appendix 5 presents playing-quality indicators (Stimp speed, trueness via holing-out test, and firmness via Clegg) in table form. Below, Clegg firmness values for greens 3, 6 and 18 are shown in a bar chart, with a target range of 80–100 Gm (gravimeters).

In the first years, the greens were on the soft side, but firmness increased over the seasons due to more intensive topdressing combined with rolling. Notably, there is a moderate correlation between Clegg values and dollar spot severity on greens 3 and 6: the firmer the greens, the more severe the dollar spot infection. This indicates that, beyond a certain point, rolling may no longer be effective in reducing dollar spot. The solution must be sought elsewhere. For green 18, no relationship between these parameters was found.

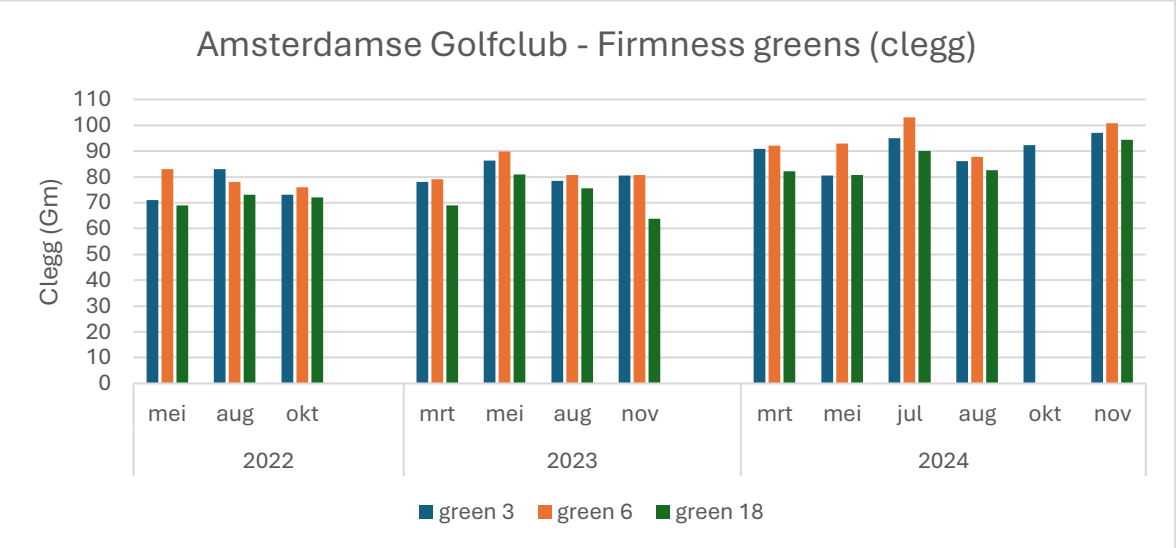


Figure 36: Clegg values over time

G. Microdochium patch *(Microdochium nivale)*

No Microdochium patch was observed at Amsterdamse Golfclub during the full study period.

H. Conclusions

Amsterdamse Golfclub showed moderate dollar spot pressure, with scores of **2.4**, **2.7** and **2.4** for greens 3, 6 and 18 respectively. Green 18 was considered the best green in 2022, but based on dollar spot severity it has now become the worst. For green 3, the opposite is true (albeit marginally). In practice, however, it is difficult to truly distinguish “best, average and worst”: all three greens display comparable quality.

Here too, greens deteriorate due to a lack of a nutritional buffer in the upper rootzone. Organic matter levels between **2 and 6 cm** range from **2.0 to a maximum of 2.5%**. In the **0–2 cm** layer, OM is usually well above **3%**, but this still appears insufficient to ensure adequate turf vitality. Moisture management does not appear to be a triggering factor.

In addition, a very high number of operations and interventions are carried out each year. The number of topdressing applications is particularly high (up to **19** in 2022). Although each application is small, they still cause leaf injury (wounding) and repeatedly demand energy from the turf to recover. Regrowth requires nitrogen. The nitrogen regime at Amsterdamse is below the national average, while the dominant turfgrass species—**browntop bentgrass**—typically requires at least **80–90 kg pure N per ha per green per year**.

3. Golfbaan Bentwoud

Across the three monitoring seasons, Bentwoud shows a relatively low level of dollar spot pressure. Fungal activity and the resulting turf damage on the greens are limited. Each year, some activity occurs only in August, but a severe damage pattern does not develop. Figure … presents, for each year, the actual infection levels plotted against the forecast probabilities from the Smith-Kerns model.

Dollar spot development overview

Table 22 shows that, on average across the three seasons, dollar spot pressure at Bentwoud is low. Only green **4A** showed a meaningful level of infection in 2022, followed by a relatively strong decline in the subsequent years. Green **4C** is virtually unaffected by dollar spot.

Table 22: Average level of dollar spot severity at Bentwoud in 2022, 2023 and 2024

Year	Green 4A	Green 4B	Green 4C	National average DS score
2022	1.7	1.3	0.0	1.0
2023	1.1	0.3	0.3	1.8
2024	0.5	0.8	0.5	1.5
3-year average	**1.2**	**0.4**	**0.3**	

A. Water management

Green **4A** is the “most dollar spot-sensitive” monitoring green at Bentwoud. Comparing soil moisture at **0–6 cm** with the layer below (**6–12 cm**) shows large differences. The thatch/mat layer present in the profile is able to retain water longer than the leaner 6–12 cm layer. As a result, VWC values between **25% and 40%** were measured throughout the year. In the 6–12 cm layer, soil moisture values of **<15%** were recorded.

Noteworthy is the drier period May–August 2023, during which lower soil moisture values were measured and some noticeable dollar spot activity was observed.

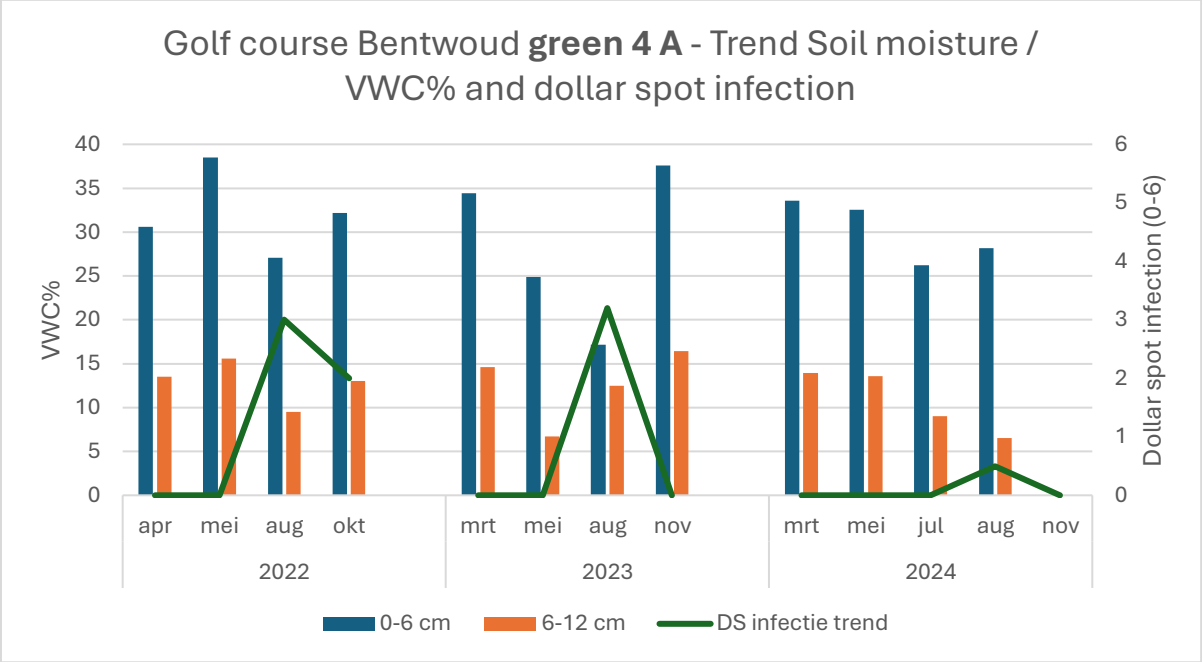


Figure 37: Soil moisture trend vs dollar spot– green 4A

Green **4B** suffers from **dry patch** along aprons and the foregreen, which was particularly visible in spring and summer 2023. Due to heavy play pressure in combination with limited staffing, it often proves impossible to supplement irrigation in time. Nevertheless, damage resulting from dollar spot activity remains low.

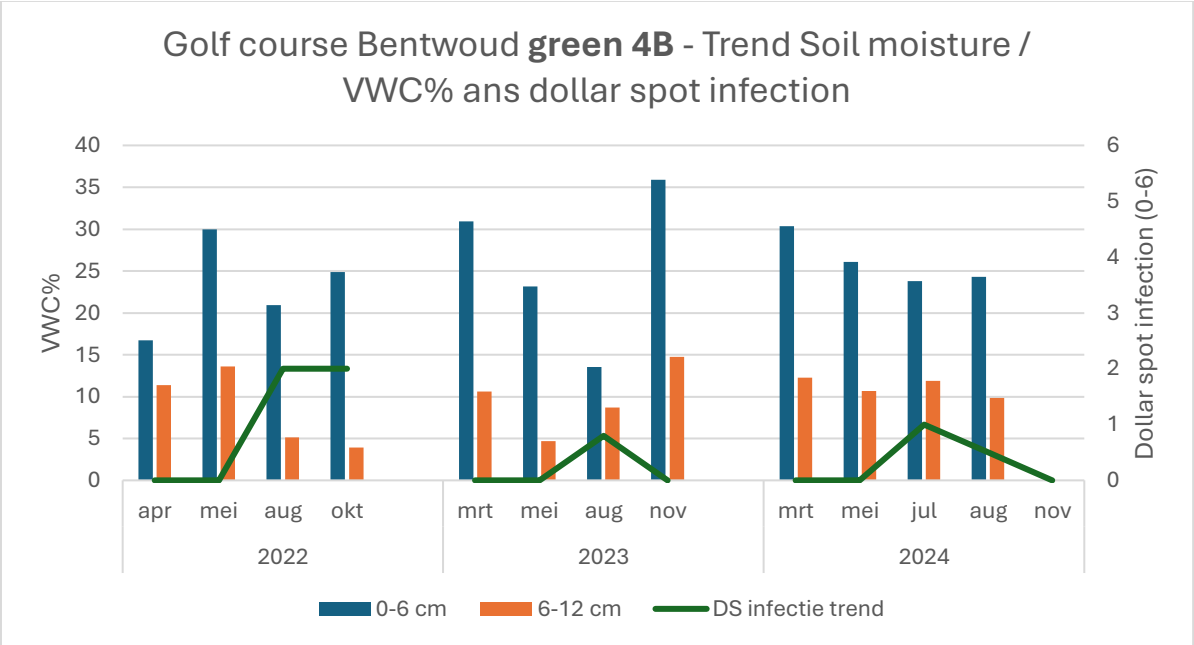


Figure 38: Soil moisture trend vs dollar spot – green 4B

Green **4C** shows damage symptoms only as a result of heavy play, not due to dollar spot. Of the monitoring greens, 4C retains the most moisture. Despite dry months, dollar spot susceptibility is virtually nil.

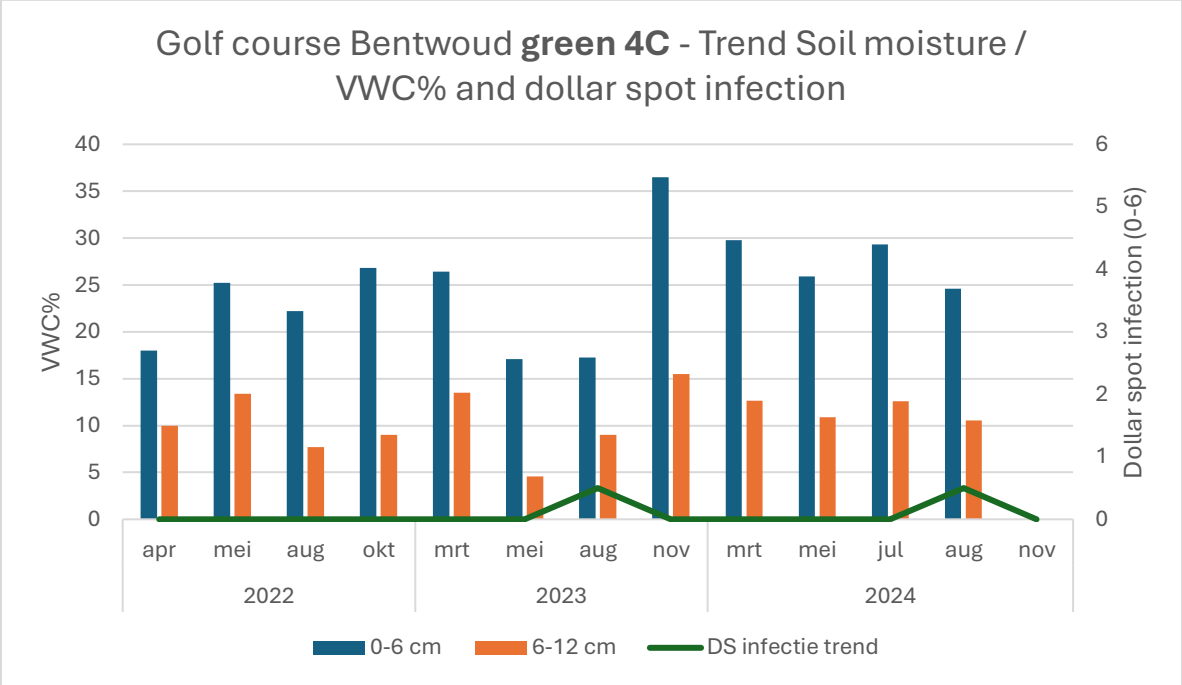


Figure 39: Soil moisture trend vs dollar spot severity – green 4C

The ubiquitous thatch layer restricts optimal drainage, but it does not result in increased disease pressure. Below the thatch layer, infiltration capacity is extremely high.

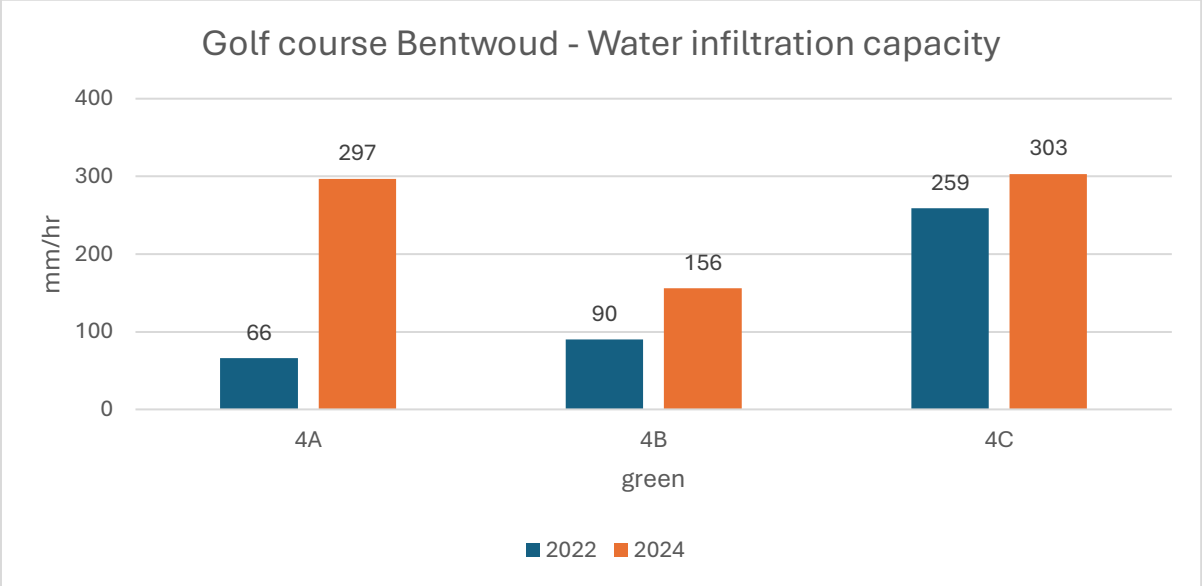


Figure 40: Average infiltration capacity over three years

B. Organic matter (OM 2-4-6)

The OM 2-4-6 profile is highly stable. The **0–2 cm** layer remains consistently high throughout all three study years (**>6%**). Below that, in the **2–4 cm** layer, organic matter content is broadly between **3% and 4%**.



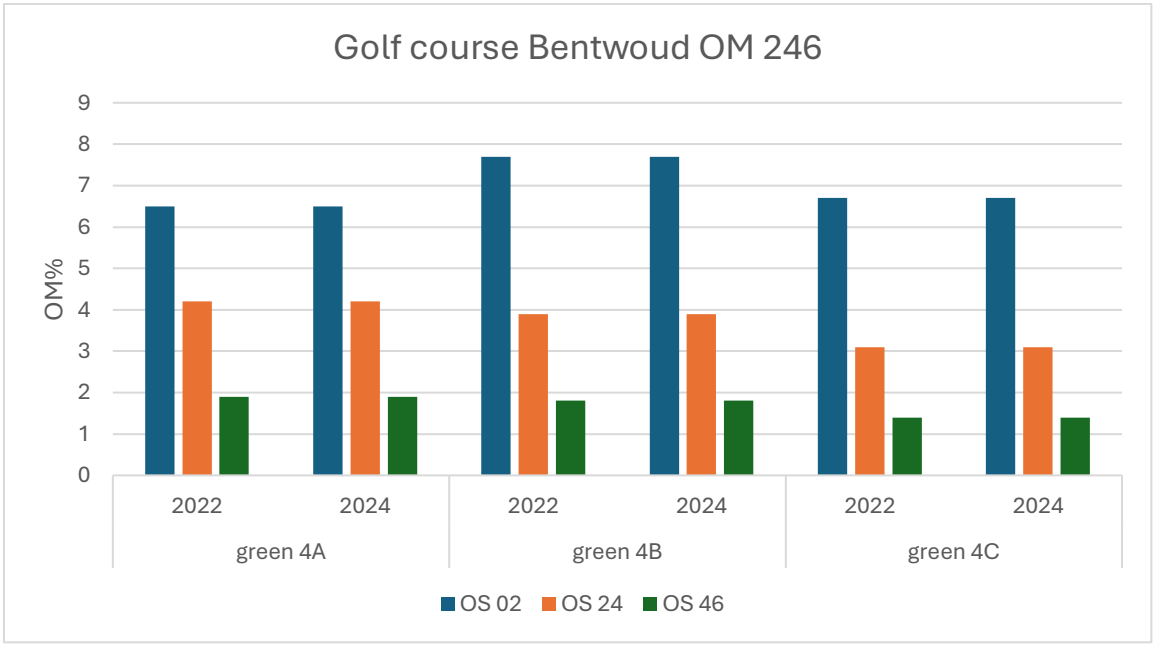


Figure 41: OM 2-4-6 development in years 1 and 3

A high C/N ratio was measured in the 0–2 cm zone. At the start in 2022, the C/N ratios for the monitoring greens were **18, 15 and 16**. By the end in 2024, these were **12, 14 and 17** for greens 4A, 4B and 4C respectively. The largest decrease occurred on green **4A**: this indicates less accumulation of (poorly decomposed) organic material and more bacterial activity—an indication that more decomposition (breakdown) of organic matter is occurring. On 4B and 4C, the C/N ratio remained largely unchanged.

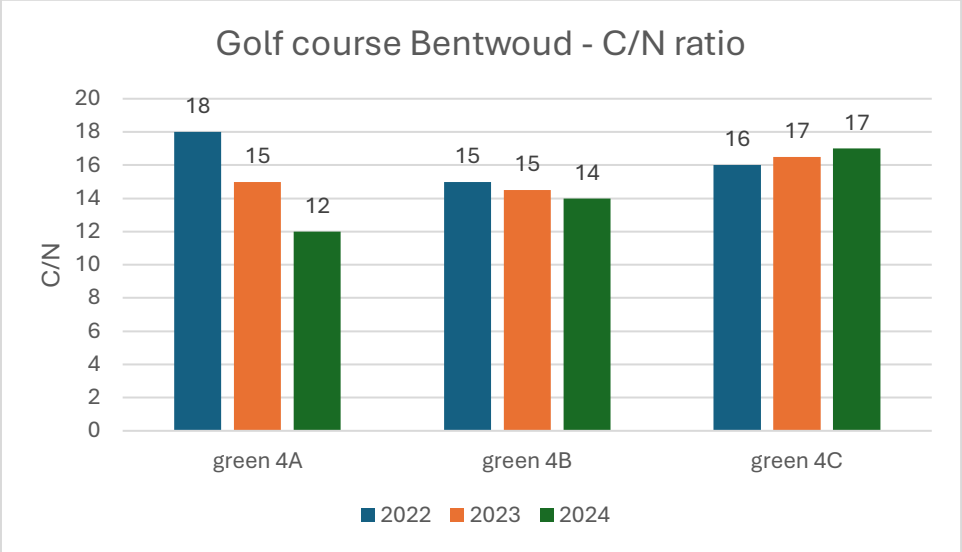


Figure 42: C/N ratios

Also noteworthy are the relatively acidic greens. Contrary to what might be expected, the dominant fine fescue performs well under these conditions. A low pH (**<5**) is in many cases also favourable for keeping dollar spot activity low.

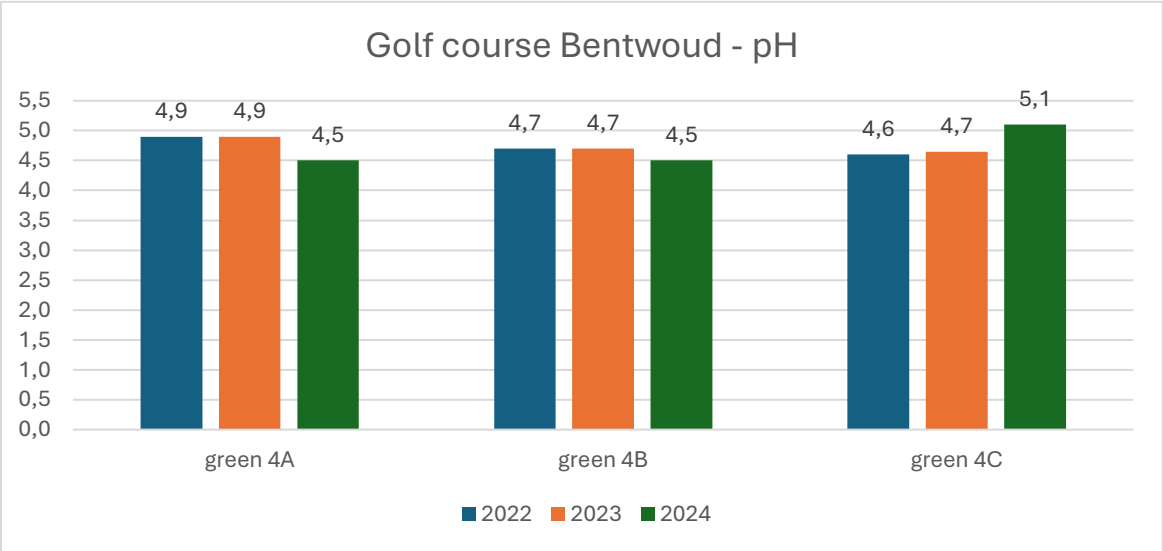


Figure 43: pH development

C. Turf composition and overseeding

At Bentwoud, the greens consist primarily of **fine fescue (Festuca rubra)**. By the end of the study period, the fine fescue share appears to have increased, supported by annual overseeding in late August with a mix consisting of **100% slender creeping red fescue and chewings/fine-leaved fescue types**, as well as a moderate nitrogen input level. The turf tolerates intensive play well and maintains an average year-round density of **>98%**.

Browntop bentgrass (Agrostis capillaris) is also present, due to occasional overseeding with an 80/20 fescue/bentgrass mixture.

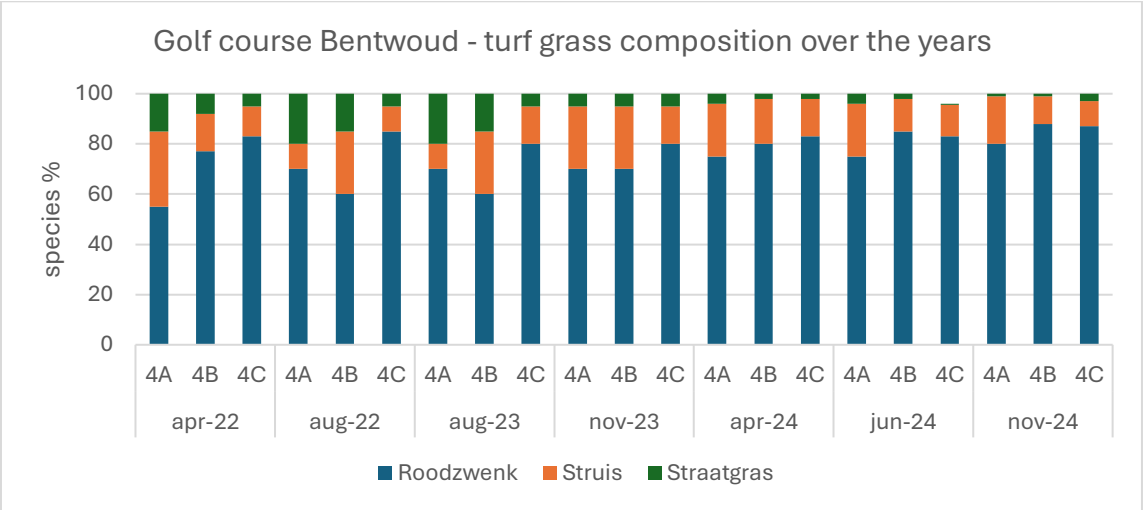


Figure 44: Turf composition development

D. Fertilisation programme: nitrogen and trace elements

Bentwoud's nitrogen input is (well) below the national average in all years, which is consistent with fine fescue-dominant greens.

Table 23: Key facts on nitrogen inputs in relation to dollar spot pressure at Bentwoud

Year	Total N (kg/ha) Bentwoud	National average total N (kg/ha)	Average DS pressure (0–5) Bentwoud	National average DS pressure
2022	65	73	1.0	1.0
2023	45	76	0.6	1.8
2024	45	88	0.6	1.5

In 2022, dollar spot infection occurred only during the warm, dry month of August. Green 4C showed no infection at all. The 65 kg pure N was applied in split applications across the year but did not appear to affect dollar spot severity.

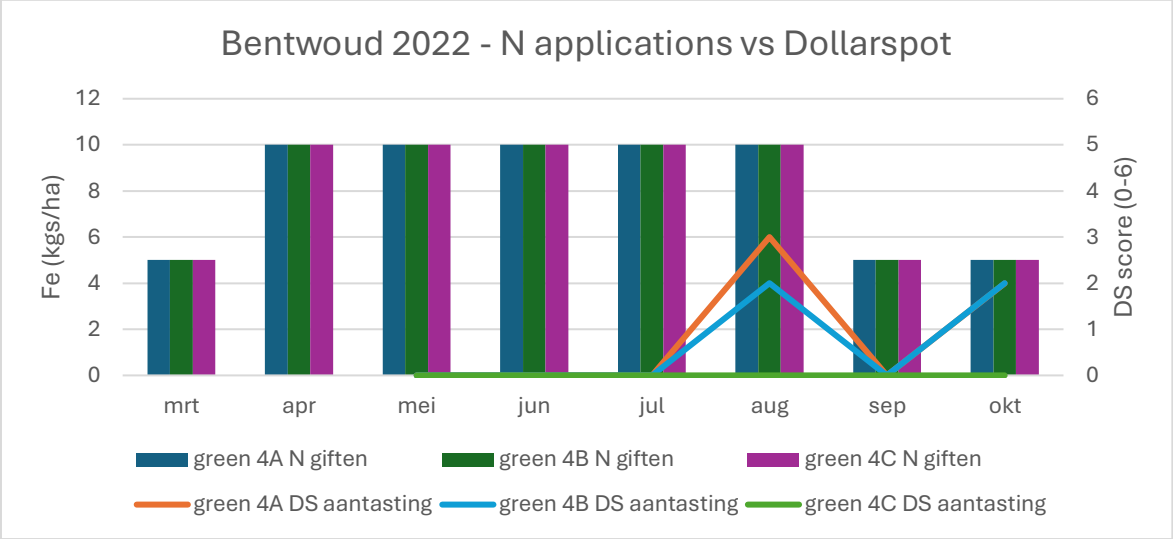


Figure 45: N applications vs dollar spot infection development in 2022

In 2023, meaningful dollar spot activity again occurred only in August, on green 4A. Nitrogen inputs were lower than the year before.

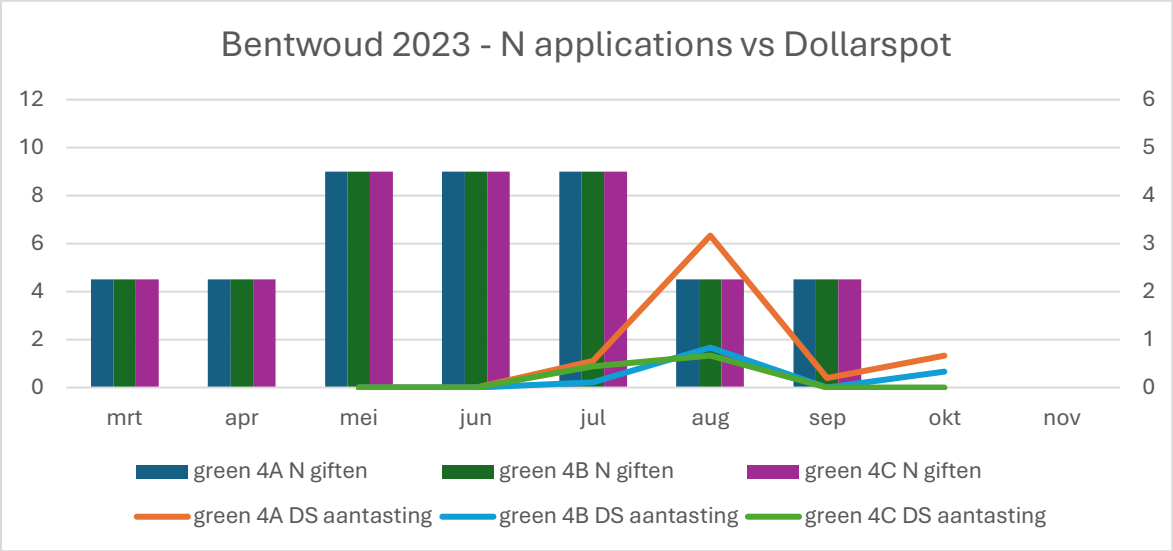


Figure 46: N applications vs dollar spot infection development in 2023

Despite extreme wetness in autumn and winter ’23/’24 and the associated play-related turf damage (and therefore stress), large-scale dollar spot activity—let alone damage—did not occur.

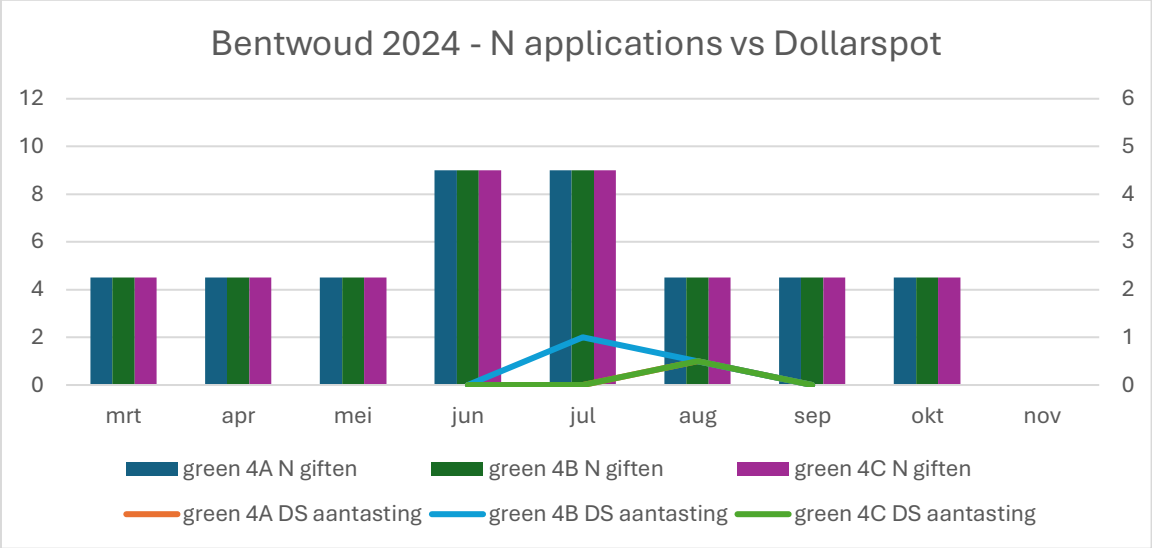


Figure 47: N applications vs dollar spot infection development in 2024

Given the limited and low dollar spot scores, no reliable relationship can be determined between nitrogen inputs and dollar spot.

Across all monitoring seasons, Bentwoud applied limited to moderate amounts of iron sulphate, at or below the average across the 12 courses. Despite this, dollar spot pressure decreased over the years and remained well below the national average throughout the study period. Higher or lower iron inputs do not appear to influence dollar spot pressure here.

Table 24: Key facts on iron sulphate use in relation to dollar spot pressure at Bentwoud

Year	Total Fe (kg/ha) Bentwoud	National average Fe (kg/ha per green)	Average DS pressure (0–5) Bentwoud	National average DS pressure
2022	60	48	1.0	0.9
2023	31	47	0.6	1.7
2024	24	38	0.6	1.6

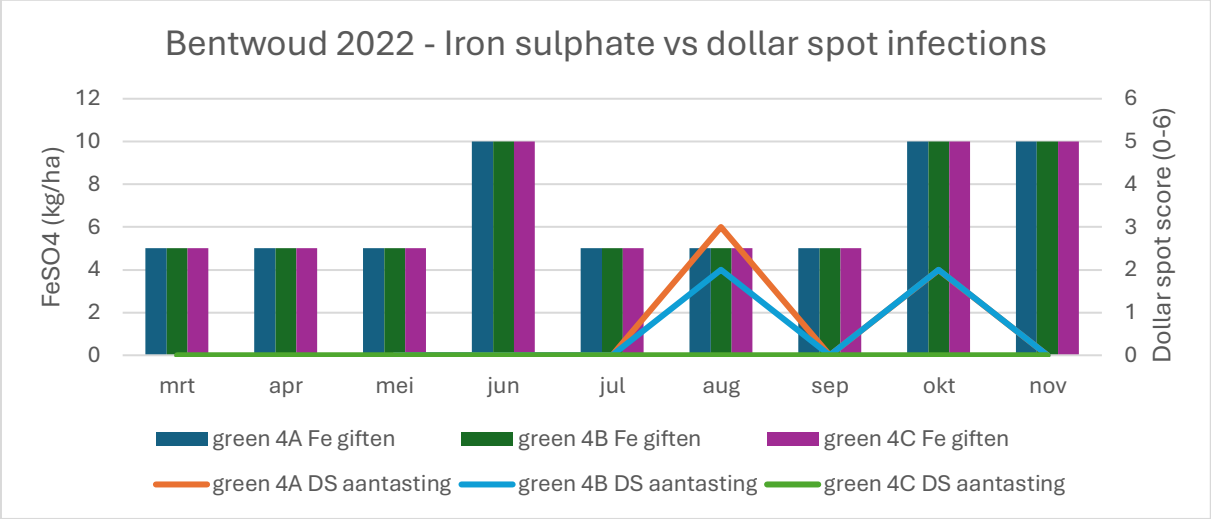


Figure 48: FeSO4 applications vs dollar spot infection development in 2022

Of the three seasons, dollar spot was most visible in 2022. Both greens 4A and 4B showed moderate infections in August. The maintenance regime did not anticipate this specifically. Throughout the year, nearly the same amount of iron sulphate was applied periodically (monthly). Only in June, October and November were double rates applied.

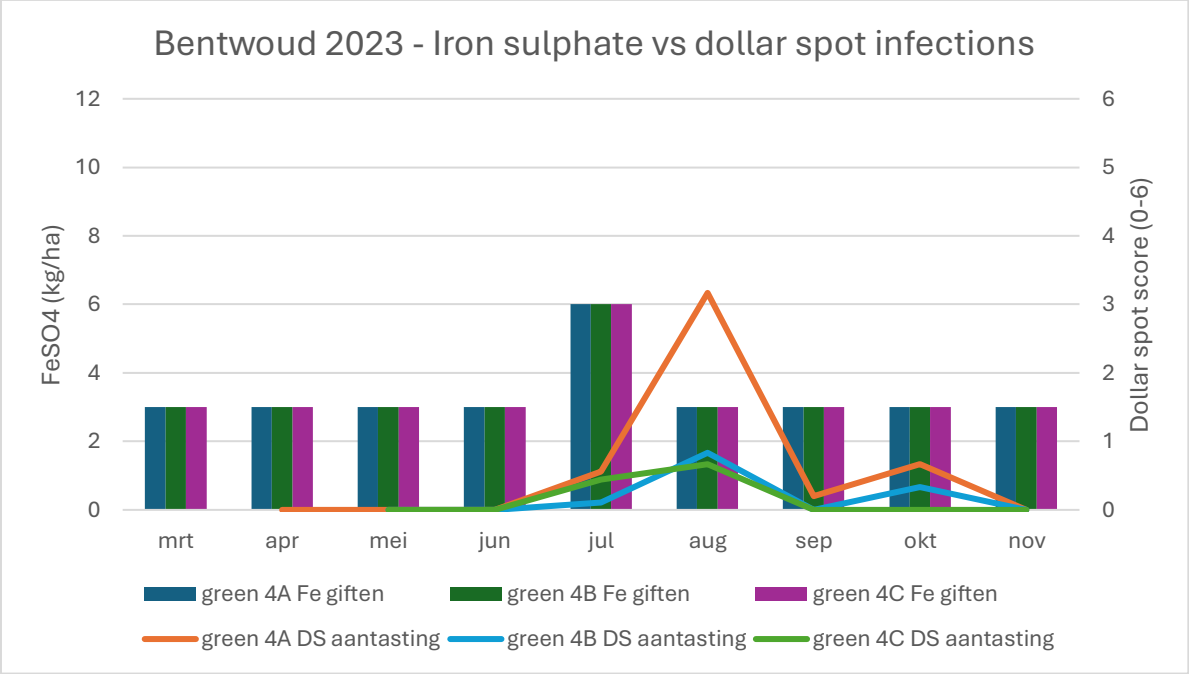


Figure 49: FeSO4 applications vs dollar spot infection development in 2023

In 2023, much less iron was applied over the year than in 2022. Dollar spot infection in August was comparable but was only visible on green 4A. Otherwise, the greens experienced little impact from the pathogen. Iron sulphate was applied in small, regular doses throughout the year, with only a double rate in July.

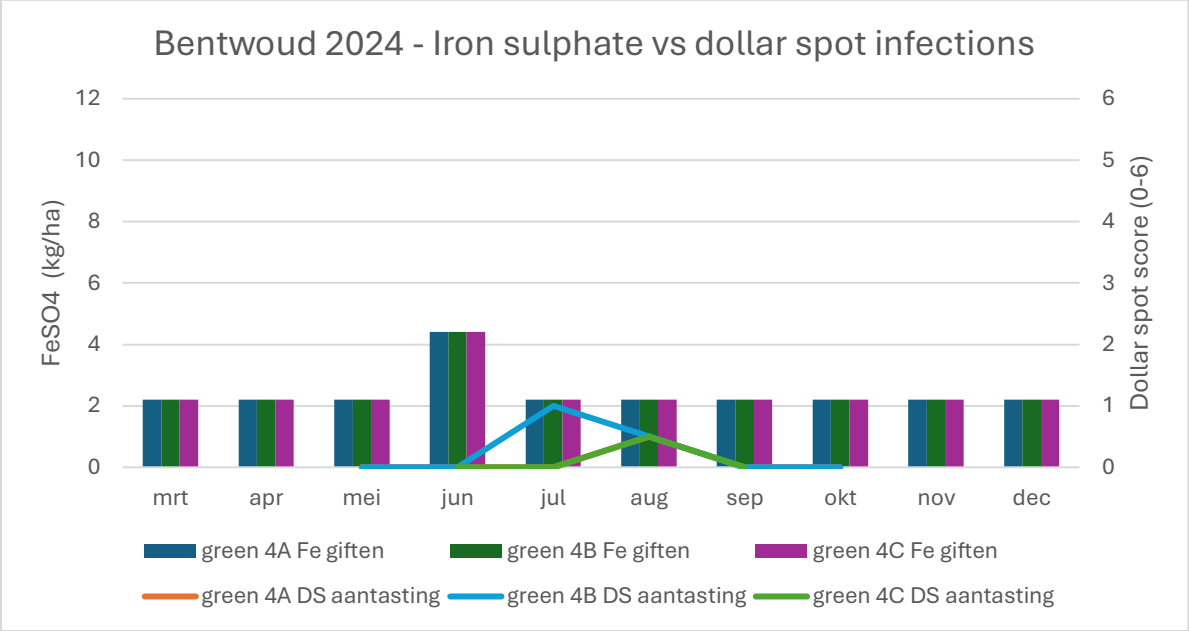


Figure 50: Fe applications vs dollar spot infection development in 2024

In 2024, iron sulphate use decreased further and apparently did not negatively affect dollar spot pressure. Although conditions elsewhere in the Netherlands were highly favourable for dollar spot, 2024 was Bentwoud's best year in terms of disease pressure.

Given the low dollar spot scores (between 0 and 1), no reliable relationship can be determined between iron sulphate applications and dollar spot.

E. Cultural practices: rolling, topdressing, aeration and other

Table 25: Overview of mechanical operations

Practice	Year	Frequency	Notes
Rolling	2022	1x per week	20 rolling weeks
	2023	1x per week	20 rolling weeks
	2024	1x per week	20 rolling weeks
Topdressing	2022	Annually 6x	8 m^3
	2023	Annually 5x	5 m^3
	2024	Annually 3x	8 m^3
Aeration	2022	Annually 4x solid tines	12 mm / 25 cm and 9 mm / 7 cm
	2023	Annually 4x solid and hollow	12 mm / 25 cm; 9 mm / 7 cm; 10 mm hollow / 4 cm depth
	2024	Annually 4x solid and hollow	12 mm / 25 cm; 2x 9 mm / 12 cm depth

In addition, greenkeeping aims to steer towards more vital greens using Protec K 0-0-25, Liquid Step trace element programme, Revolution wetting agent, Thatch Less Tour Turf, and Ocean Glass seaweed. Irrigation water has a high pH (**>8**), but despite the low soil pH, the fine fescue does not appear to suffer from this.

F. Playing quality indicators

Appendix 4 presents playing-quality indicators (Stimp speed, trueness via holing-out test, and firmness via Clegg) in table form. Below, Clegg firmness values for greens 4A, 4B and 4C are shown in a bar chart, with a target range of 80–100 Gm (gravimeters).

There are insufficient data for Stimp and trueness to draw conclusions about their relationship with dollar spot occurrence.

Clegg values are predominantly between 80 and 100, with occasional outliers lower and higher. Appendix 5 provides correlations between Clegg firmness and dollar spot severity. The hypothesis that firmer greens would be less susceptible to dollar spot has not (yet) been confirmed for Bentwoud greens. There is little to no relationship.

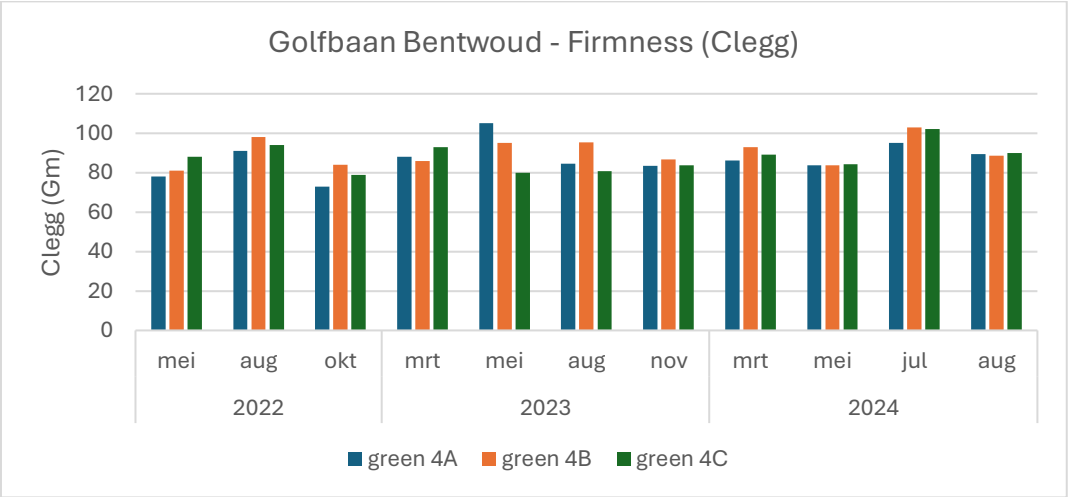


Figure 51: Clegg values over time

G. Microdochium patch

Virtually no winter fusarium activity was observed. Only during the final inventory round in November 2024 were a few small spots observed on green 4B.

H. Conclusions

With scores of **1.2** (green 4A), **0.4** (green 4B) and **0.3** (green 4C), Bentwoud shows **very low to low** dollar spot susceptibility. Both culturally and in terms of playing performance, the greens are of high quality.

Nevertheless, there are management points of attention. Although play intensity is very high, the fine fescue greens are (so far) holding up very well. The question is whether this situation is sustainable long-term or whether, at some point, disease pressure (likely Microdochium) will increase. Over the full study period, organic matter levels in the **0–2 cm** layer are too high and infiltration capacity is too low. Therefore, it is necessary to create more “connection” to the highly infiltrating underlying layer.

Be mindful of timing: these operations can have a disturbing effect on fine fescue growth patterns. Fine fescue generally recovers more slowly than browntop bentgrass.

4. Domburgse Golf Links

Overview of dollar spot development

Table 26 shows the average infection level per year for the monitored greens.

Table 26. Average level of dollar spot infection on Domburgse Golf Links in 2022, 2023 and 2024

	Green 7	Green 8	Green 9	National average DS infection
2022	0.5	1.3	0.8	0.9
2023	0.5	1.3	0.0	1.7
2024	1.2	1.8	0.3	1.6
Average	**0.9**	**1.5**	**0.4**	

Across the three monitoring seasons, dollar spot pressure remained fairly limited until autumn. However, during the warm autumns of 2022 and 2023 pressure increased rapidly, resulting in substantial outbreaks (with visible damage) in October and November. The particularly wet winter of 2023/2024 further exacerbated the situation, as unrecovered dollar spot damage in spring 2024 made the greens more susceptible to renewed infections, which indeed led to significant damage on greens 7 and 8.

Figures showing the actual infection levels per year plotted against the predictions ("probability %") of the Smith Kerns forecasting model are presented in Appendix 3.

A. Water management

Despite low soil moisture contents across all three years, infection levels on greens 7 and 9 remained limited (maximum score 2). Green 8 showed higher dollar spot activity, with locally more severe damage. Particularly in spring 2023, soil moisture levels at both 0–6 cm and 6–12 cm dropped well below 10%, and green 8 experienced the greatest stress.

Figures 52–54 illustrate the relationship between soil moisture dynamics and dollar spot development on greens 7, 8 and 9.

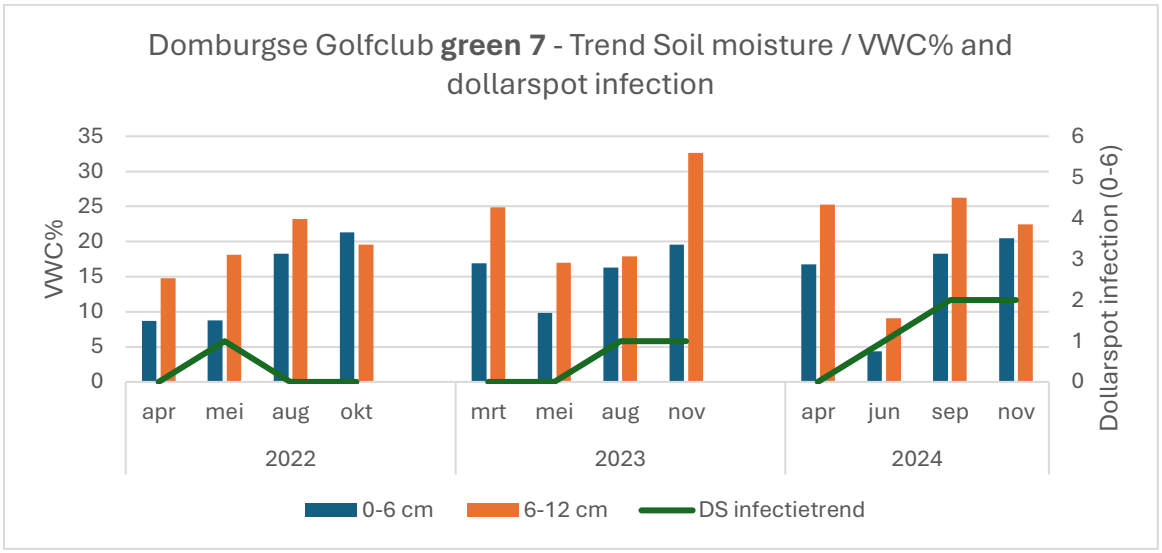


Figure 52: Soil moisture trend vs dollar spot infections – green 7

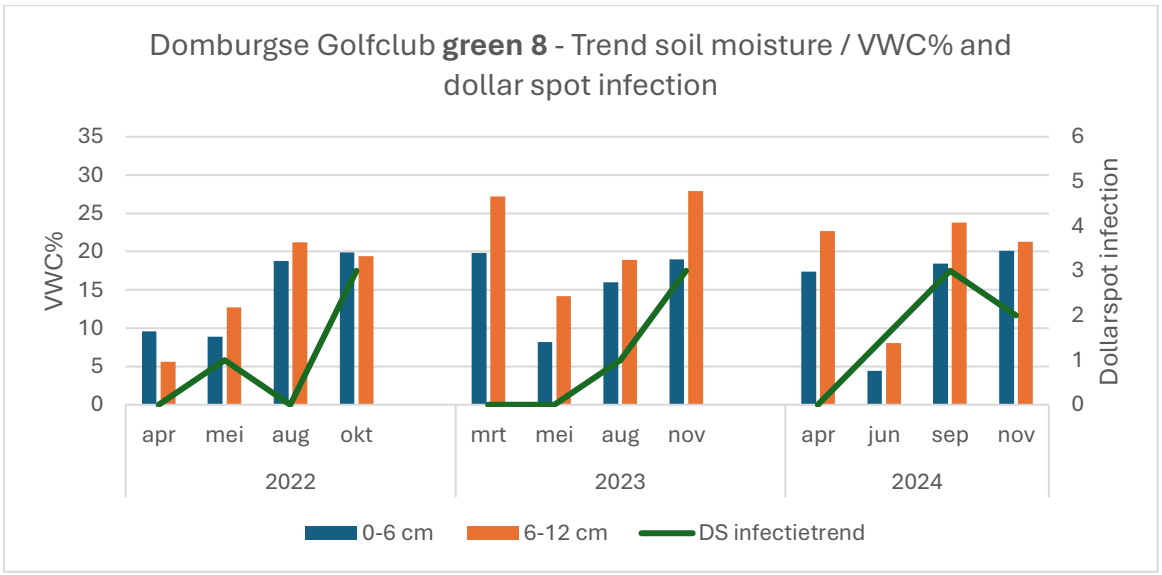


Figure 53: Soil moisture trend vs dollar spot infections – green 8

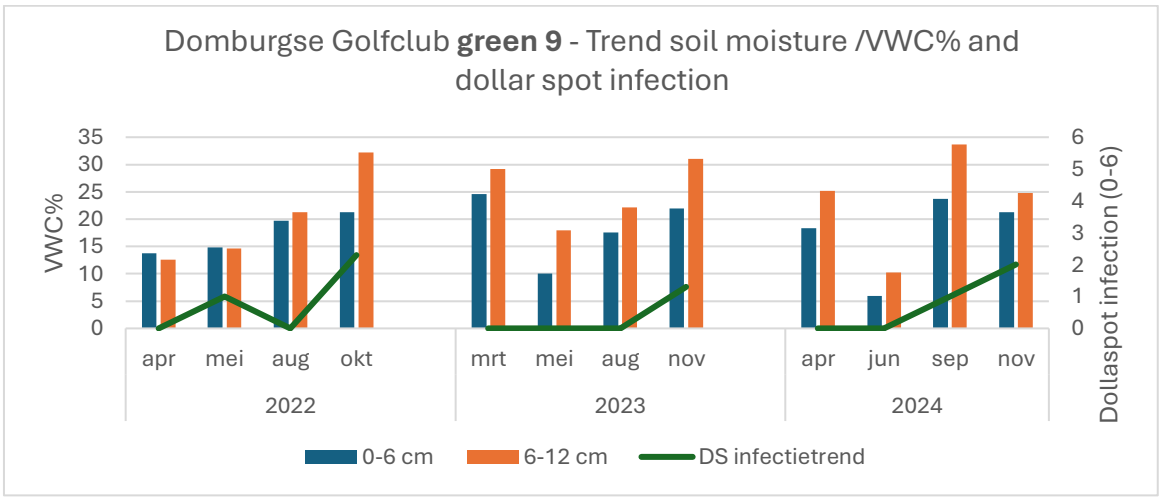


Figure 54: Soil moisture trend vs dollar spot infections – green 9

As expected for a links course located adjacent to coastal dunes, the water infiltration capacity of the greens, measured from the turf surface, is very high (Figure 55).

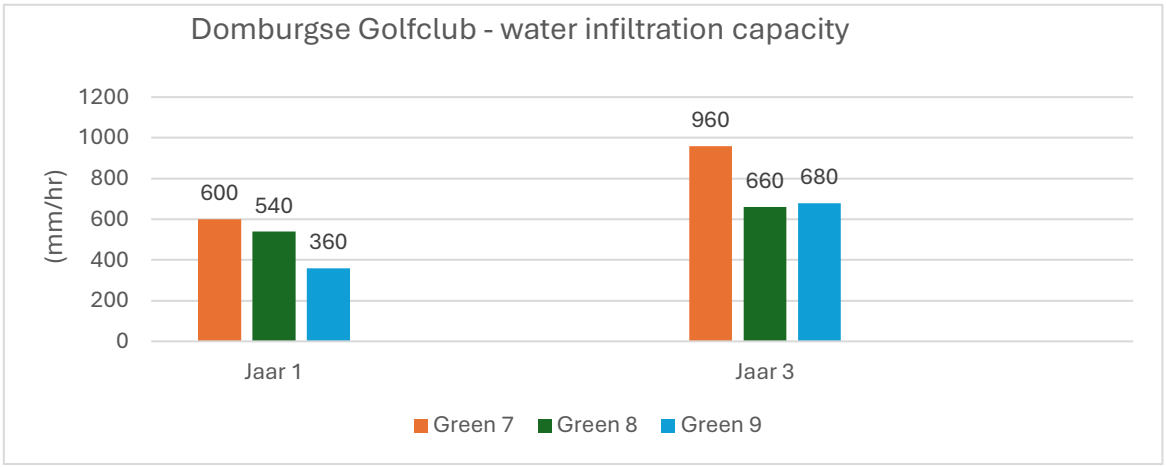


Figure 55: Average water infiltration capacity over three years

B. Organic matter (2–4–6 cm)

Organic matter content on greens 7 and 8 was highest in the 2–4 cm layer. Green 9 deviated from this pattern, showing a leaner 0–2 and 2–4 cm layer in the first year, which shifted towards higher organic matter content at 2–4 and 4–6 cm depth by year three. Organic matter content in the 0–2 cm layer of green 8 increased substantially between year 1 and year 3. However, higher organic matter content did not appear to improve tolerance to dollar spot compared with the other two greens.

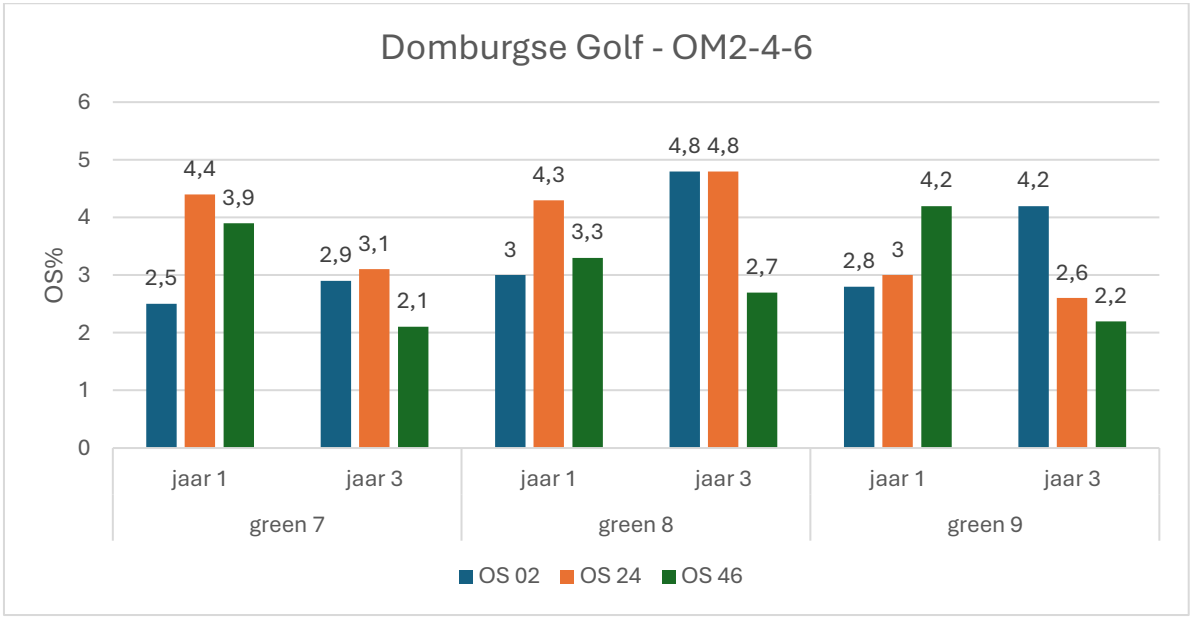


Figure 56: OM246 development in years 1 and 3

The C/N ratio varied strongly between years and showed no clear relationship with dollar spot tolerance.

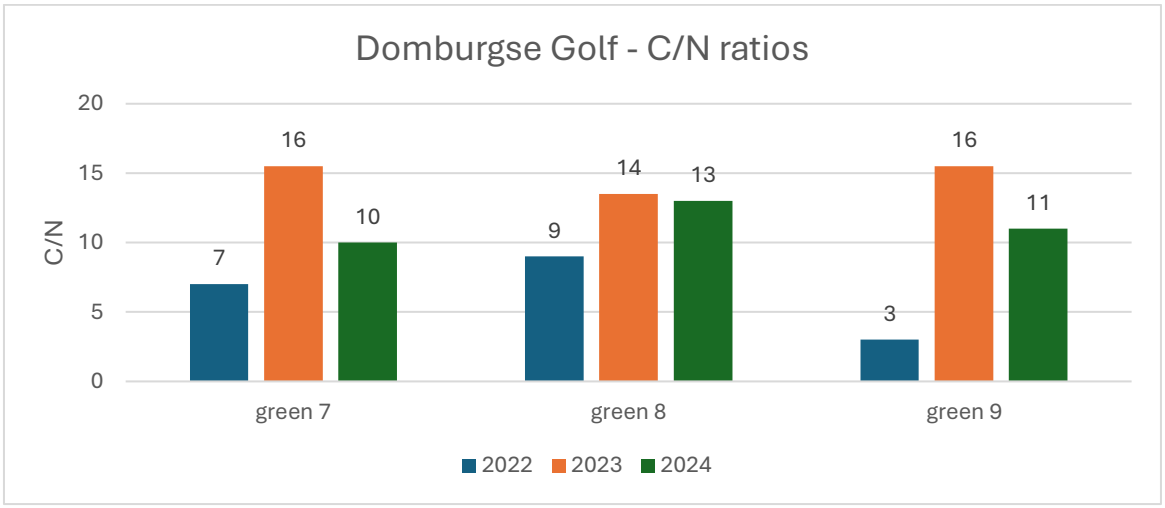


Figure 57: C/N ratios

Soil pH values ranged between 6 and 7, the highest among all participating golf courses. These conditions are highly favourable for fine fescue (Festuca rubra) and support a more active soil biology.

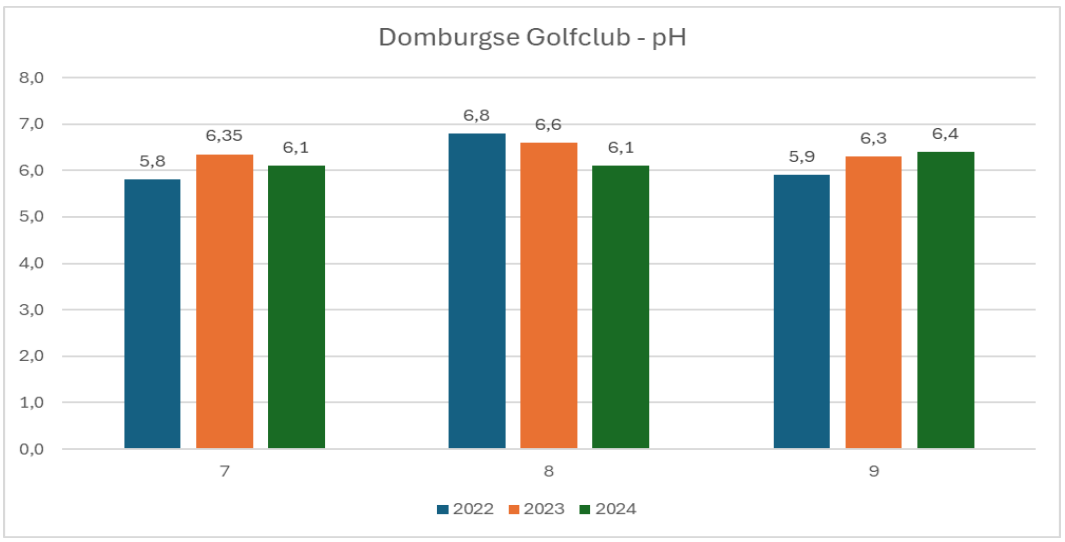


Figure 58: pH development

C. Turf composition and overseeding

The turf on this links course is characteristically dominated by fine fescue during the first years of monitoring. A notable increase in bentgrass (Agrostis capillaris) was observed from summer 2024 onwards, despite consistent overseeding with 100% fine fescue each year. Overseeding is carried out annually at the end of August (200–300 kg/ha) using pot seeding with 12 or 18 mm equipment.

Figure 59 shows the development of turf composition over time.

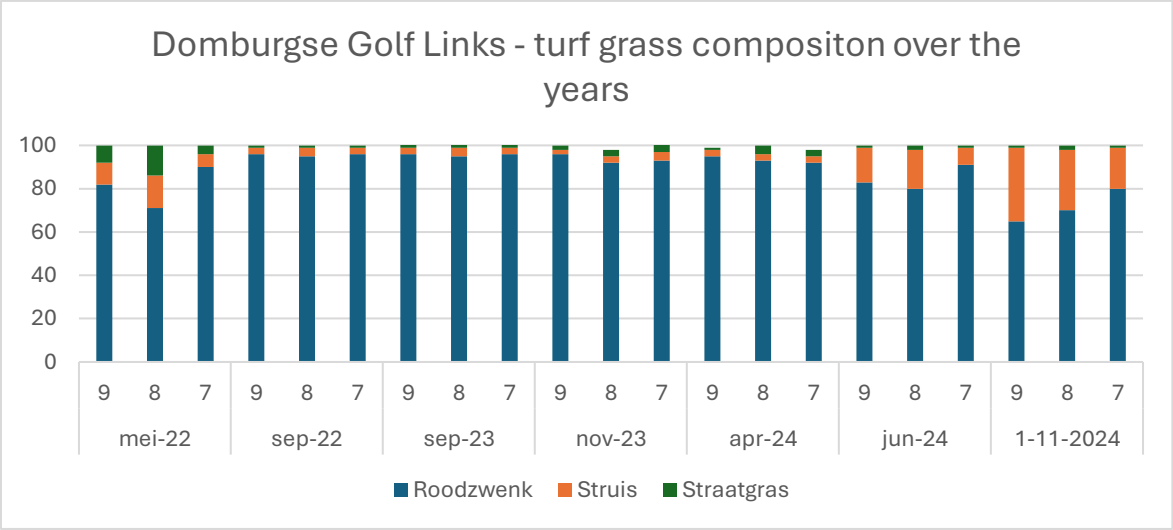


Figure 59: Development of turf grass composition

D. Fertilisation programme: nitrogen and iron sulphate

As a links course dominated by fine fescue, Domburgse Golf Links applies relatively low nitrogen inputs. Over the three monitoring seasons, total nitrogen input and application timing remained consistent. The first (and usually only) nitrogen application occurs in spring in granular form. No additional nitrogen is applied later in the season, even following dollar spot outbreaks.

Table 27. Nitrogen inputs in relation to dollar spot pressure on Domburgse Golf Links

Year	Total N (kg/ha)	National average N (kg/ha)	Average DS pressure	National average DS
2022	42	73	0.8	1.0
2023	40	76	0.6	1.8
2024	40	88	1.1	1.5

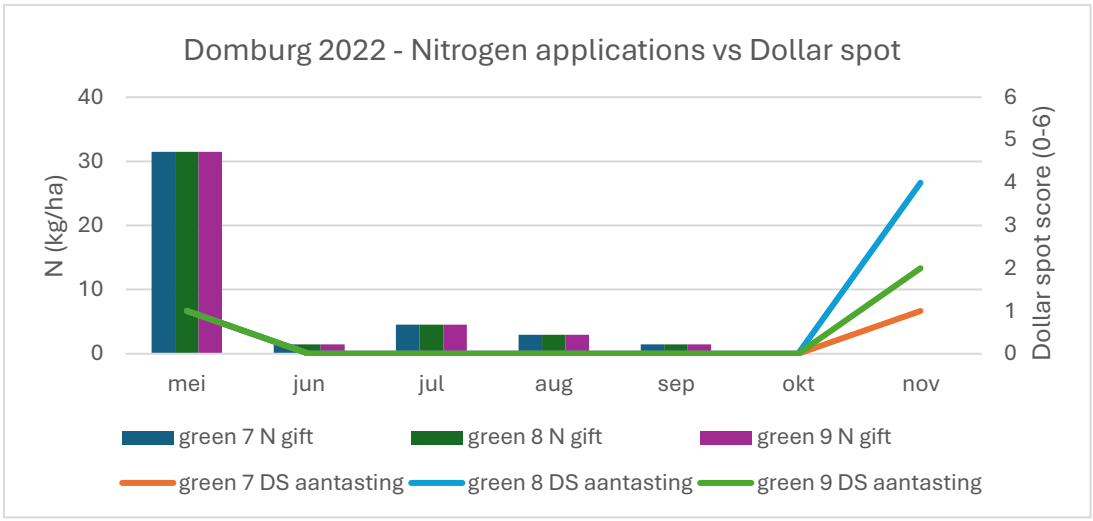


Figure 60: N applications vs dollar spot infection in 2022

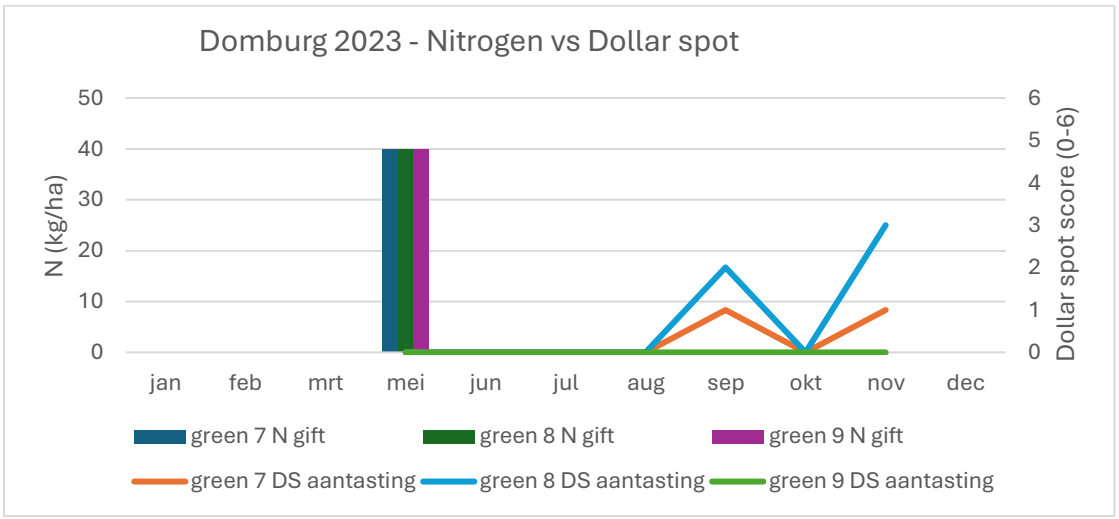


Figure 61: N applications vs dollar spot infection in 2023

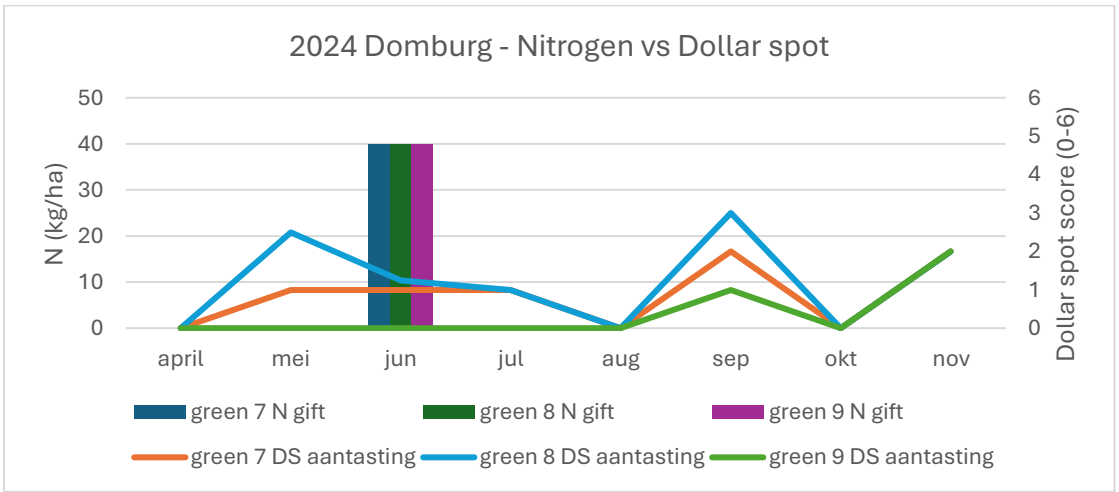


Figure 62: N applications vs dollar spot infection in 2024

Nitrogen does not appear to be the key factor in dollar spot control at Domburg; iron use seems more influential. Table 28 summarises iron sulphate application rates.

Table 28. Iron sulphate use in relation to dollar spot pressure on Domburgse Golf Links

Year	Fe (kg/ha) Domburg	National avg Fe (kg/ha)	Average DS pressure	National avg DS
2022	68	48	0.8	0.9
2023	77	47	0.6	1.7
2024	28	38	1.1	1.6

In 2022, regular iron sulphate applications successfully kept dollar spot under control. When this regularity was disrupted in late summer, pressure increased, culminating in a significant outbreak with visible damage in October (score 4 on green 8). A preceding heavy iron application (lawnsand) failed to prevent this outbreak.

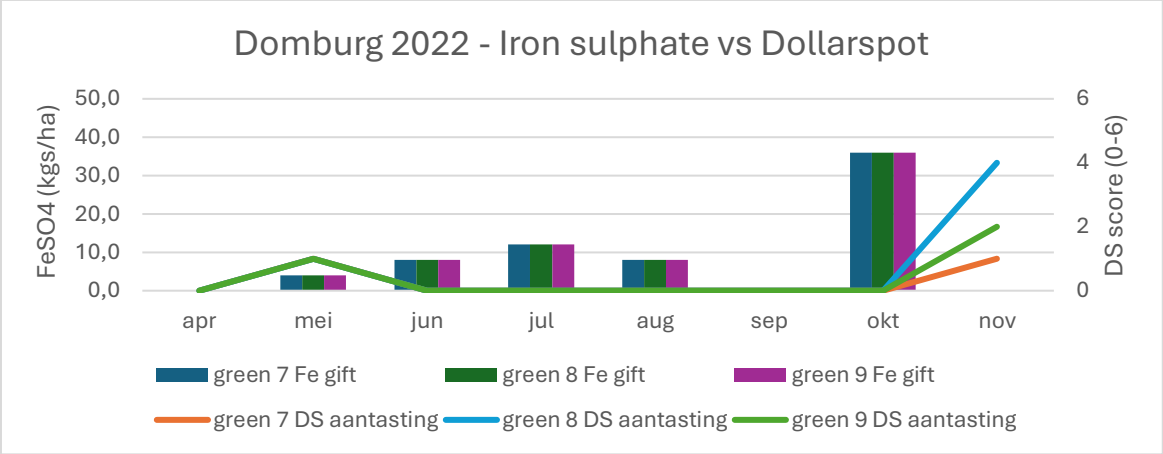


Figure 63: Fe applications vs dollar spot infection in 2022

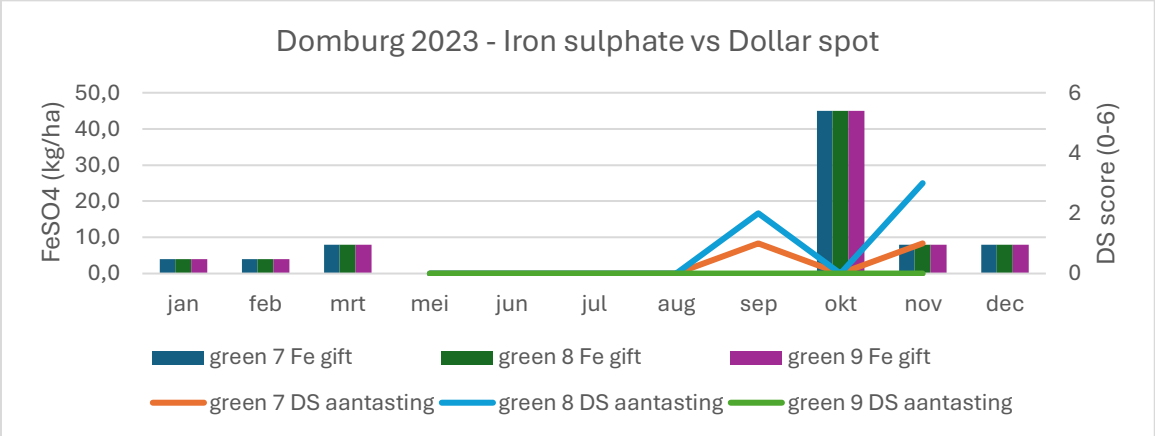


Figure 64: Fe applications vs dollar spot infection in 2023

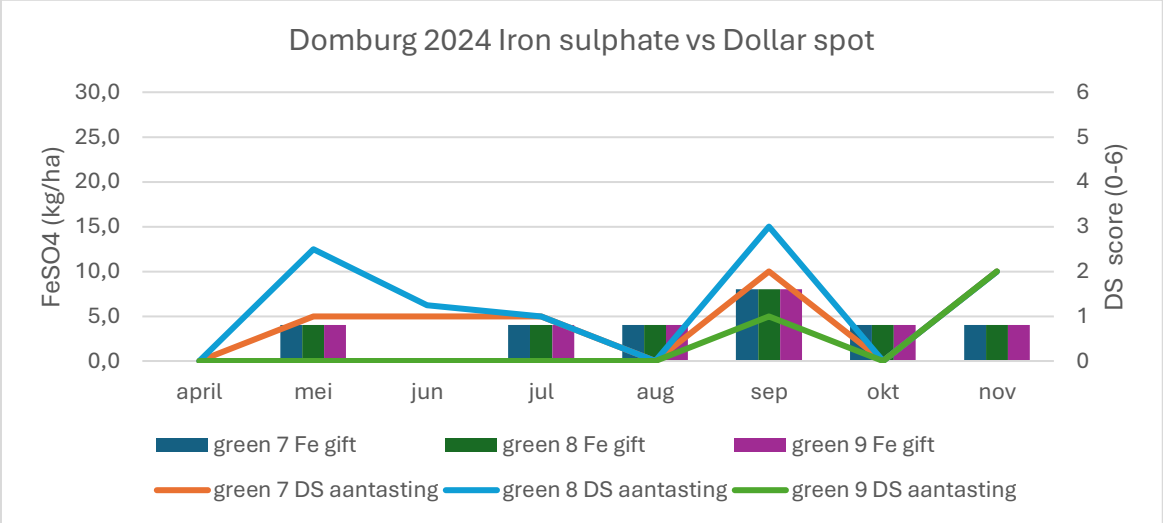


Figure 65: Fe applications vs dollar spot infection in 2024

In 2023, infection again occurred late in the season, with damage that did not recover. In 2024, iron sulphate use was substantially reduced compared with previous years, resulting in more latent dollar spot activity and more severe damage in the second half of the season.

E. Cultural practices: rolling, topdressing, aeration

The fertilisation programme is based primarily on TX10 5-2-8 applied once fine fescue growth begins, depending on weather conditions. In the dry year 2022 this occurred only in June. Additional inputs include seaweed (Ascopuur), 10-0-10, Mantle and TE-Mag. Wetting agent Aquapremium is applied from early spring, and Stressbuster is used to maintain turf vitality.

Table 29. Overview of rolling, topdressing and aeration practices

Practice	Year	Frequency	Remarks
Rolling	2022	5× per week	25 rolling weeks
	2023	4× per week	26 rolling weeks
	2024	5× per week	25 rolling weeks
Topdressing	2022	4× 7.5 t, 1× 40 t	Large application in August
	2023	70 m³	Applied in 5 operations
	2024	80 m³	Almost all in 1 operation + 3 dustings
Aeration	2022	1× solid 18 mm; 4× 6 mm	August, combined with topdressing
	2023	1× 16 mm + various Maredo	August, with overseeding and topdressing
	2024	1× solid 12 mm	August, with topdressing

F. Playing quality parameters

Clegg hardness values (Figure 66) show that greens are firm, consistent with a links-style course. No meaningful correlation was found between Clegg values and dollar spot occurrence. Data on green speed (stimp) and trueness were insufficient to draw conclusions.

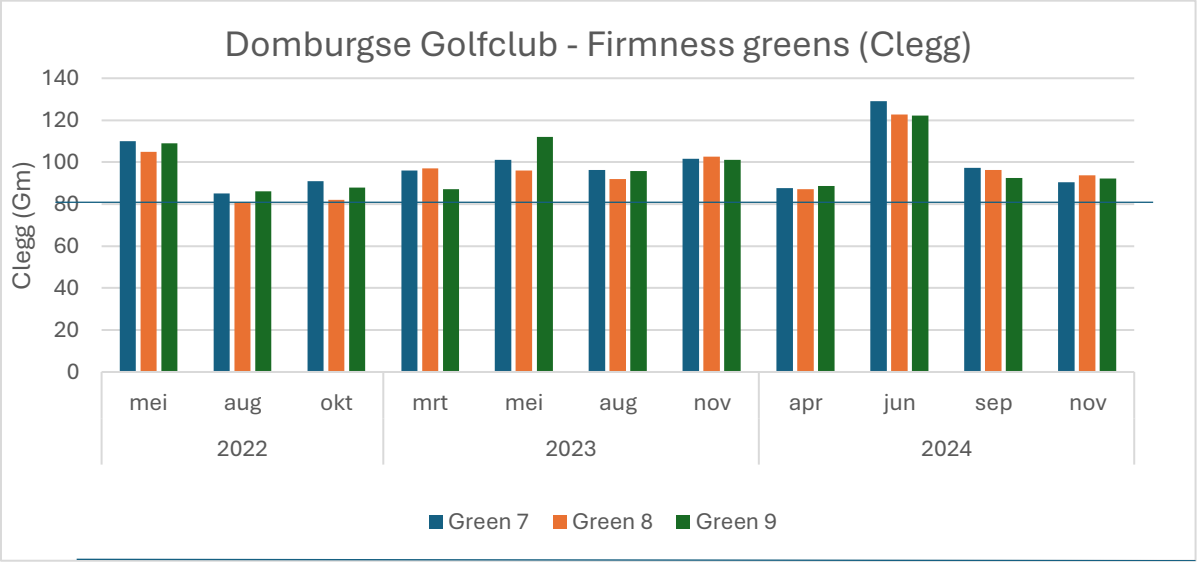


Figure 66: Clegg values over time

G. Snow mold *(Microdochium nivale)*

In autumn 2022 all three greens showed light snow mould infection (score 2). By spring 2023 only green 8 still showed mild symptoms, which did not reoccur thereafter.

H. Conclusions

Average dollar spot scores for greens 7, 8 and 9 were 0.9, 1.5 and 0.4 respectively. Greens 7 and 9 show very low susceptibility, while green 8 tends towards moderate susceptibility, particularly in the final year (2024).

Domburg is unique due to its coastal location. External influences such as wind-blown dune sand, salt-tolerant weeds, wild bentgrasses and elevated soil pH manifest more strongly than on inland courses. Local microclimatic conditions, such as shelter from wind, quickly translate into increased dollar spot susceptibility—particularly on green 8.

The low-disturbance maintenance strategy proved effective until the extreme seasons of 2023 and 2024. These years demonstrated the need for more proactive management, anticipation and rapid response to unusual conditions, such as high temperatures and humidity in October.

5. Edese Golfclub Papendal

Overview of dollar spot development

Table 30 presents the average annual dollar spot infection levels per monitored green.

Table 30. Average dollar spot infection on Edese Golfclub Papendal in 2022, 2023 and 2024

	Green 5	Green 9	Green 14	National average DS
2022	0.0	0.0	1.4	0.9
2023	0.5	0.6	0.7	1.7
2024	2.6	2.1	4.1	1.6
Average	**0.9**	**0.9**	**1.7**	

During the first two years, Edese Golfclub performed well below the national average in terms of dollar spot occurrence. Green 14 has historically been a problem green, which is reflected in the 2022 results.

In 2024, however, the situation changed significantly. Dollar spot became widespread and caused substantial damage across all greens, including greens 5 and 9. In addition to 2024 being a high-pressure year nationwide, this shift can also be explained by a change in maintenance contractor and the appointment of a new head greenkeeper.

Dollar spot development over time, in relation to Smith-Kerns predictions, is presented in Appendix 3.

A. Water management

The greens at Edese Golfclub are sand-based on the native soil, with a relatively fine texture. Topdressing has been carried out for many years using M50 sand (330 µm) to ensure adequate water infiltration.

Despite this, the water-holding capacity of the rootzone remains relatively high.

Figures 67–69 show soil moisture levels at depths of 0–6 cm and 6–12 cm, together with the general development of dollar spot pressure over the years 2022, 2023 and 2024.

Greens are sand-based on native soil with a relatively fine texture. Long-term topdressing with M50 330 µm sand ensures reasonable infiltration, but water-holding capacity of the upper layers remains high. Soil moisture levels generally exceeded the 20% target at 0–6 cm, and drought stress does not appear to be the primary trigger for dollar spot at Papendal.

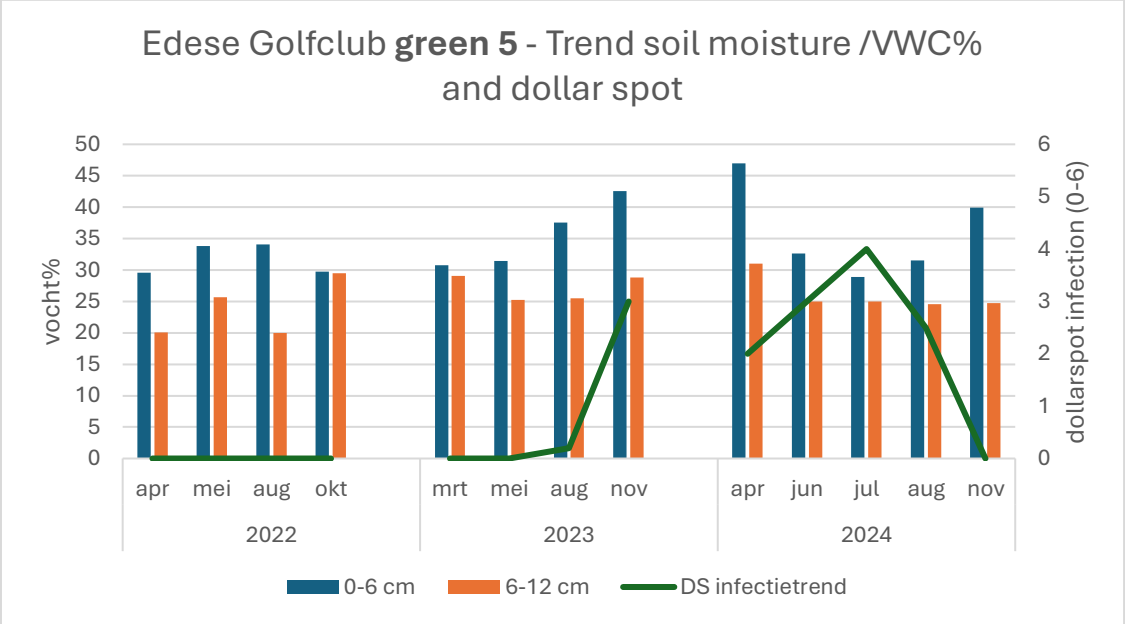


Figure 67. Soil moisture dynamics and dollar spot development – Green 5

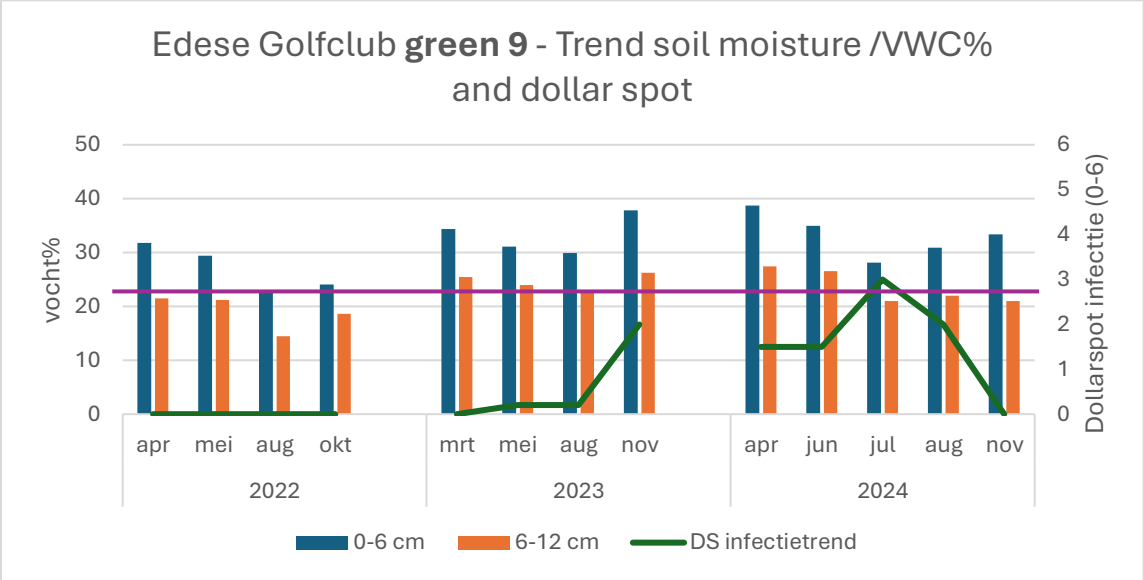


Figure 68: Soil moisture dynamics and dollar spot development – Green 9

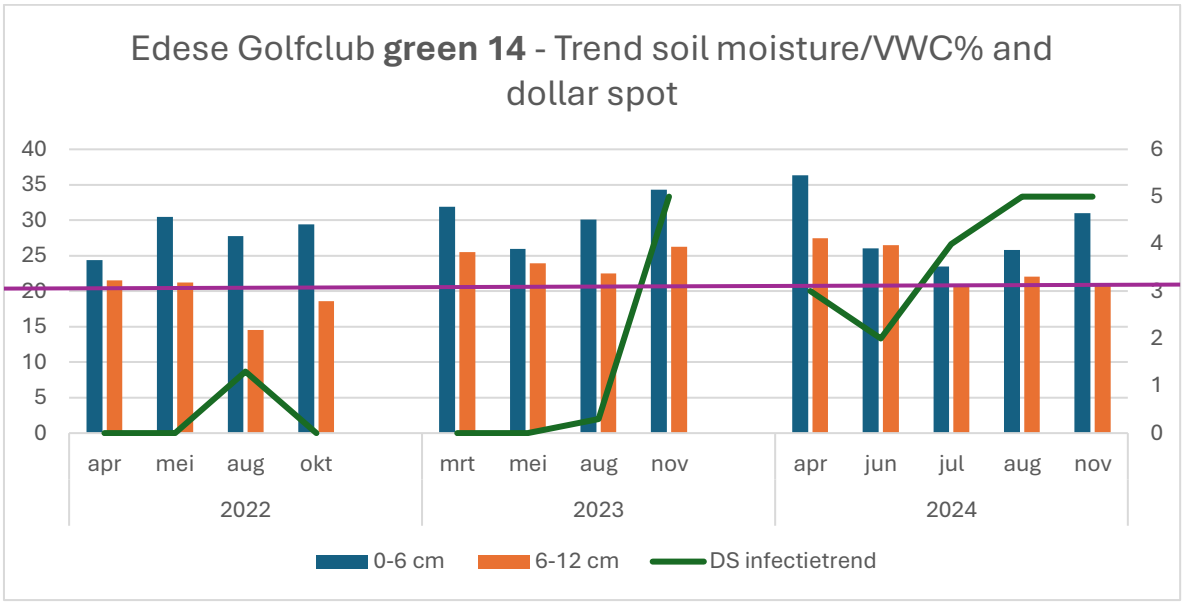


Figure 69: Soil moisture dynamics and dollar spot development – Green 14

Based on these data, soil moisture does not appear to have been a limiting factor. The target value of 20% (0–6 cm) was generally achieved during monitoring, and moisture levels at 6–12 cm were also adequate.

Even the most susceptible green (14) shows a moisture pattern comparable to greens 5 and 9. This suggests that drought stress is not the primary trigger for dollar spot at Edese Golfclub.

The water infiltration capacity is generally low, particularly on green 9, where values fall below the benchmark of 50 mm per day. Remarkably, the most susceptible green (14) shows the highest infiltration capacity, yet also the highest dollar spot pressure.

Infiltration capacity was generally low, particularly on green 9, which fell below 50 mm/day. Interestingly, green 14—most susceptible to dollar spot—showed the highest infiltration capacity.

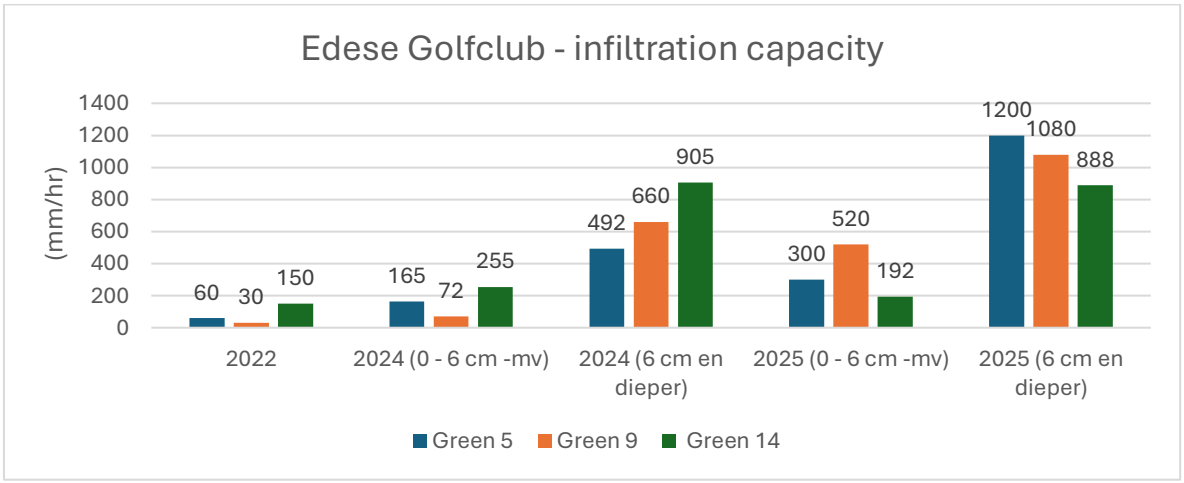


Figure 70: Average water infiltration capacity over three years

B. Organic matter, C/N ratio and pH

Organic matter content increased markedly in the 0–2 cm layer, with large contrasts to deeper layers 2-4 and 4-6 cm. Infiltration capacity improved markedly by 2024, except on green 9. Notably, thatch thickness on green 9 decreased during the monitoring period, and a strong negative correlation was found between thatch thickness and dollar spot severity: more thatch, less dollar spot. Organic matter content has increased significantly in the 0–2 cm layer, resulting in a pronounced difference compared to the 2–4 cm and 4–6 cm layers.

Infiltration capacity improved substantially by 2024, except for green 9. From 6 cm depth and deeper, infiltration is more than adequate for all greens.

A notable observation is the decrease in thatch thickness on green 9 during the monitoring period. Appendix 7 shows this in relation to average dollar spot severity per year. For green 9, thatch thickness shows a strong negative correlation with dollar spot severity—meaning that more thatch is associated with less dollar spot.

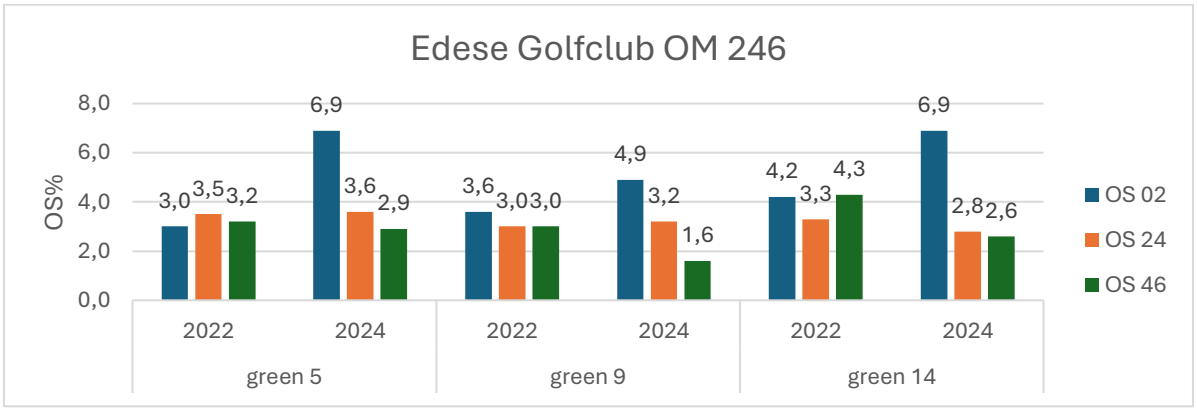


Figure 71: OM246 development in years 1 and 3

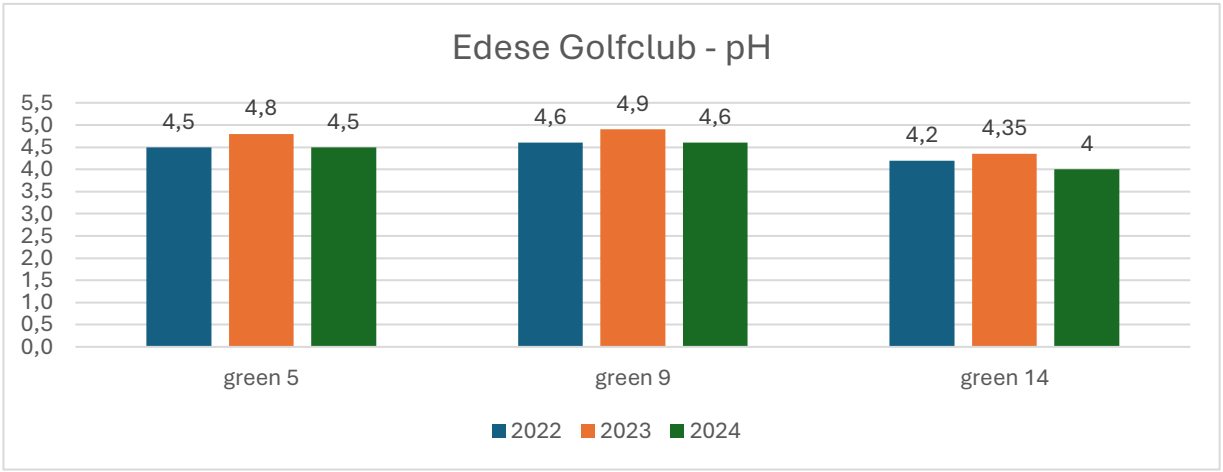


Figure 72: pH development

C. Turf composition and overseeding

The greens consist predominantly (>90%) of *Agrostis spp.*, with smaller proportions of *Poa annua* and a few percent *Festuca rubra*.

A notable feature—particularly on greens 9 and 14—is the relatively high presence of *Agrostis canina* (velvet bentgrass), a fine-leaved, low-input species that forms a substantial thatch layer and retains more moisture in the upper rootzone.

On green 9 in particular, the higher proportion of *Agrostis canina* appears to contribute to reduced dollar spot activity. In other words, an increase in thatch appears to result in lower disease pressure. The challenge is to identify the optimal level of thatch.

Greens are dominated (>90%) by Agrostis species, with smaller proportions of Poa annua and Festuca rubra. Particularly on greens 9 and 14, a high proportion of Agrostis canina was observed. This fine-leaved, low-input species produces relatively high thatch levels, which may contribute to reduced dollar spot activity. Finding the optimal balance remains a key challenge.

Figure 73 shows the turf grass composition changes throughout the study period. Note: for the assessment the total proportion of Agrostis has been considered without distincting between subspecies like e.g. canina and capillaris.

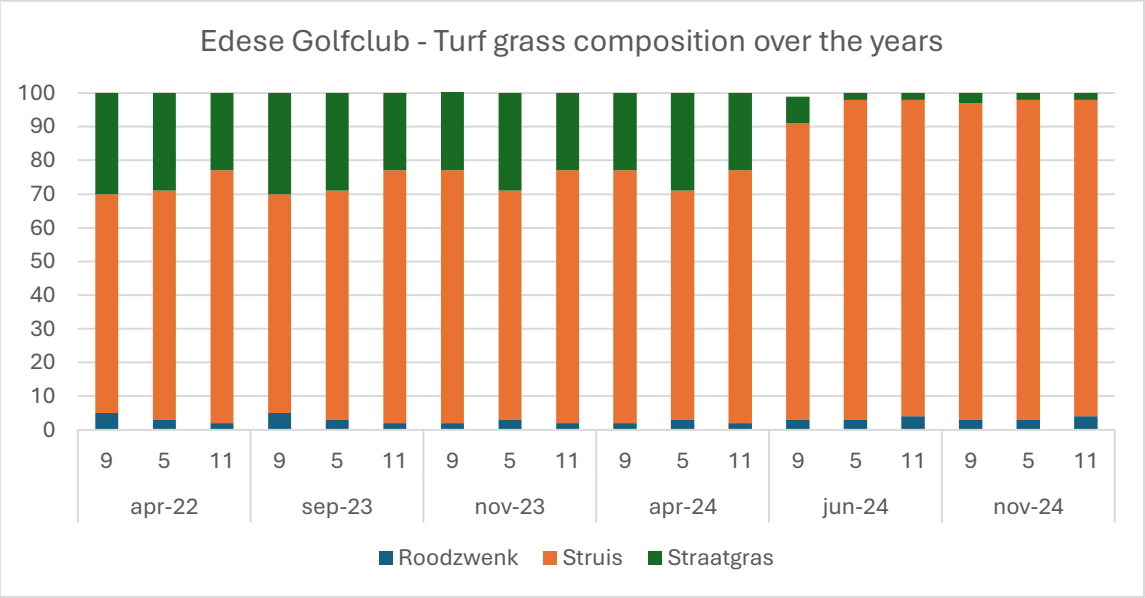


Figure 73: Development of turf grass composition

The overseeding programme focuses on frequent applications of 100% *Agrostis capillaris*:

- 4 times per year in 2022 and 2024
- 6 times per year in 2023
- application rates between 15 and 40 kg/ha

Frequent overseeding promotes turf renewal, introduces improved cultivars, and increases genetic diversity, thereby enhancing disease tolerance.

D. Fertilisation programme

Nitrogen inputs in 2022 and 2023 were below the national average, as was dollar spot pressure. In 2024, both nitrogen input and dollar spot pressure increased sharply. Iron sulphate applications were consistently above national averages, but were unable to suppress severe dollar spot outbreaks in 2024.

Table 31. Nitrogen inputs in relation to dollar spot pressure at Edese Golfclub

	Total N (kg/ha)	National average N	DS severity (0–5)	National average DS
2022	70	79	0.5	0.9
2023	68	76	0.6	1.7
2024	110	88	3.0	1.6

Based on the multi-year trends, disease pressure increased rapidly after the summer of 2023, resulting in severe damage (scores ≥3). Due to wet conditions and the onset of winter, insufficient recovery occurred, leaving residual damage that acted as a source of infection in spring 2024.

A more intensive nitrogen regime did not result in improved disease control.

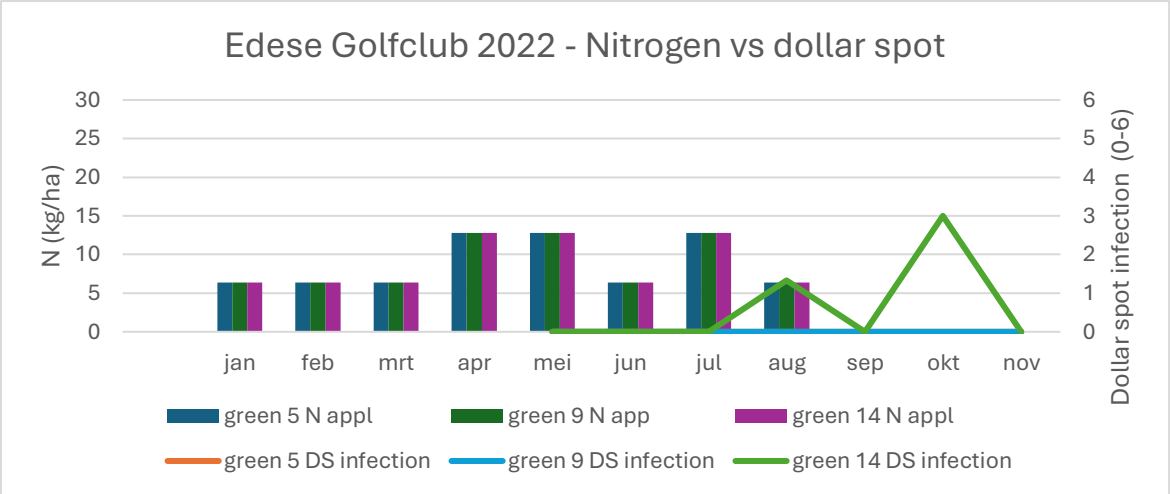


Figure 74. Nitrogen applications vs. dollar spot development (2022)

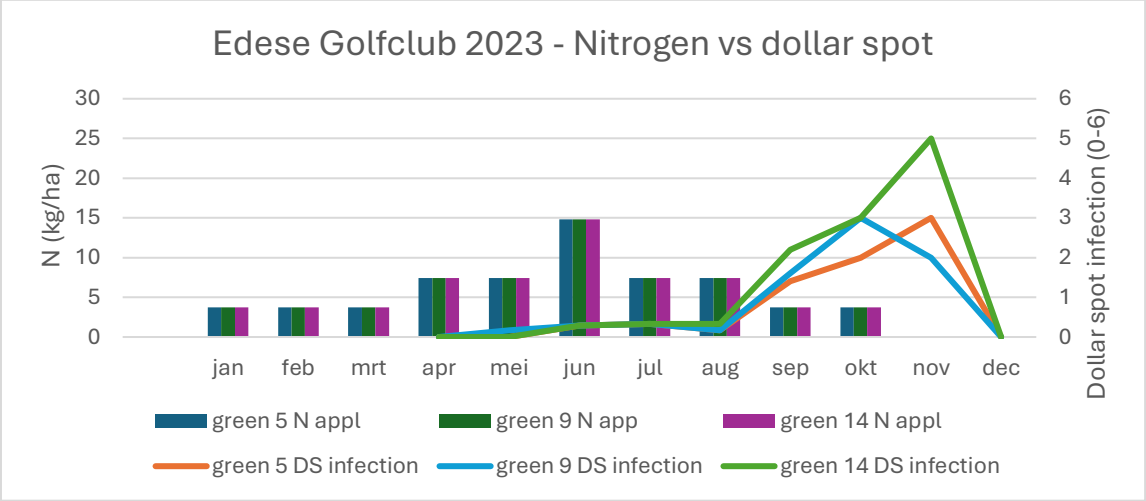


Figure 75. Nitrogen applications vs. dollar spot development (2023)

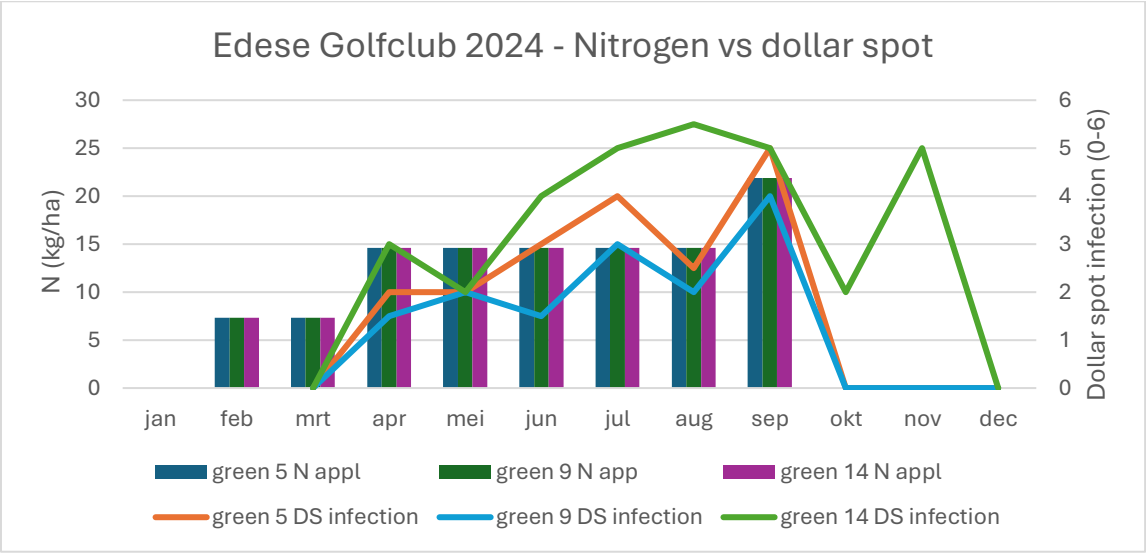


Figure 76. Nitrogen applications vs. dollar spot development (2024)

Iron sulphate is also part of the fertilisation programme and has been applied at relatively high levels compared to other courses.

Table 32. Iron sulphate inputs in relation to dollar spot pressure at Edese Golfclub

	Total Fe (kg/ha)	National average Fe	DS severity (0–5)	National average DS
2022	64	48	0.5	0.9
2023	56	47	0.6	1.7
2024	48	38	3.0	1.6

Iron applications were initially applied consistently throughout the year, mainly as iron sulphate. In the summer of 2023, application rates were increased in response to rising disease pressure. However, this did not prevent a sharp increase in dollar spot severity, particularly on green 14.

Applications in 2024 also failed to reduce disease activity.

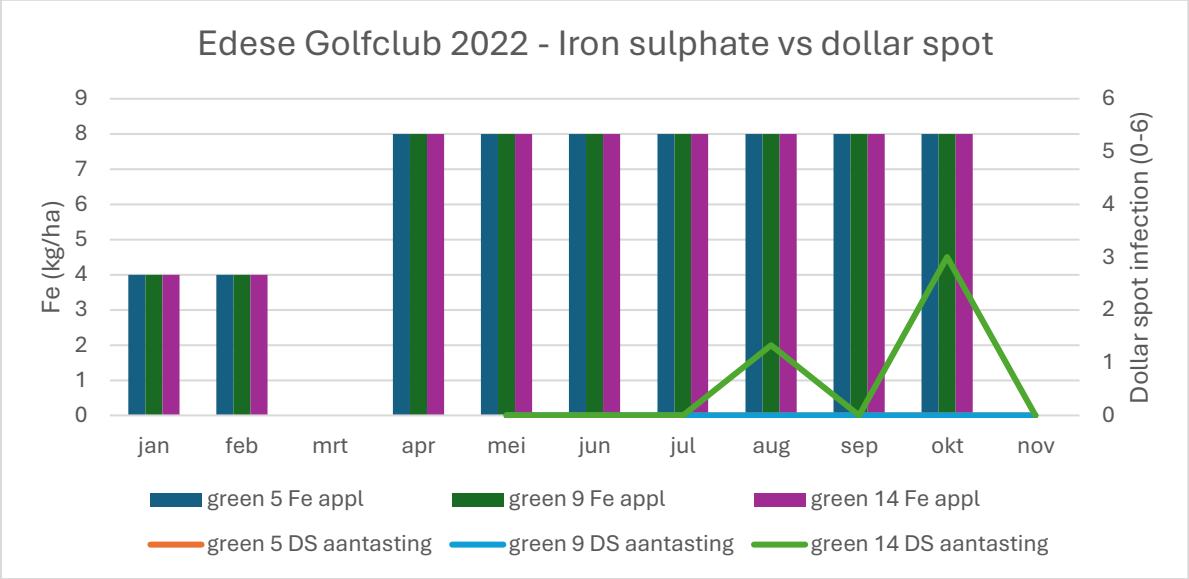


Figure 77. Iron applications vs. dollar spot development (2022)

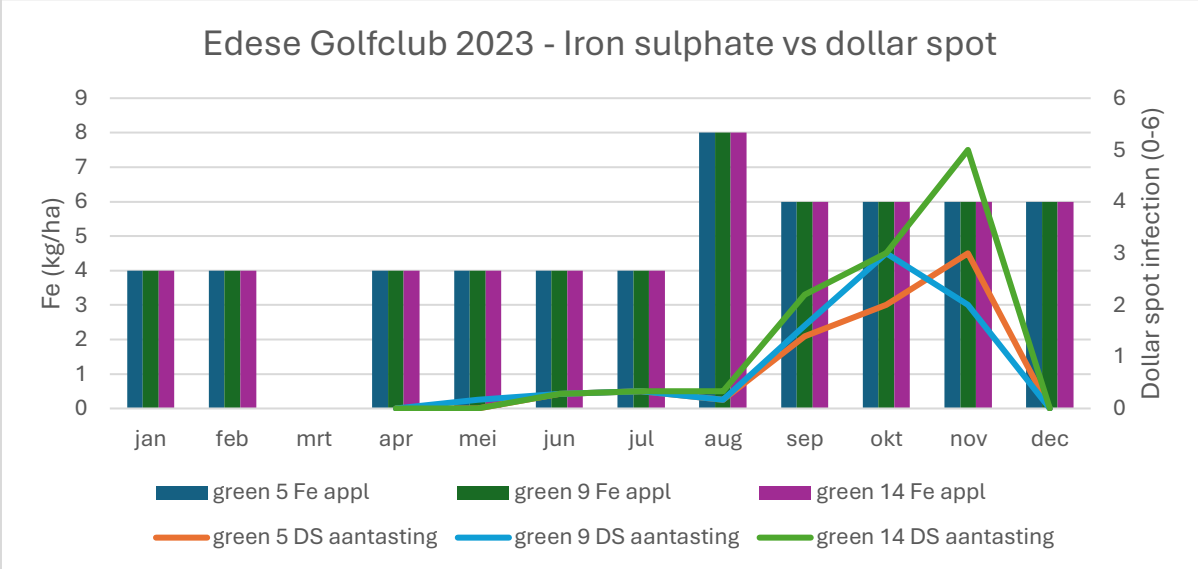


Figure 78. Iron applications vs. dollar spot development (2023)

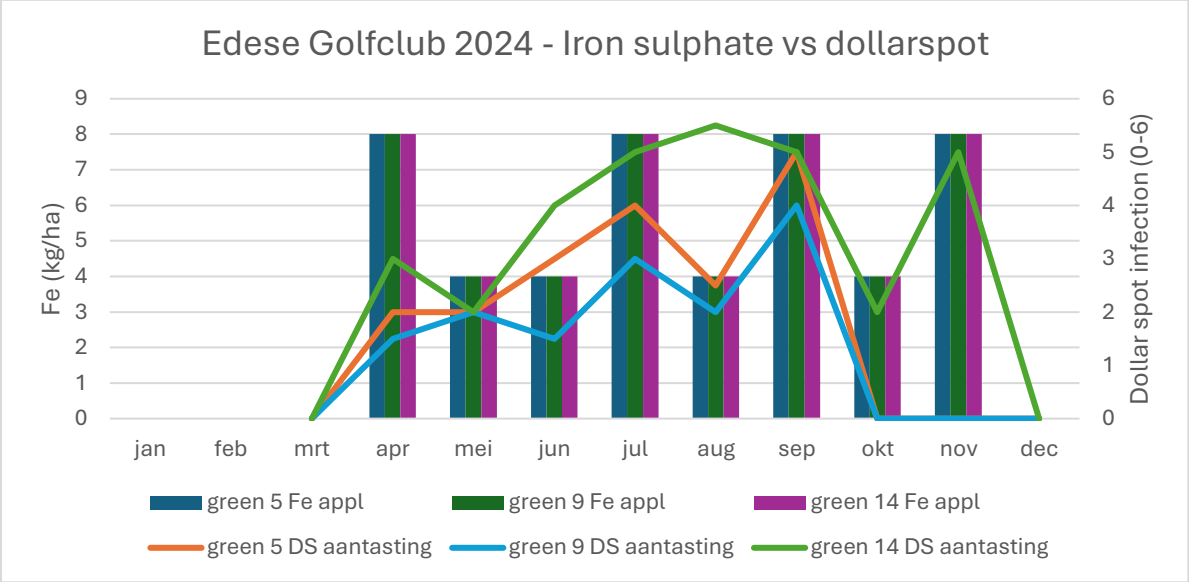


Figure 79. Iron applications vs. dollar spot development (2024)

E. Cultural practices

A notable feature of green management at Edese Golfclub is the absence of rolling during the first two monitoring years. The greenkeeper's rationale was that the fine sand fraction could lead to compaction and reduced infiltration following rolling. Rolling was only applied as a finishing operation after aeration.

Following the change in greenkeeping team in 2024, rolling was introduced under the new management regime.

Table 33. Overview of cultural practices: rolling, topdressing and aeration

	Frequency	Remarks
Rolling		
2022	0	—
2023	0	—
2024	3.1/week	29 applications
Topdressing		
2022	13×/year	~80 m³ total
2023	15×/year (~4 m³/event)	~60 m³ total
2024	12× (?)	~70 m³ total
Aeration		
2022	3× (12 mm deep); 1× (8 mm shallow)	>20 cm and 6 cm depth
2023	2× (12 mm deep) + 11× slit aeration	—
2024	3× (12 mm deep); 1× (8 mm)	>20 cm and 10 cm depth

No additional micronutrient fertilisation was reported beyond nitrogen and iron.

F. Playing quality

Greens were relatively soft during wet periods (Clegg <80 Gm). No strong correlation between Clegg values and dollar spot was found. Playing performance parameters (stimp, trueness and firmness/Clegg) are presented in Appendix 5.

Clegg values for greens 5, 9 and 14 are shown in:

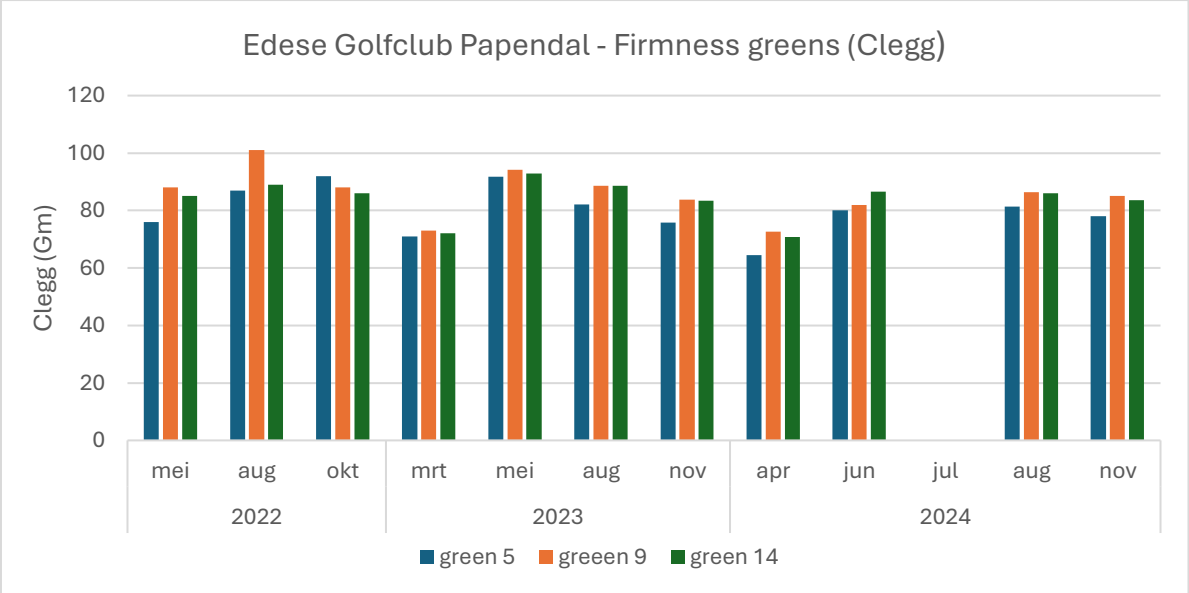


Figure 80. Clegg values over time

During wetter periods, greens tend to be soft (Clegg ≤80 Gm), resulting in longer moisture retention and increased leaf wetness duration. Although Clegg values were relatively low in the wet year 2024, no strong correlation between firmness and dollar spot was observed.

It should be noted that the greens were not rolled until 2024.

Insufficient data are available for stimp and trueness to determine any relationship with dollar spot.

G. Snow mold (*Microdochium nivale*)

Only green 9 showed minor symptoms of snow mould (or Microdochium patch) in autumn. No specific management measures were applied. The other greens did not show symptoms.

H. Conclusions

Edese Golfclub is one of the courses where green quality changed during the study.

- Green 5 shifted from “best” to “average”
- Green 9 improved from “average” to “best”

Average dollar spot scores:

- Green 5: 1.3
- Green 9: 1.2
- Green 14: 2.3 (moderate, remains the weakest green)

Up to and including 2023, performance was good. Green 14 remained a structural problem green.

A major factor was the transition in greenkeeping teams in January 2024, which had a direct impact on disease susceptibility and overall green quality. AHA de Man handed over responsibility to De Enk Golf & Groen. This had a direct impact on disease susceptibility and, consequently, on overall green quality—independent of the fact that 2024 was also the most disease-conducive year nationwide. In 2024, Edese Golfclub recorded an average dollar spot score of 3.0, meaning the course was affected **severely**. All damage thresholds were exceeded, and fungicides were ultimately applied.

The underlying cause appears to be:

- insufficient proactive management
- suboptimal timing of interventions

Use of the Smith-Kerns model with a lower threshold (12–15%) could significantly improve decision-making.

6. Golf & Country Club Geijsteren

Overview of dollar spot development

In 2022, dollar spot pressure at Geijsteren was low due to the application of multiple fungicide treatments. In the following years, no chemical crop protection products were used. This likely explains the relatively high level of dollar spot severity observed in the 2023 season.

In addition, the scoring approach of the greenkeeper should be considered. The assessment of disease severity was stricter than on other courses, while the damage threshold (i.e. the point at which fungicides would be applied) was not exceeded.

In 2024, in contrast to many other courses, infection levels were considerably lower and aligned with the national average.

Table 34. Average dollar spot severity at Golfclub Geijsteren in 2022, 2023 and 2024

	Green 6	Green 8	Green 17	National average DS severity
2022	0.9	0.8	0.0	1.0
2023	3.2	3.2	3.2	1.8
2024	1.8	1.7	1.5	1.5
Average (3 yrs)	2.5	2.4	2.1	

Appendix 3 presents graphs of Smith-Kerns predictions in relation to observed dollar spot severity. In both 2023 and 2024, visible dollar spot activity occurred at prediction levels below 15%.

A. Water management

The push-up greens at Geijsteren show a consistent pattern across all three monitored greens. Soil moisture levels measured during site visits were generally around or above 20% at both 0–6 cm and 6–12 cm depths.

Only in 2022 did values drop significantly below this threshold, although it is unclear whether this influenced disease development, as fungicides were applied that year.

For 2023 and 2024, soil moisture remained relatively stable around 20%, except during spring 2023. In that year, all greens with moisture levels below 20% showed increased dollar spot activity.

Despite high disease severity scores (3–4) in 2023, the damage threshold was not exceeded, and dollar spot was successfully managed through cultural practices.

In the variable and wet year of 2024, damage remained well under control, and no drought stress occurred at any point during the season.

Conclusion: Drought may have been a trigger in 2023. It was not a factor in 2024

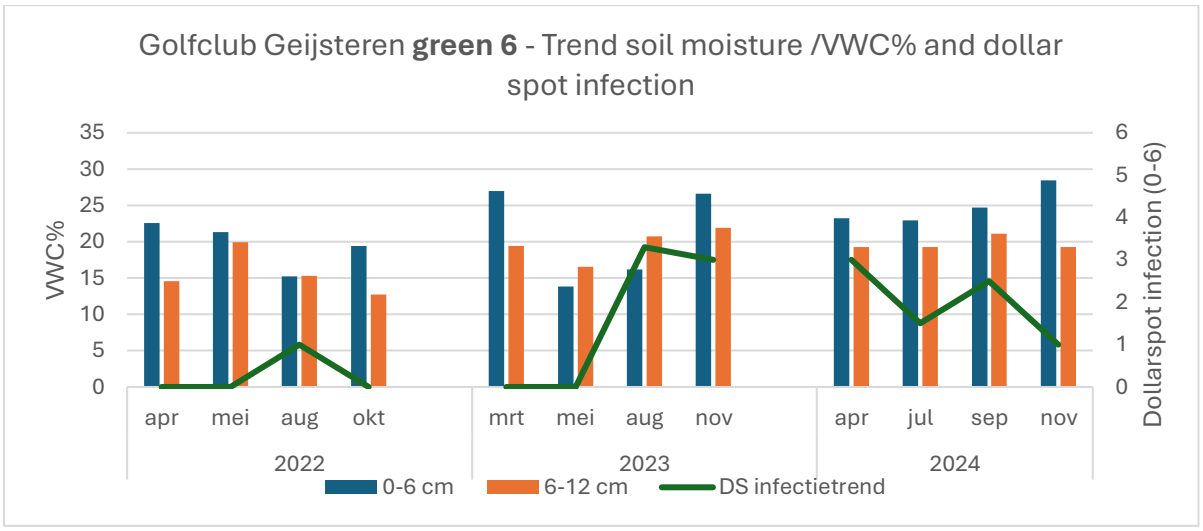


Figure 81. Soil moisture dynamics and dollar spot development – Green 6

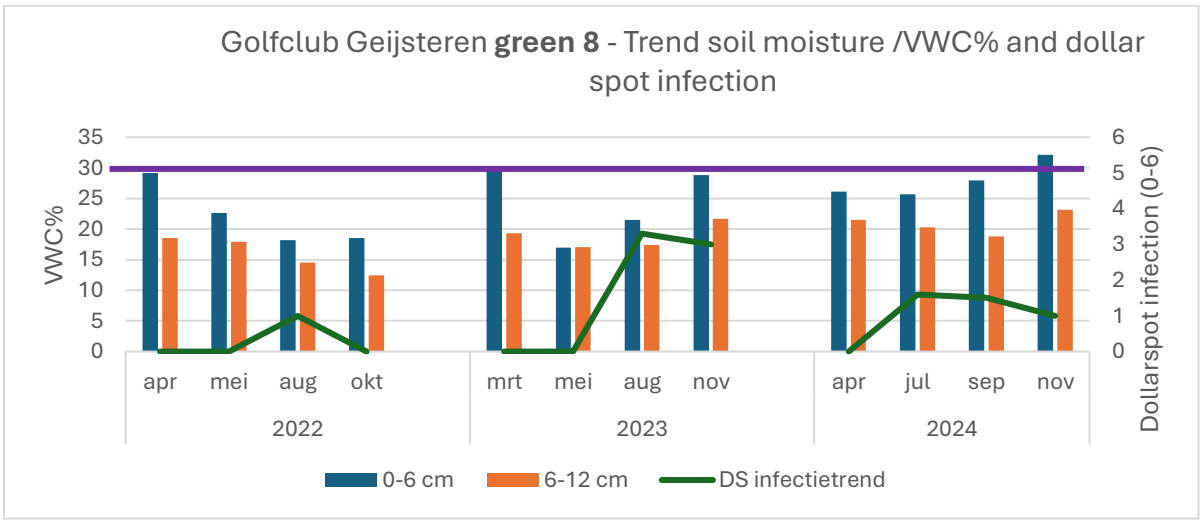


Figure 82. Soil moisture dynamics and dollar spot development – Green 8

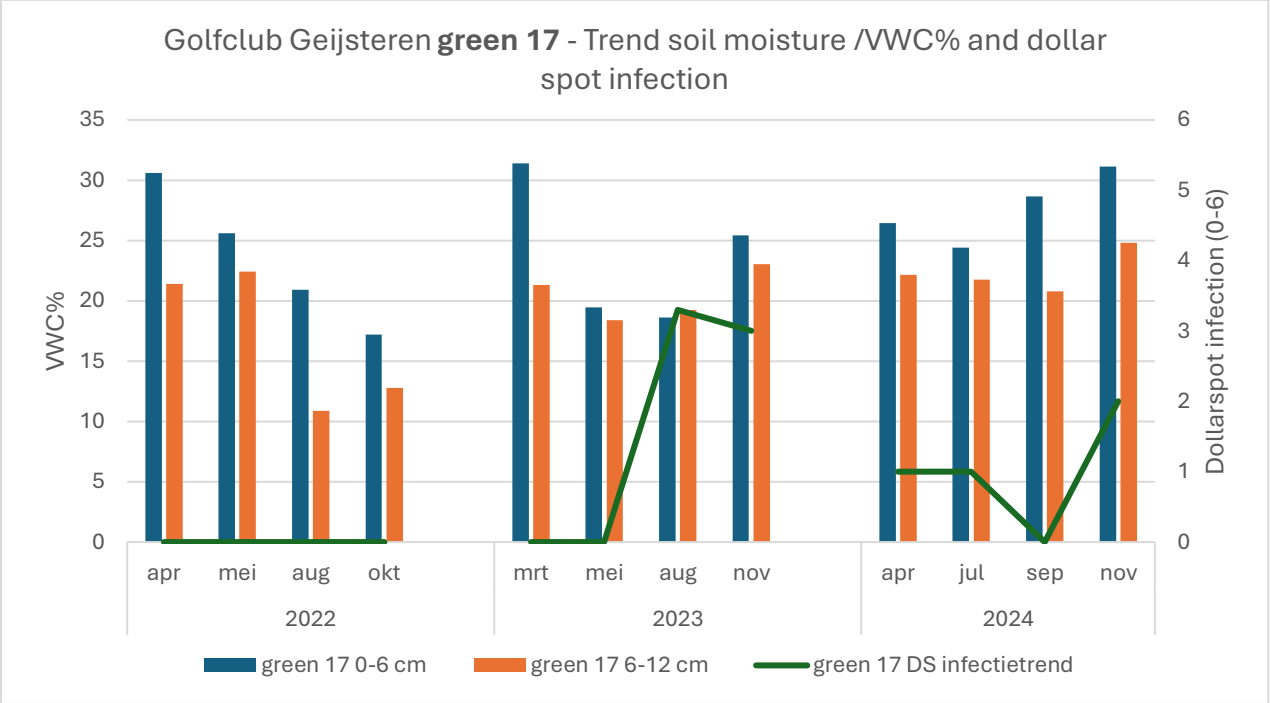


Figure 83. Soil moisture dynamics and dollar spot development – Green 17

The infiltration rate was relatively low for green 17 in the first year. However, measurements at 6 cm depth show that infiltration was very good for all greens.

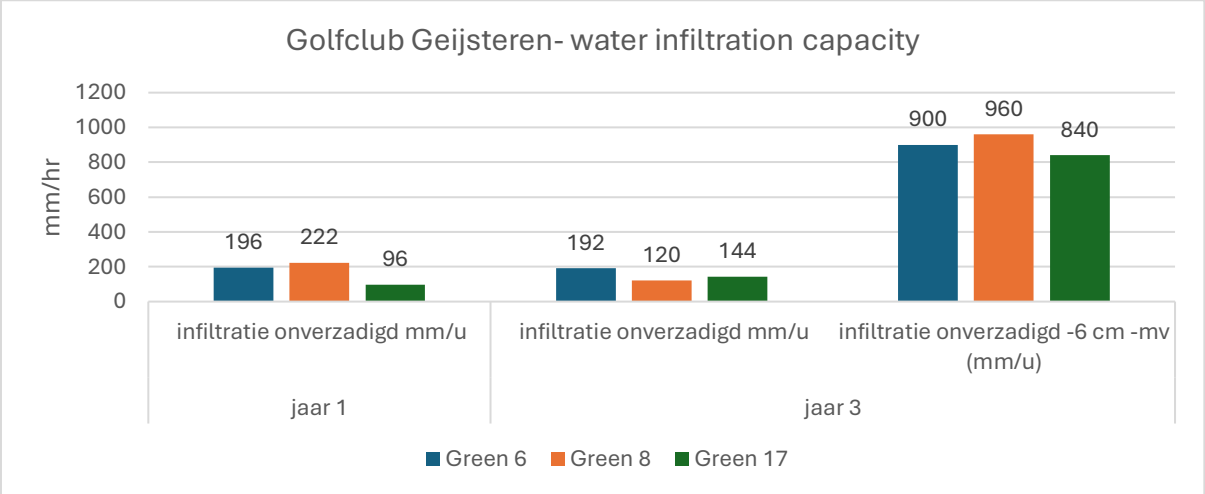


Figure 84. Average water infiltration capacity in years 1 and 3

B. Organic matter, C/N ratio and pH

Since 2022, organic matter content in the 0–2 cm layer has increased significantly. However, values in the 2–4 cm and 4–6 cm layers remain between 2.0 and 2.8%, which is insufficient to provide effective buffering capacity for the turf.

The C/N ratio increased from 7 to 9 on green 8 and from 8 to 10 on green 17

This indicates that organic matter breakdown exceeds accumulation.

The pH has remained relatively stable over the three-year period, ranging between 5.0 and 5.4.

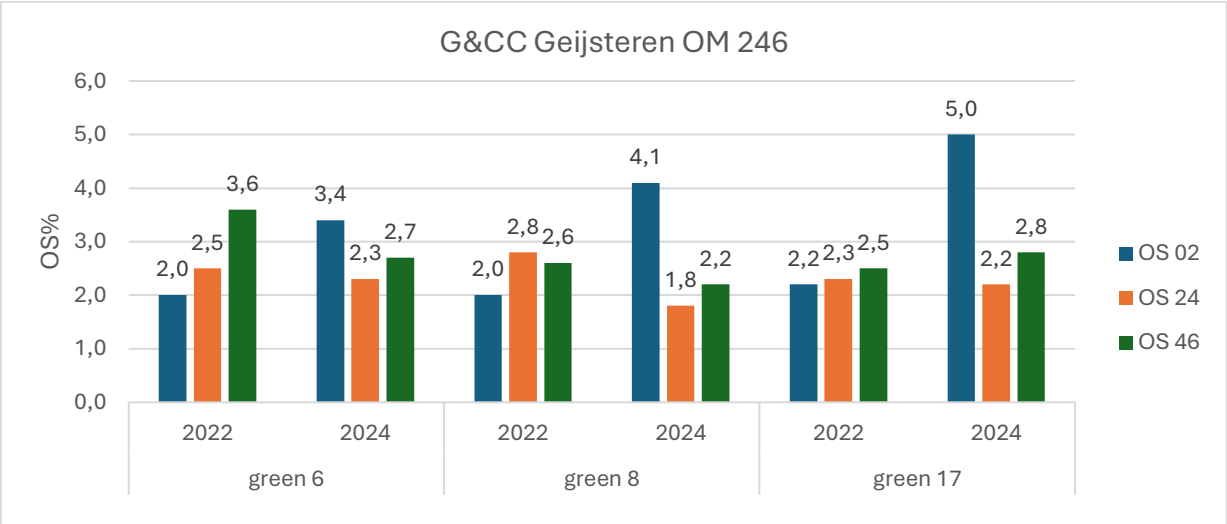


Figure 85. Organic matter development (0–2–4–6 cm) in years 1 and 3

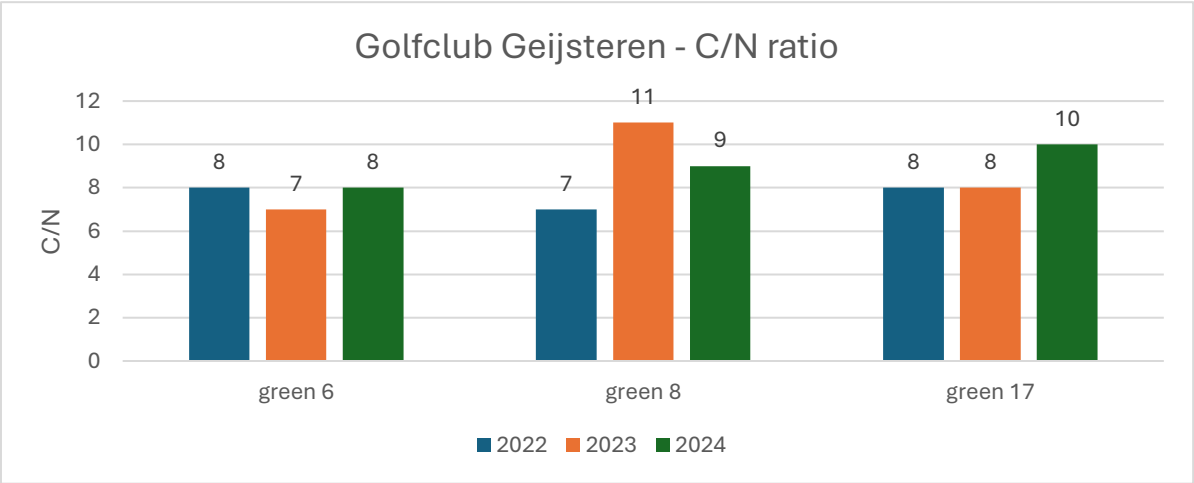


Figure 86. C/N ratios

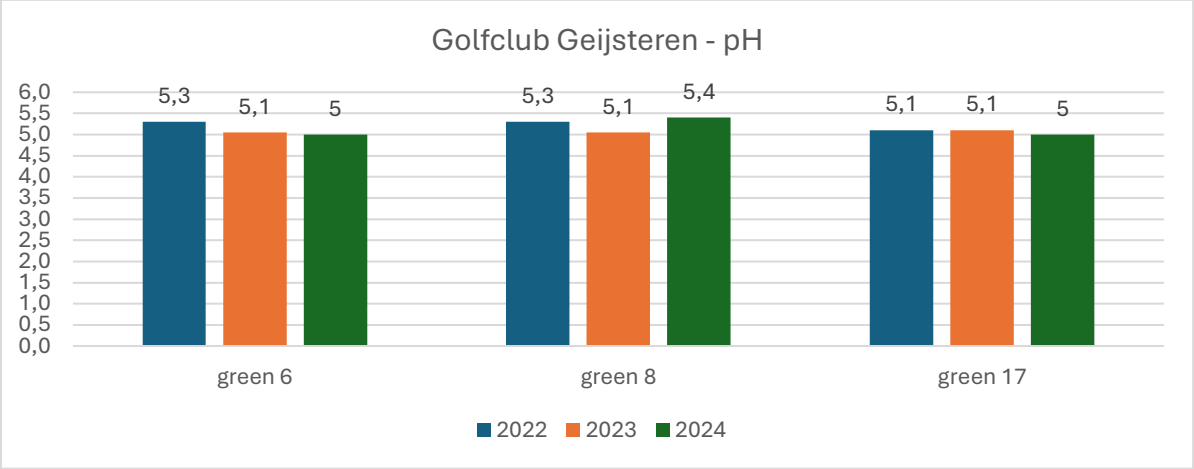


Figure 87. pH development

C. Turf composition and overseeding

At the start of the study (2022), the greens consisted of a mix of:

- *Agrostis capillaris* (browntop bentgrass)
- *Agrostis stolonifera* (creeping bentgrass)

Overseeding practices:

- spring and autumn: *A. capillaris*
- summer: blends of *A. stolonifera* cultivars

(Figure 88 shows the development of turf composition; note that "Agrostis" represents a mixture of both species.)

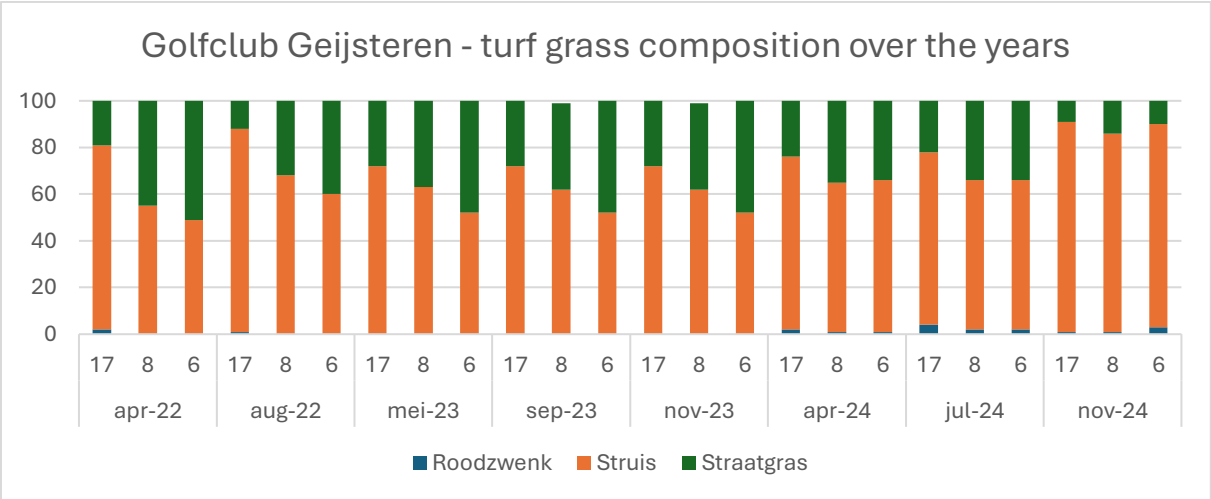


Figure 88. Turf composition development

Since 2024, overseeding has also included *Festuca rubra* (red fescue), particularly on the more drought-sensitive greens 6 and 8.

A reduction in *Poa annua* has also been observed, which is a positive development.

The full overseeding programme and seed mixtures are presented in Appendix 4.

D. Fertilisation: nitrogen and iron sulphate

Table 35. Nitrogen inputs in relation to dollar spot pressure at Geijsteren

	Total N (kg/ha)	National average N	DS severity (0–5)	National average DS
2022	74	79	0.5	1.0
2023	96	76	3.2	1.8
2024	76	88	1.7	1.5

In 2023, higher nitrogen inputs compared to 2022 did not reduce dollar spot severity. However, since the damage threshold was not exceeded, the greens remained playable.

This can be explained by the turf's recovery capacity, supported by adequate nutrient supply.

During both 2023 and 2024:

- nitrogen applications were used throughout the growing season
- this supported recovery and turf resilience
- overseeding required sufficient nutrient availability

Despite damage in late 2023, the greens entered winter 2024 in good condition. Early nitrogen applications in 2024 stimulated growth during a wet and stressful spring.

Although dollar spot became active early, severity remained limited (levels 2–3), maintaining good playability.

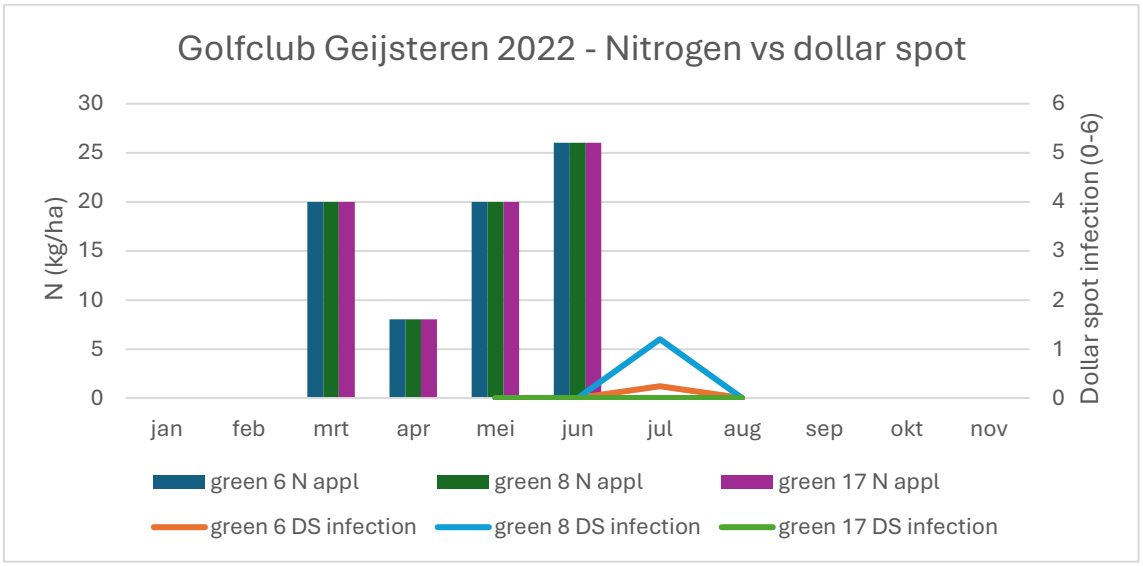


Figure 89. Nitrogen applications vs. dollar spot development (2022)

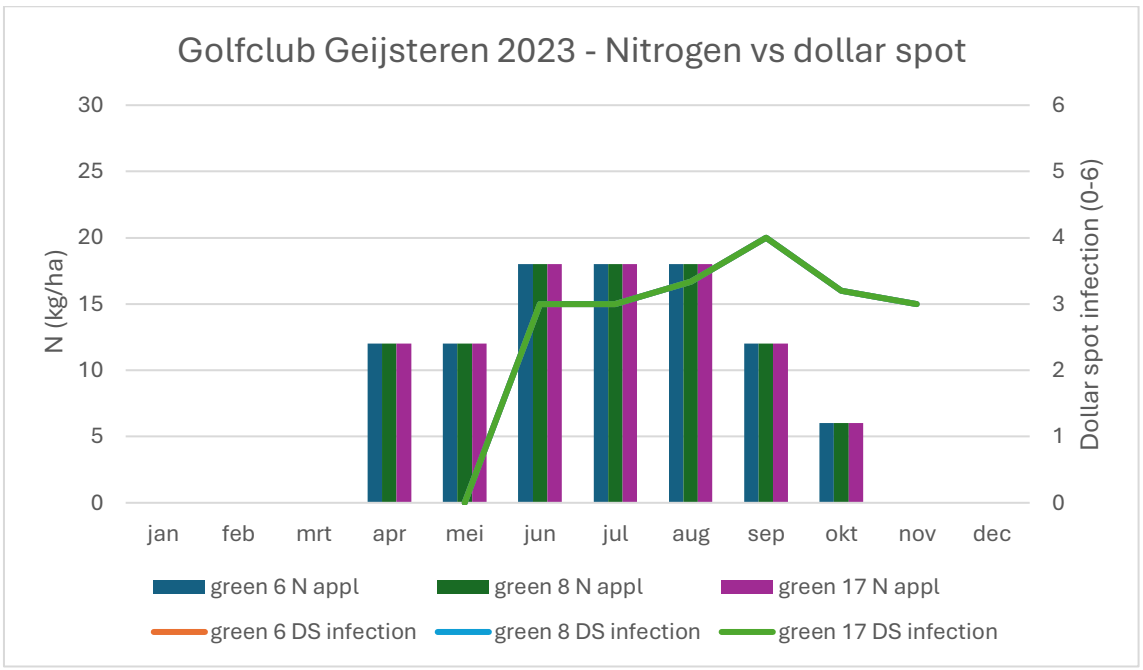


Figure 90. Nitrogen applications vs. dollar spot development (2023)

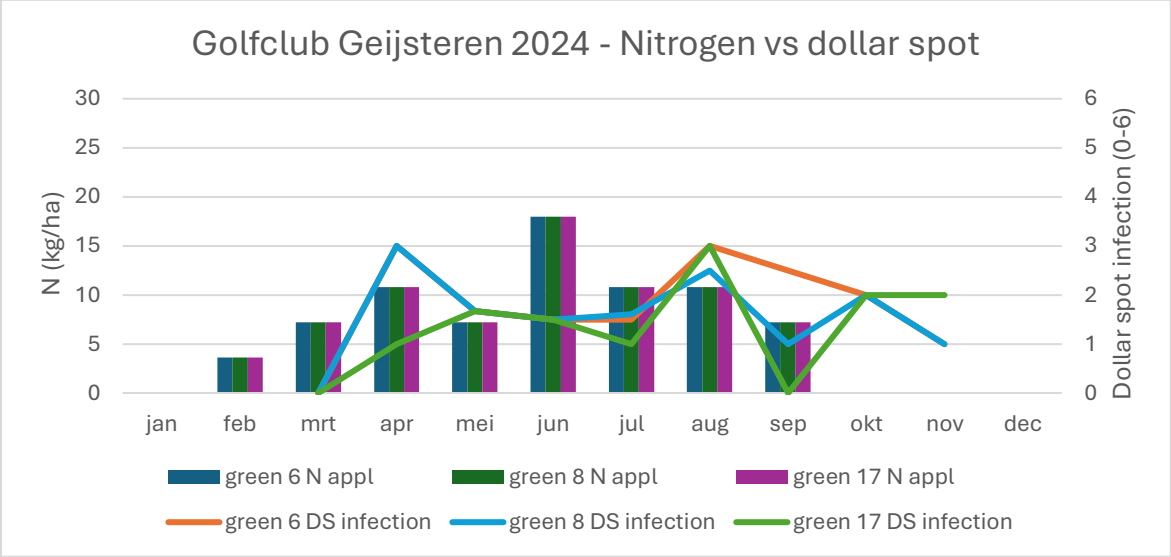


Figure 91. Nitrogen applications vs. dollar spot development (2024)

Iron sulphate use was initially low compared to the national average. In 2023 and 2024, applications increased but remained relatively modest overall.

Table 36. Iron sulphate inputs in relation to dollar spot pressure at Geijsteren

	Total Fe (kg/ha)	National average Fe	DS severity (0–5)	National average DS
2022	25	48	0.5	0.9
2023	41	47	3.2	1.7
2024	30	38	1.7	1.6

Iron applications were mainly carried out from summer onwards. As dollar spot damage tends to be more severe in the second half of the season, iron applications helped reduce peak severity.

The large application in July 2024 appears to have contributed significantly to reducing disease pressure.

Overall, nitrogen and iron inputs in 2023 and 2024 were effective in keeping dollar spot damage within acceptable limits.

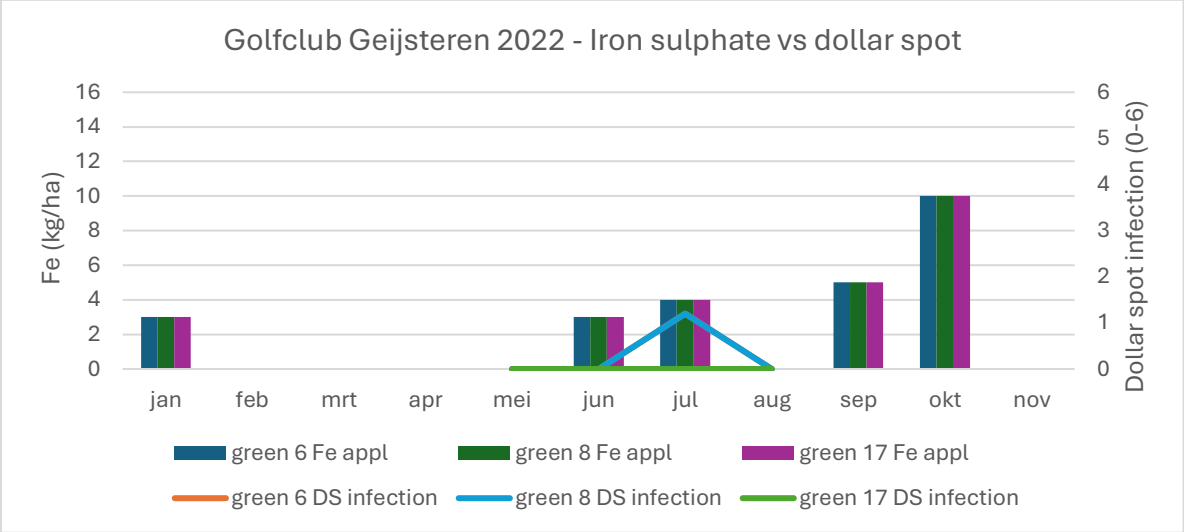


Figure 92. Iron applications vs. dollar spot development (2022)

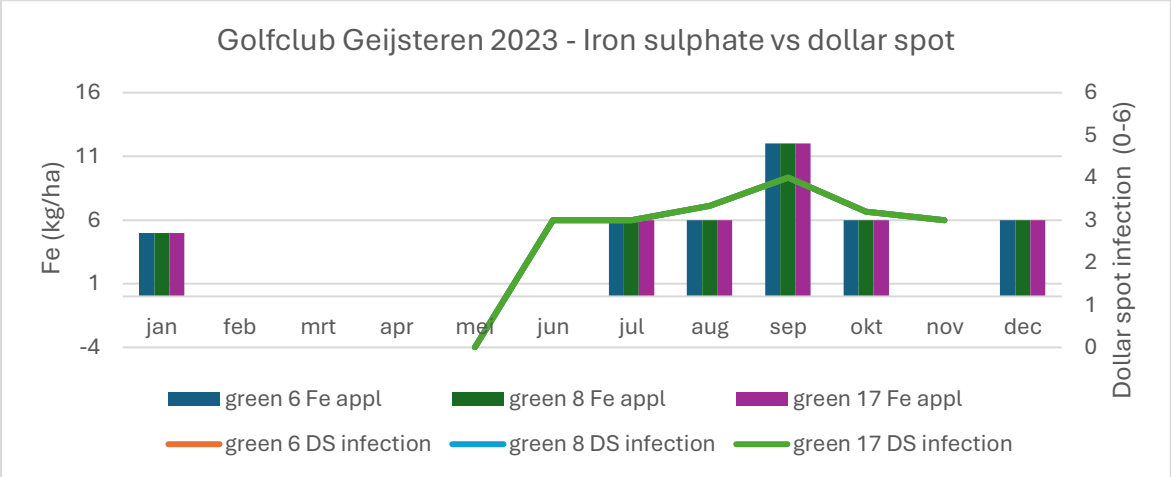


Figure 93. Iron applications vs. dollar spot development (2023)

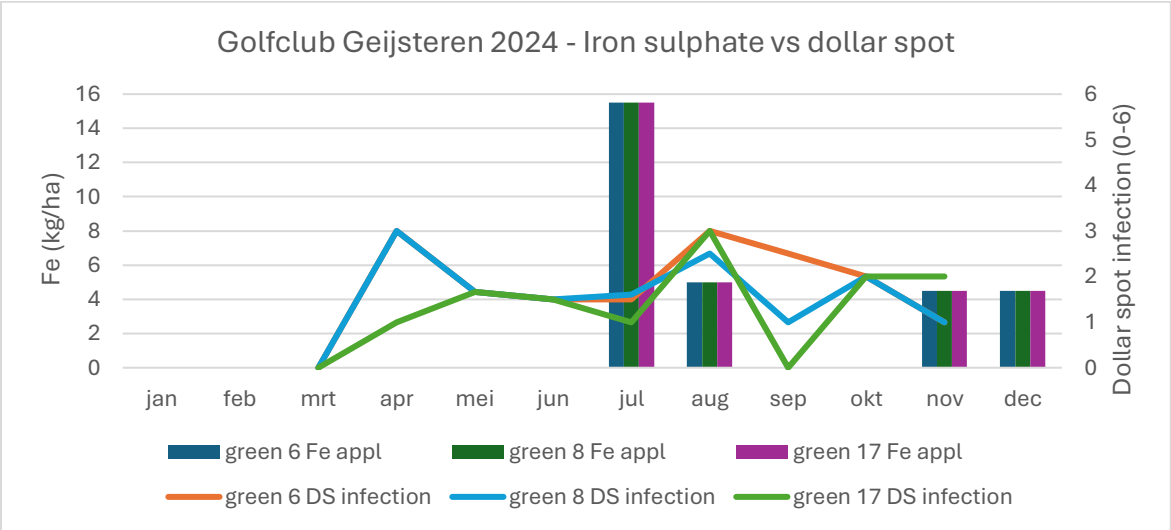


Figure 94. Iron applications vs. dollar spot development (2024)

E. Additional Best Management Practices

Fertilisation includes both liquid and granular applications, using products such as:

- Marathon
- Greenmaster NK
- BAS Foliar
- ammonium sulphate (2024)

Additional inputs (2023):

- Melgreen Mn
- Hakaphos Grün
- Vitanica Si
- Algaegreen

Table 37. Overview of cultural practices: rolling, topdressing and aeration

	Frequency	Remarks
Rolling		
2022	2×/week	Daily during tournaments
2023	1×/week	Daily during tournaments
2024	2×/week	Daily during tournaments
Topdressing		
2022	19×/year	~40–45 m³ total (15–20 m³ per event)
2023	12×/year	~50 m³ total (1× 25 m³ + 11× 2.5 m³)
2024	12×/year	~32.5 m³ total (11× 2.5 m³ + 1× 5 m³)
Aeration		
2022	6×/year	Various depths and diameters
2023	5×/year	Including deep aeration and shallow operations
2024	3×/year	Reduced frequency

For a graphical overview of annual sand volumes, see Appendix 6.

F. Playing performance

Playing performance parameters (stimp, trueness and firmness/Clegg) are presented in Appendix 5.

Clegg values for greens 6, 8 and 17 are shown in:

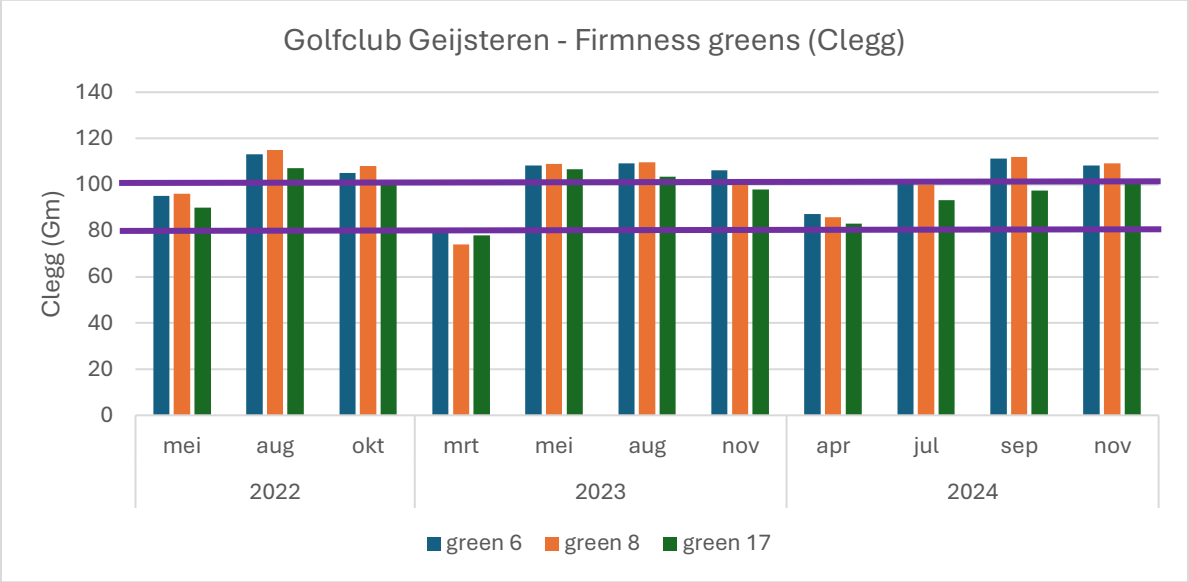


Figure 95. Clegg values over time

Insufficient data are available for stimp and trueness to determine any relationship with dollar spot occurrence.

G. Snow mold (*Microdochium nivale*)

The greens are relatively sensitive to snow mould. In 2022, severe infections occurred on greens 6 and 8 (severity scores 4–6), leading to two fungicide applications with Heritage.

In 2023 and 2024, all greens remained susceptible (scores 2–3), but the disease was effectively managed through:

- iron (sulphate) applications
- topdressing
- overseeding
- timely aeration (not too late in the season)
- balanced nitrogen fertilisation

Disease development is presented graphically in the appendix.

H. Conclusions

Over the full study period, the monitored greens scored:

- Green 6: 2.5
- Green 8: 2.4
- Green 17: 2.1

This represents a **moderate disease level**, but overall green quality has improved over time.

In 2022:

- dollar spot pressure was high but did not result in damage
- early fungicide application (Signum) in June prevented damage
- turf recovered well

In 2023:

- disease pressure increased significantly from summer onwards
- prolonged activity resulted in visible damage
- drought combined with low organic matter (2–6 cm) contributed
- longer leaf wetness on fine-leaved creeping bentgrass amplified the effect

From 2023 onwards:

- increased fertilisation and iron use
- combined with intensive overseeding
- improved turf resilience

As a result, fungicide use was avoided in 2023 and 2024.

The introduction of red fescue into the overseeding programme marks a further step towards improving integrated turf quality, sustainability and long-term resilience at Geijsteren.

7. Golf & Country Club Lauswolt



Additional hazards on Golf Course Lauswolt following excessive rainfall during the winter of 2023/2024
(photo: R. Ferdinands)

Dollar Spot Development

Golfclub Lauswolt does experience dollar spot, but in practice not—or only to a very limited extent—on the monitored greens. Throughout all monitoring seasons, infection levels remained at or below the national average and below the damage threshold. The most sensitive year was 2023, when the nationally observed pattern of sudden and severe infection in the (early) autumn was also reflected at Lauswolt.

Table 38. Average level of dollar spot infection at Golfclub Lauswolt in 2022, 2023 and 2024

Year	Green 4	Green 11	Green 17	National average DS
2022	0.2	0.2	0.3	1.0
2023	1.4	1.4	1.7	1.8
2024	0.7	0.7	1.3	1.5
Average	**0.6**	**0.6**	**0.9**	

Appendix 3 presents dollar spot predictions based on the Smith-Kerns model, plotted against observed disease activity and/or damage symptoms. A notable characteristic at Lauswolt is that dollar spot only becomes active at higher predicted probability levels than at other courses. While at most courses initial activity is observed below 15%, at Lauswolt this typically occurs only once probabilities exceed 20%.

A. Rootzone Water Management

With regard to soil moisture, green 11 stands out compared to greens 4 and 17. The differences between moisture levels at 0–6 cm and 6–12 cm are greatest here. This could represent a stress factor, although dollar spot infection levels do not directly reflect this. On greens 4 and 17, moisture distribution throughout the 0–12 cm profile is well balanced.

Overall, soil moisture management appears to be well under control and does not seem to be the decisive factor influencing higher or lower dollar spot pressure.

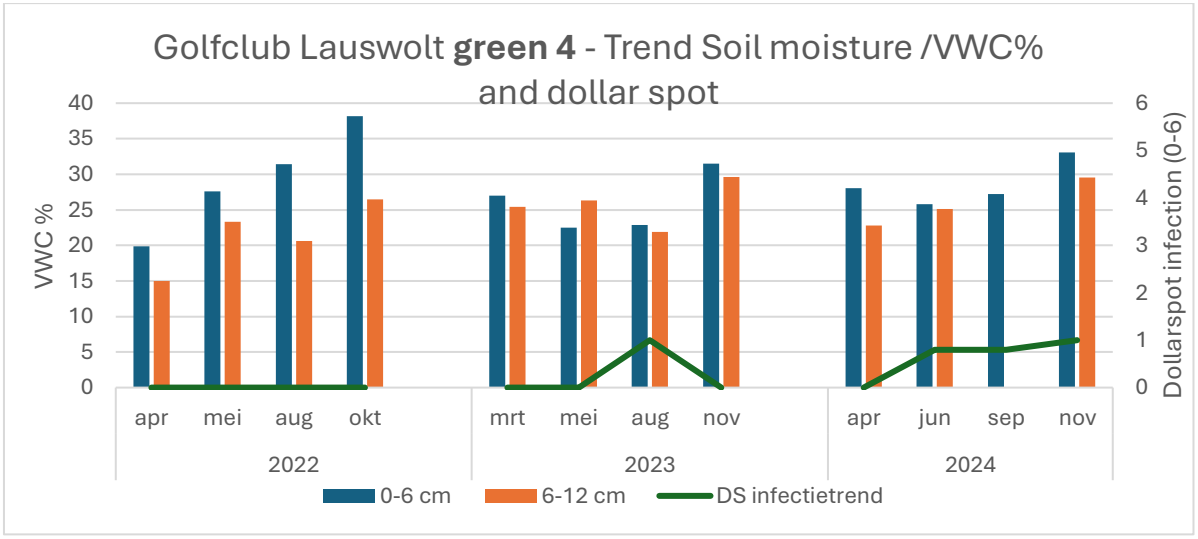


Figure 96: Soil moisture vs. dollar spot development – Green 4

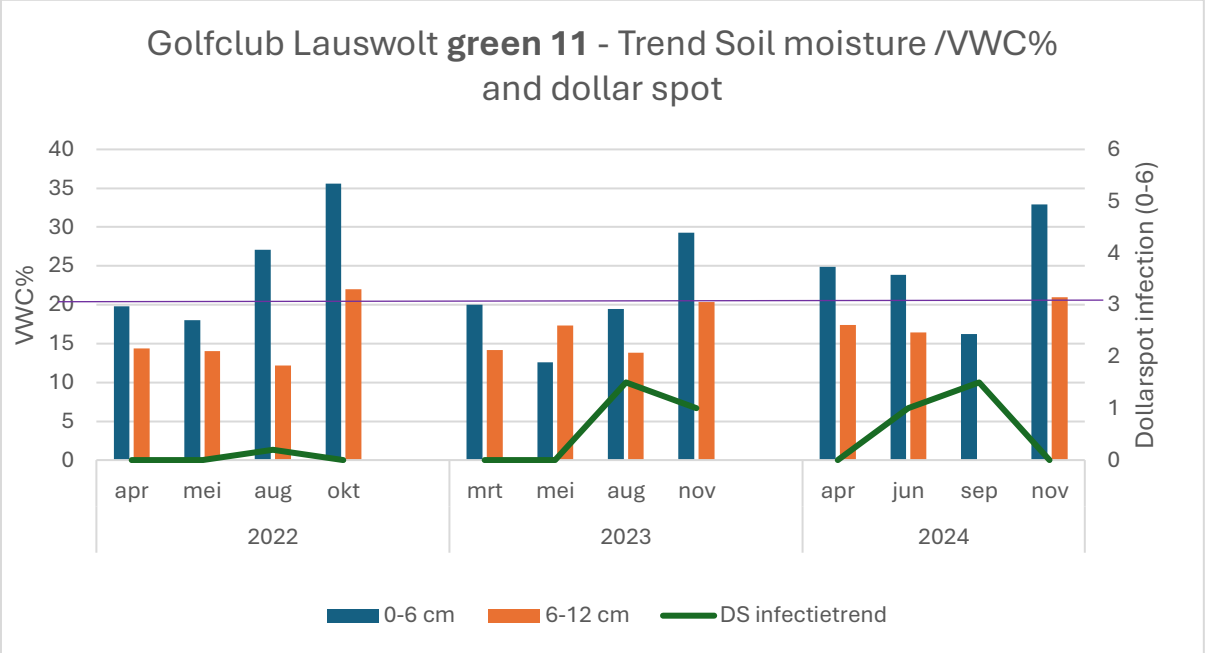


Figure 97: Soil moisture vs. dollar spot development – Green 11

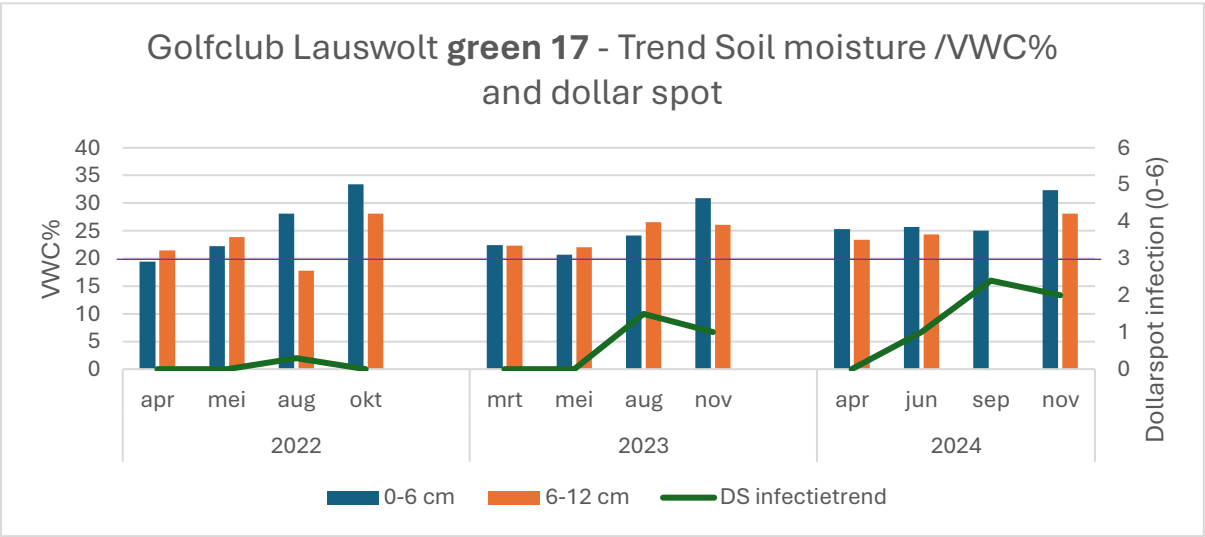


Figure 98: Soil moisture vs. dollar spot development – Green 17

The infiltration capacity declined during the study period. For green 17, infiltration at the end of the period dropped below the target value of 50 mm/hour. This may partly explain the higher soil moisture levels measured in the 0–6 cm and 6–12 cm layers.

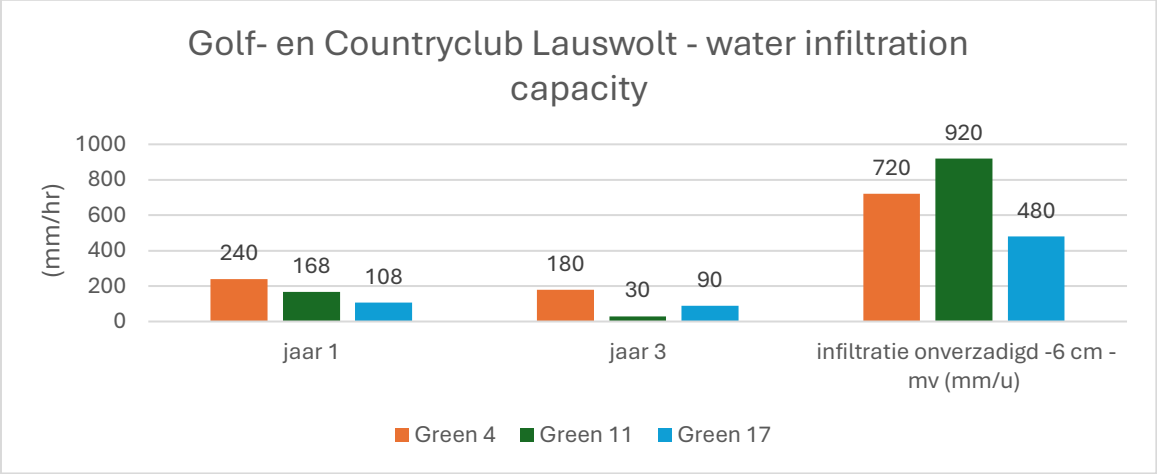


Figure 99: Average water infiltration capacity (Year 1 vs. Year 3)

B. Organic Matter and C/N Ratio

Organic matter content in the 0–2 cm layer increased during the study period for greens 4 and 11, while it decreased on green 17. Notably, organic matter levels at 2–4 cm and 4–6 cm declined on all greens compared with 2022.

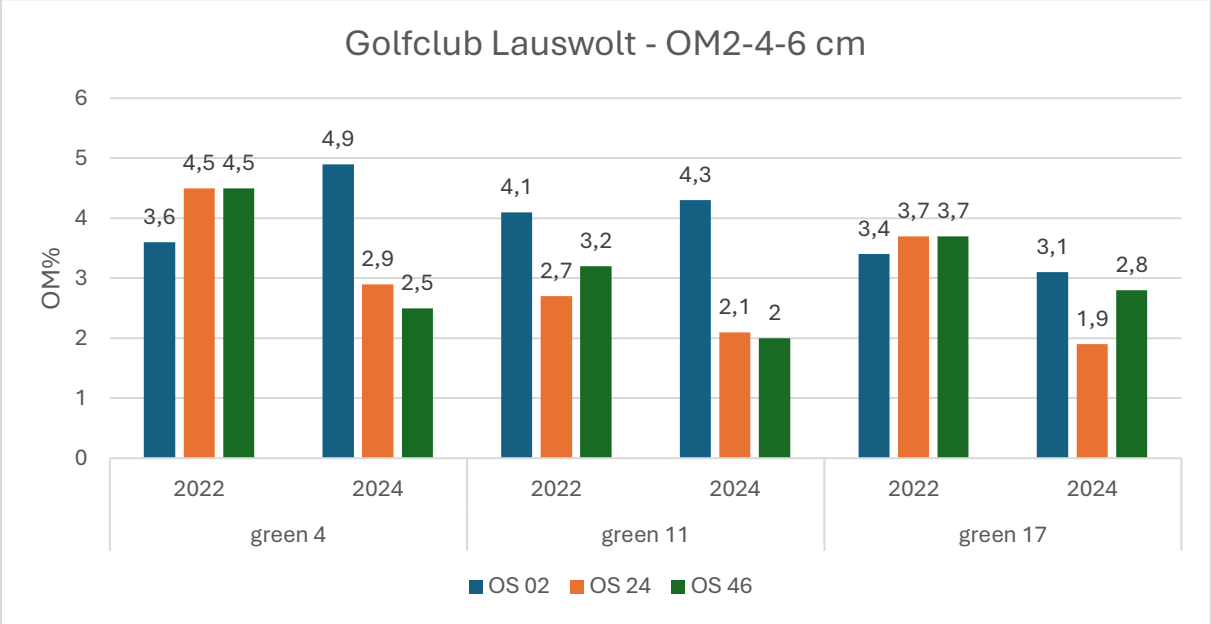


Figure 100: Organic matter (2–4–6 cm) development (Year 1 vs. Year 3)

The C/N ratio showed an increasing trend on green 17, indicating a relative accumulation of carbon and organic matter in the upper 0–6 cm layer. Based on only three seasons of data, it remains difficult to draw firm conclusions regarding C/N dynamics. Turf species composition also plays an important role in carbon accumulation. For example, green 4 contains a higher proportion of fine fescue than greens 11 or 17.

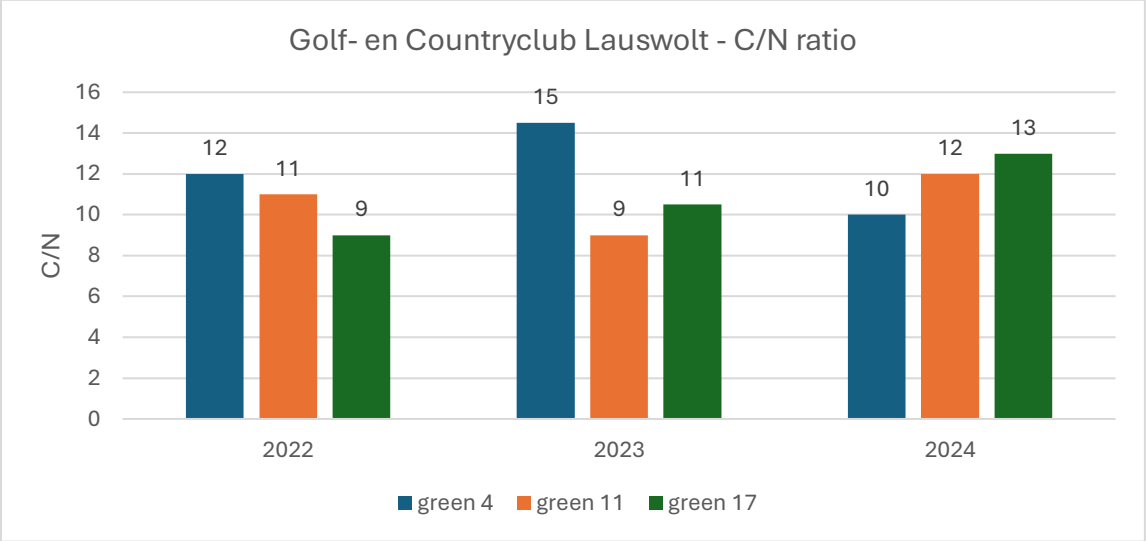


Figure 101: C/N ratios

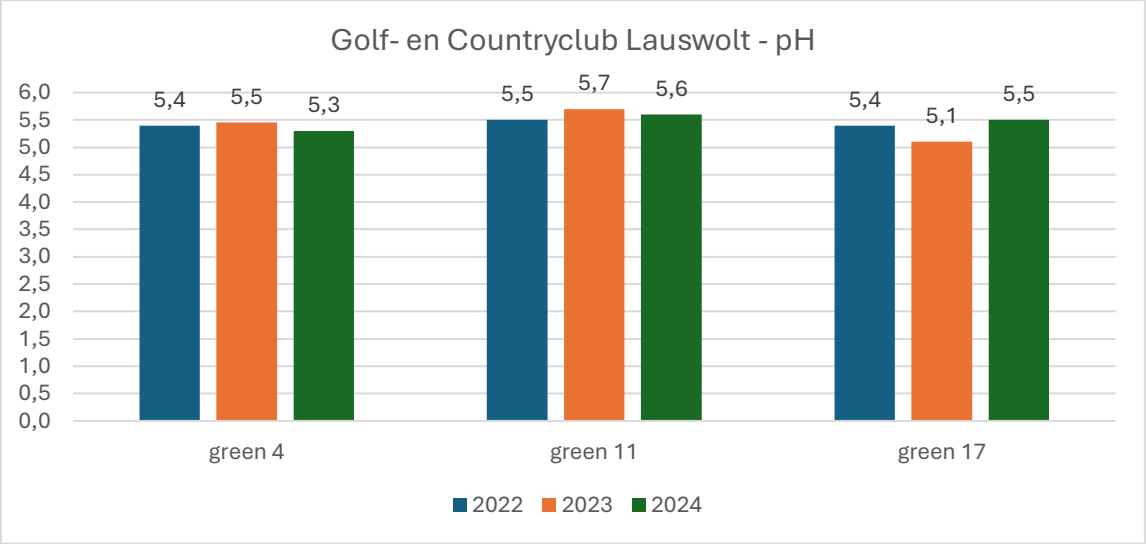


Figure 102: pH development

C. Turf Composition and Overseeding

The three monitored greens each have a distinct turf species composition. On greens 11 and 17, *Agrostis capillaris* (colonial bentgrass) is the dominant species. On green 4, *Festuca rubra* (fine fescue) dominates, with its share continuing to increase. *Poa annua* is mainly present on green 17.

The overseeding programme is identical for all greens. Each year, colonial bentgrass is overseeded twice (20 kg/ha), and once annually with a blend consisting of 100% common and slender creeping fine fescues (100 kg/ha). The ambition to increase fine fescue presence is clearly visible on green 11 and especially on green 4.

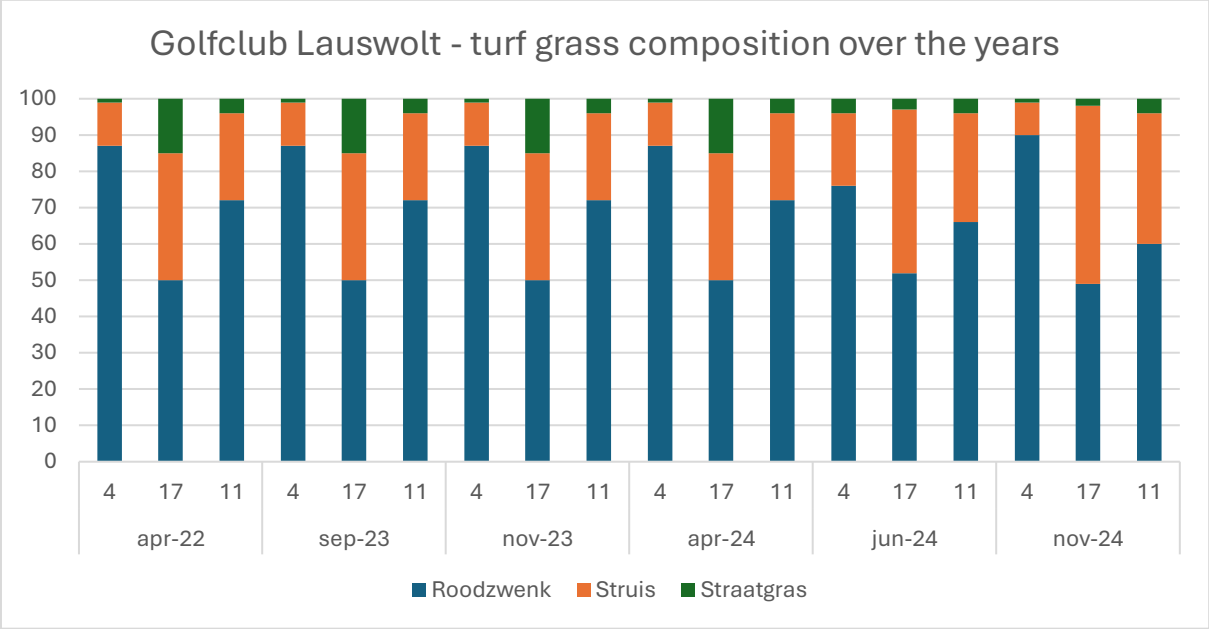


Figure 103: Development of turf composition

D. Fertilisation Programme: Nitrogen and Iron Sulphate

Nitrogen inputs at Lauswolt are consistently well below the national average of the twelve participating courses.

Table 39. Nitrogen inputs in relation to dollar spot pressure at Golfclub Lauswolt

Year	Total N (kg/ha) Lauswolt	National average N	Avg. DS pressure	National avg. DS
2022	54	79	0.6	0.9
2023	33	76	0.6	1.7
2024	40	88	0.9	1.6

In 2022, most nitrogen was applied early in the season. Dollar spot infections were extremely limited and did not result in damage. Weather conditions were also favourable, characterised by dry easterly winds and low relative humidity.

In 2023, nitrogen input was lower than in 2022 but applications were more evenly distributed throughout the year. In line with national trends, dollar spot pressure increased during summer but remained limited to activity/damage level 2. Following an exceptionally wet winter, dollar spot activity emerged earlier in 2024, yet regular nitrogen applications appear to have prevented more severe damage.

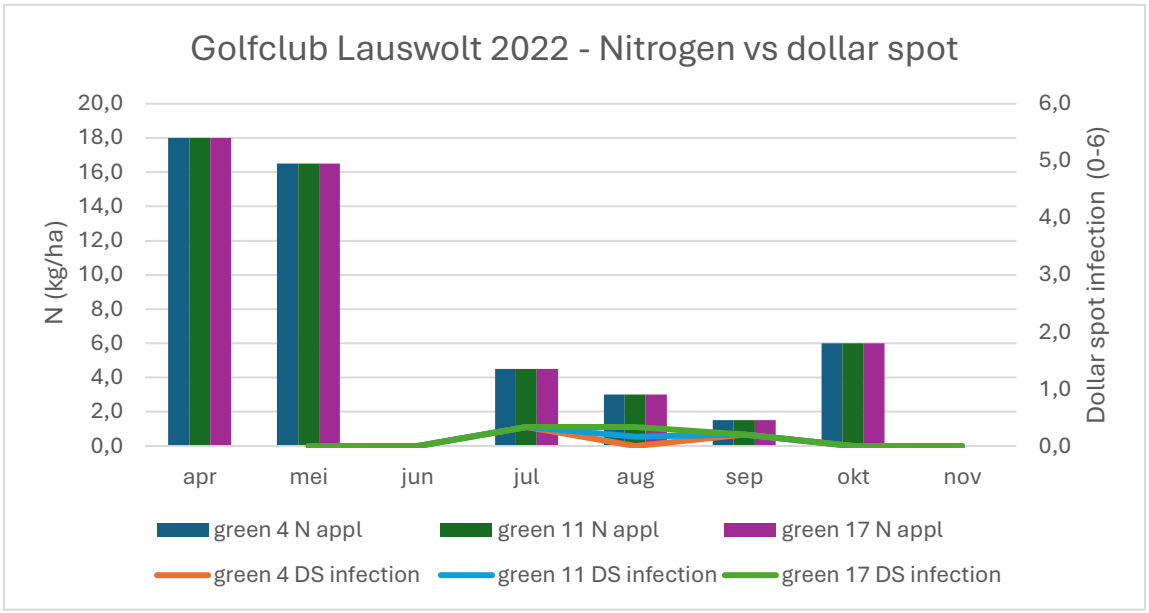


Figure 104: Nitrogen applications vs. disease progression (2022)

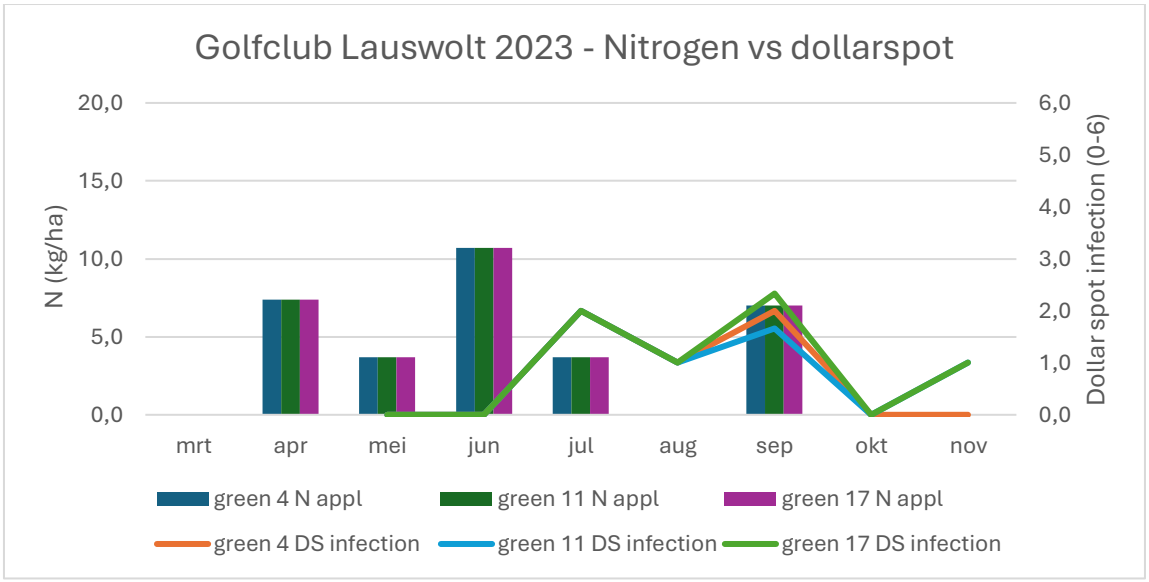


Figure 105: Nitrogen applications vs. disease progression (2023)

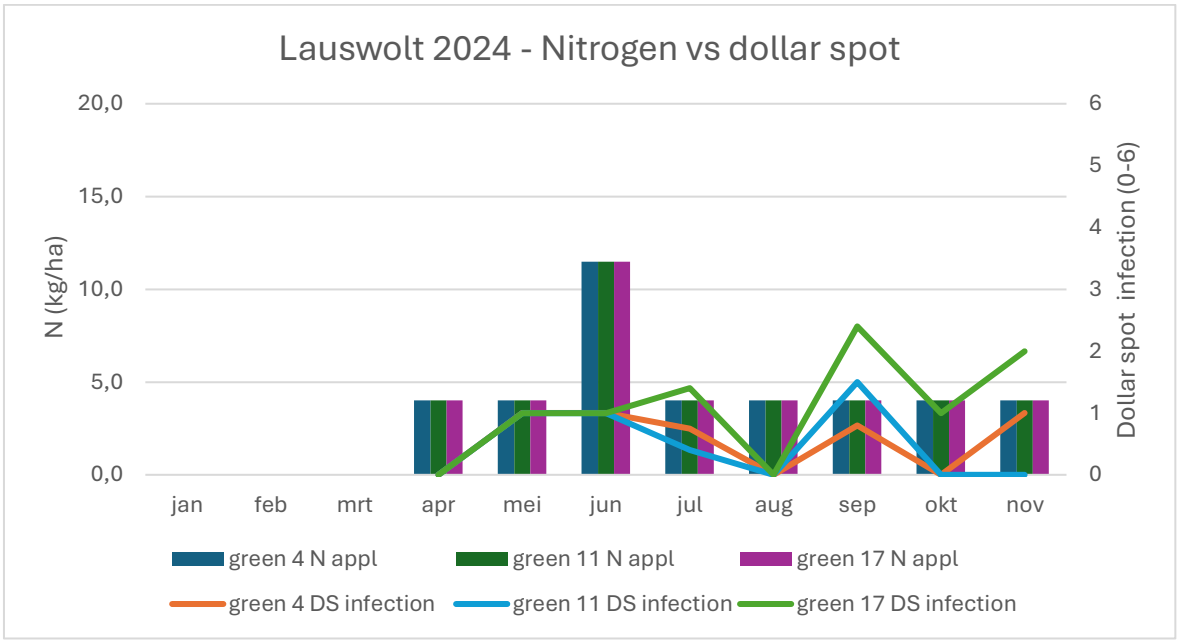


Figure 106: Nitrogen applications vs. disease progression (2024)

Iron sulphate use was below the national average in 2022 and above average in 2023 and 2024. Applications consisted partly of iron sulphate sprays and partly of granular lawnsand in autumn. Due to the wetter conditions in 2023 and 2024, iron inputs were increased.

Table 40. Iron sulphate use in relation to dollar spot pressure at Golfclub Lauswolt

Year	Total Fe (kg/ha)	National average Fe	Avg. DS pressure	National avg. DS
2022	33	48	0.6	0.9
2023	65	47	0.6	1.7
2024	50	38	0.9	1.6

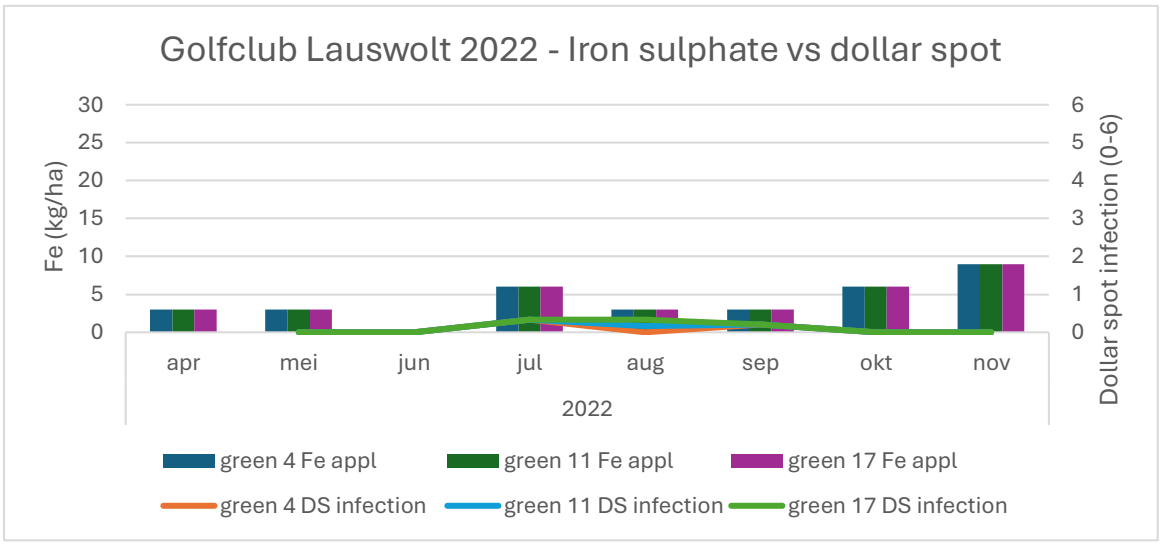


Figure 107: FeSO4 applications vs. disease progression (2022)

In 2023, lawnsand was applied three times in addition to small iron sulphate doses. Lawnsand is a granular product containing 9% iron and is applied at rates of 150–250 kg/ha. Its advantage is improved persistence during periods of intense rainfall, reducing iron losses through leaching.

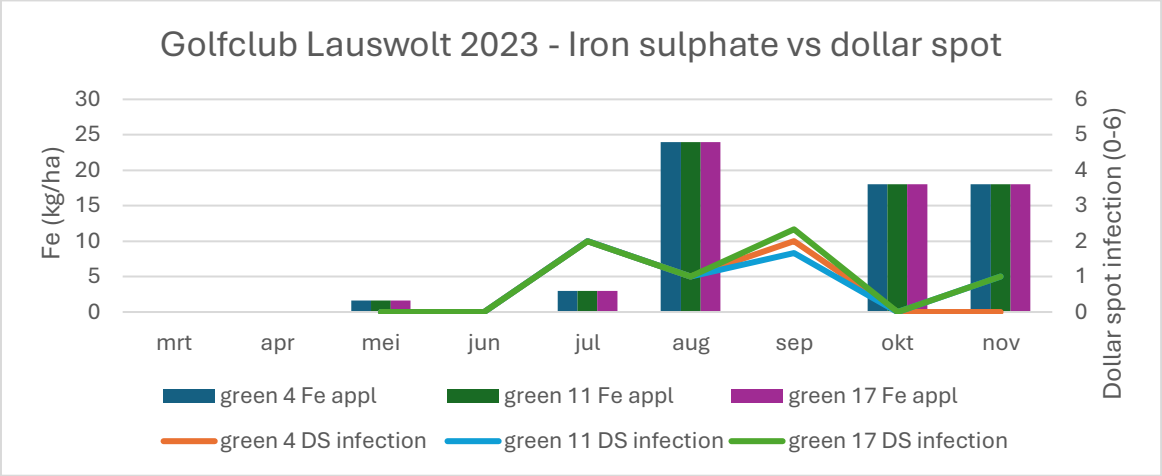


Figure 108: FeSO4 applications vs. disease progression (2023)

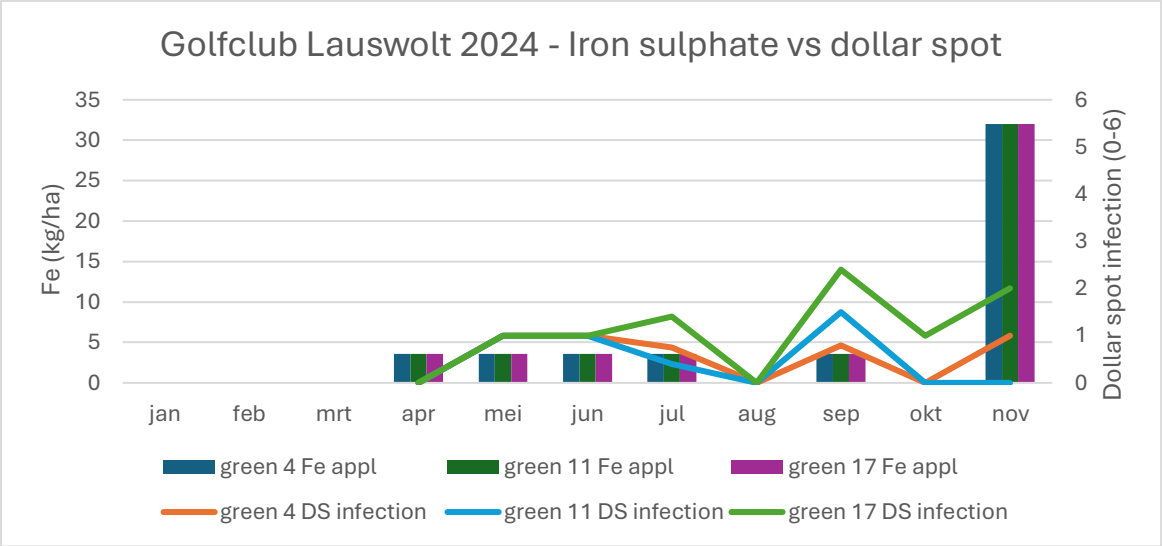


Figure 109: FeSO4 applications vs. disease progression (2024)

E. Cultural Practices: Rolling, Topdressing and Aeration

Mechanical maintenance practices are summarised below. A graphical overview of annual topdressing volumes is provided in Appendix 6.

Table 41: Maintenance practices (rolling – topdressing – aeration)

	Frequency	Remarks
Rolling 2022	0.5× per week	8 weeks
Rolling 2023	1× per week	17 weeks
Rolling 2024	1× per week	31 weeks
Topdressing 2022	74 m³/ha	7 applications
Topdressing 2023	60 m³/ha	5 applications
Topdressing 2024	50 m³/ha	6 applications
Aeration 2022	3× solid tines	6 mm / 12 cm
Aeration 2023	2× solid tines	8 mm / 12 cm
Aeration 2024	1× solid tines	8 mm / 12 cm (deep aeration in winter)

F. Playing Quality

Clegg hammer measurements for greens 4, 11 and 17 generally fell within the target range of 80–100 gravimeters. A weak correlation between Clegg values and dollar spot pressure was found on green 4, indicating that additional data are required before reliable conclusions can be drawn.

Playing performance metrics (stimp, trueness, Clegg hardness) are presented in Appendix 5.

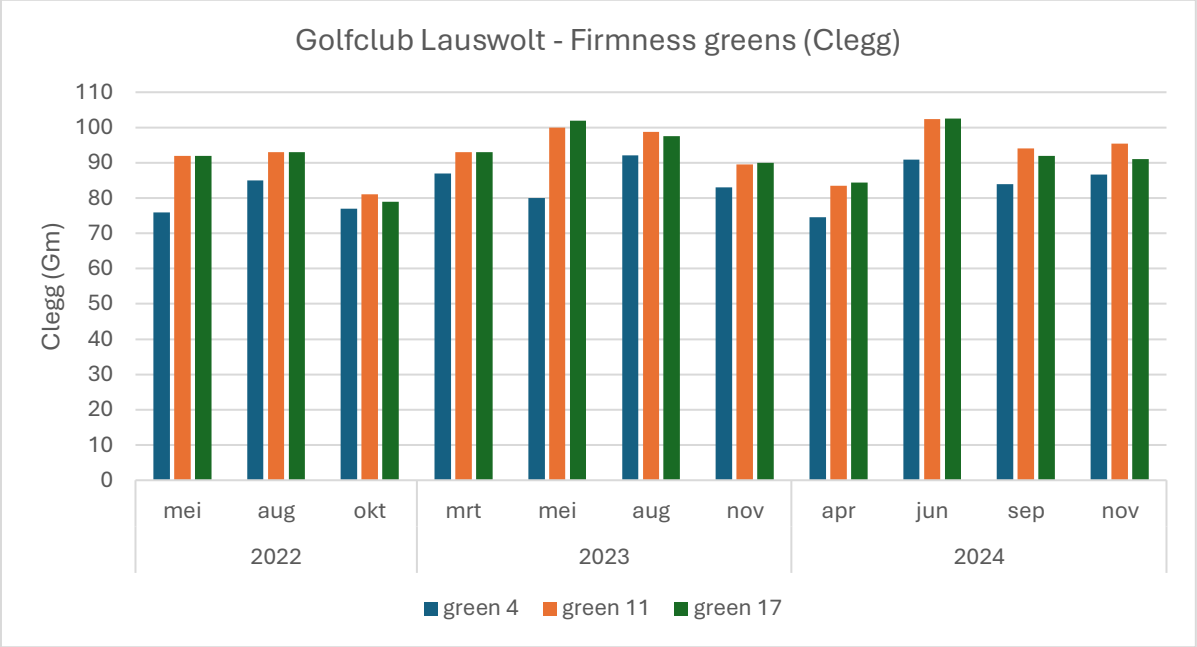


Figure 110: Clegg values over time

Insufficient data were available for stimp and trueness to assess relationships with dollar spot development.

G. Snow mold (*Microdochium nivale*)

Throughout the three monitoring seasons, all greens regularly exhibited light Microdochium patch infections (scores 1–2). Routine preventive practices—such as topdressing, overseeding and iron sulphate applications—generally prevented disease escalation.

In September 2024, more widespread summer Microdochium infections were observed on greens 11 and 17 (score 3). During the November 2024 assessment, disease pressure had already declined substantially, partly due to the application of lawnsand.

For a complete overview of assessments, see Appendix 12.

H. Conclusions

With scores of 0.7 for greens 4 and 11 and 1.0 for green 17, dollar spot pressure across the study years can be classified as very low to low. The most sensitive year was 2023, when scores approached level 2 (moderate). This was effectively anticipated and mitigated through evenly distributed nitrogen and iron sulphate applications, preventing serious damage.

During peak dollar spot activity in September and October, additional iron fertilisation and topdressing had already been implemented. Although fungal activity emerged early in 2024, the number of mechanical interventions (topdressing and aeration) was reduced compared with previous years. A “low disturbance” approach forms part of Lauswolt’s management strategy, particularly suited to greens with a high proportion of fine fescue.

Despite—or perhaps because of—this reduced disturbance regime, dollar spot pressure declined substantially on greens 4 and 11. On green 17, which contains less fine fescue, some residual symptoms persisted.

It is also important to note that dew irrigation introduced from summer 2024 onwards appears to have had a beneficial effect in suppressing dollar spot. Additional monitoring years will be required to further quantify and confirm this effect.

8. The Links Valley Golf



Irrigation on green 2 *(photo: M. de Bruijne)*

Dollar Spot Development

During the study period, The Links Valley Golf shows a positive development with respect to dollar spot infections. While the course scored above the national average in 2022, results improved in subsequent years and a clear favourable trend became visible.

Table 42. Average level of dollar spot infection at The Links Valley Golf in 2022, 2023 and 2024

Year	Green 2	Green 6	Green 9	National average DS
2022	1.3	1.3	1.3	0.9
2023	1.0	1.1	1.1	1.7
2024	0.9	0.9	1.0	1.6
Average	**1.0**	**1.0**	**1.1**	

The monitored greens at Links Valley appear relatively insensitive to variable weather conditions and the associated stress on the turf plant. Across all seasons, there is almost continuous dollar spot activity, yet it remains consistently limited.

A. Water Management

All monitored greens at The Links Valley are characterised by (very) high soil moisture levels in the 0–6 cm layer, ranging from around 20% in dry periods to more than 35% under wetter conditions. The 6–12 cm layer shows moisture levels generally between 10% and 15%.

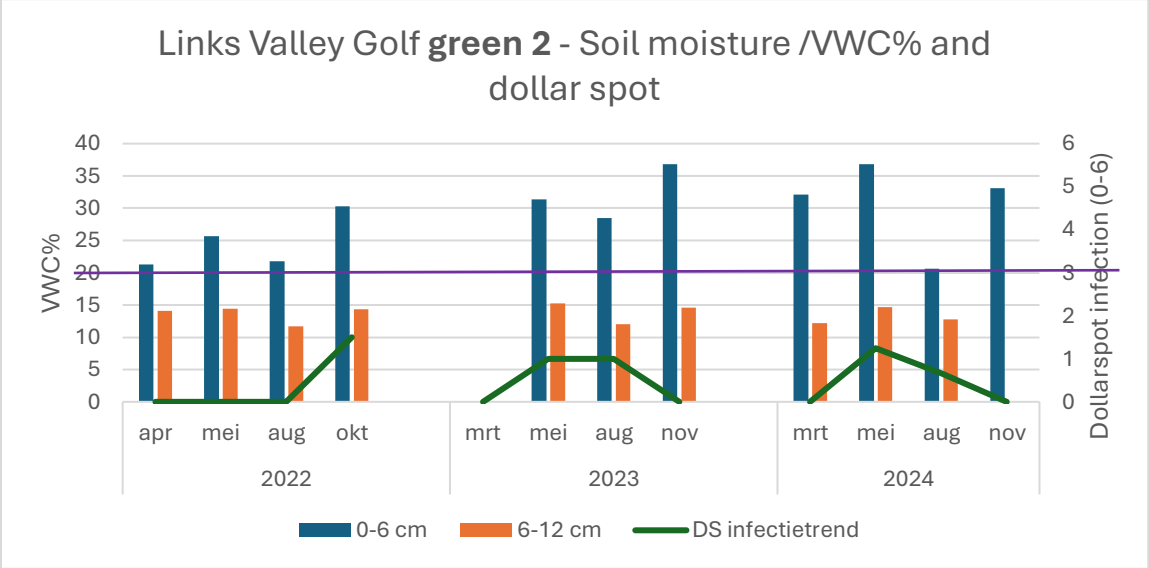


Figure 111: Soil moisture vs. dollar spot development – Green 2

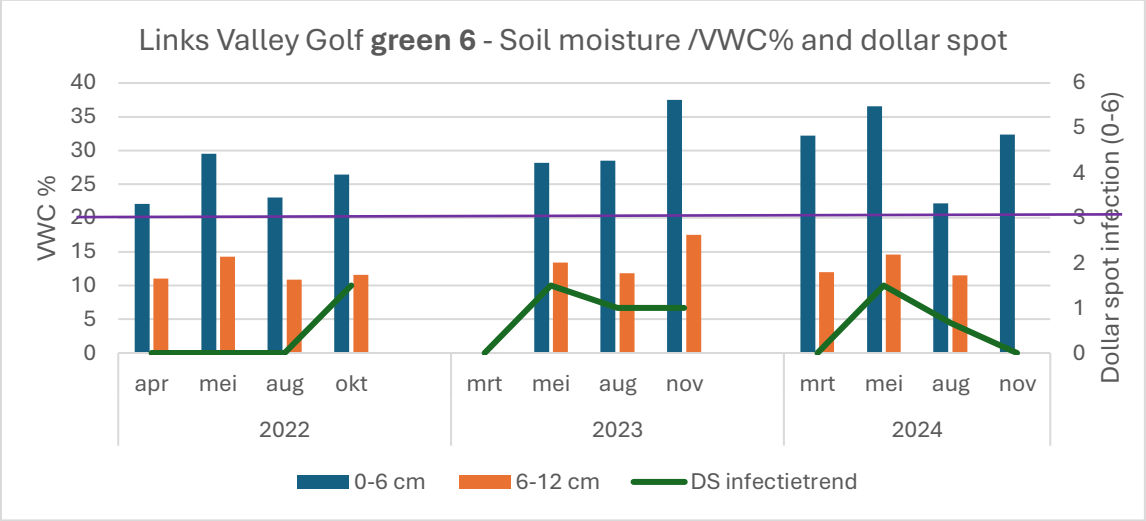


Figure 112: Soil moisture vs. dollar spot development – Green 6

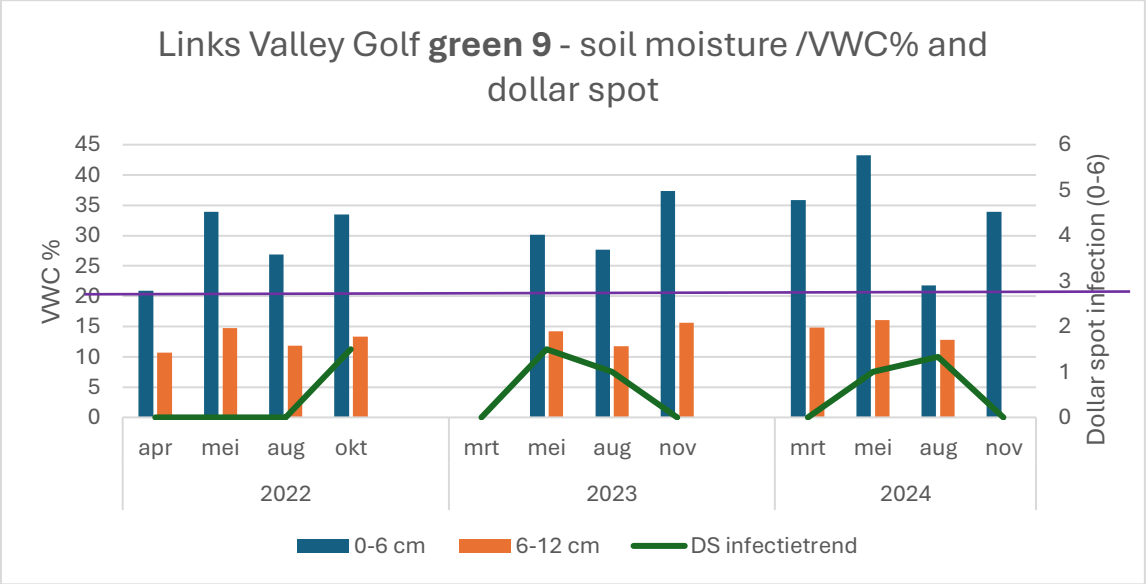


Figure 113: Soil moisture vs. dollar spot development – Green 9

Figure 114 shows the water infiltration capacity of the greens. In 2022, greens 6 and 9 met the target standard of 50 mm/hour, but just over two years later none of the greens met this standard anymore, with infiltration values not exceeding 42 mm/hour. This also explains the high moisture levels observed in the upper 0–6 cm layer. However, from 6 cm depth onwards, water is drained extremely rapidly, with infiltration rates of 4200 mm/hour and higher.

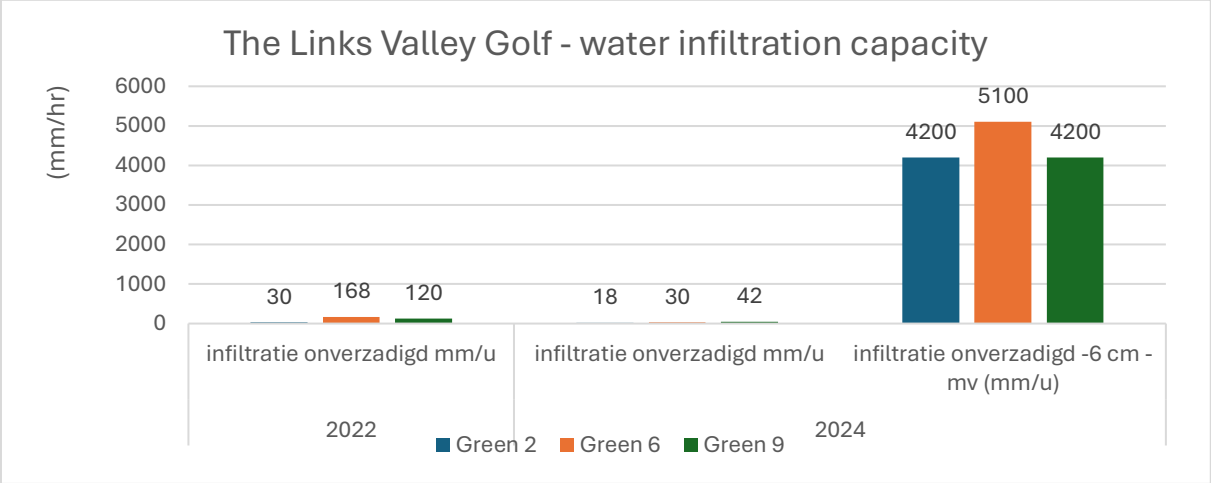


Figure 114: Average water infiltration capacity in years 1 and 3

B. Organic Matter (2–4–6 cm), C/N Ratio and pH

Differences in infiltration performance in the upper rootzone are reflected in organic matter content measured at 0–2, 2–4 and 4–6 cm. For all greens, the contrasts between 0–2 and 4–6 cm are substantial. While in 2022 organic matter at 2–4 cm was still below 2%, it increased by 2024 to above 2%. At 4–6 cm, the increase was much more limited.

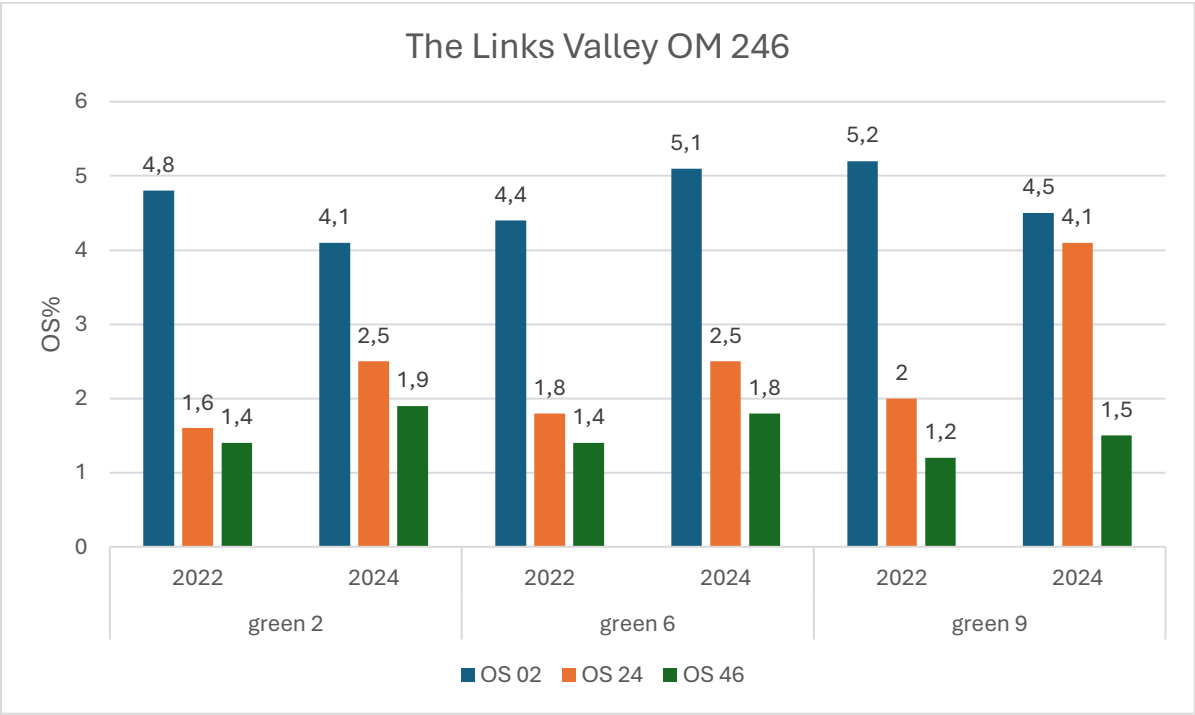


Figure 115: Organic matter (2–4–6 cm) development (Year 1 vs. Year 3)

Another noteworthy development is the increase in thatch thickness (see Appendix 7), where a strong correlation was found with dollar spot severity: a thicker thatch layer corresponds with lower observed dollar spot infection levels.

For the C/N ratio, greens 2 and 6 show a decrease after three seasons, while green 9 remains more or less stable. This indicates less carbon accumulation within organic matter and increased bacterial activity breaking down organic material. Frequent cultivation with the Maredo unit—aimed at incorporating more sand into the upper 6 cm—appears to contribute significantly to this process.

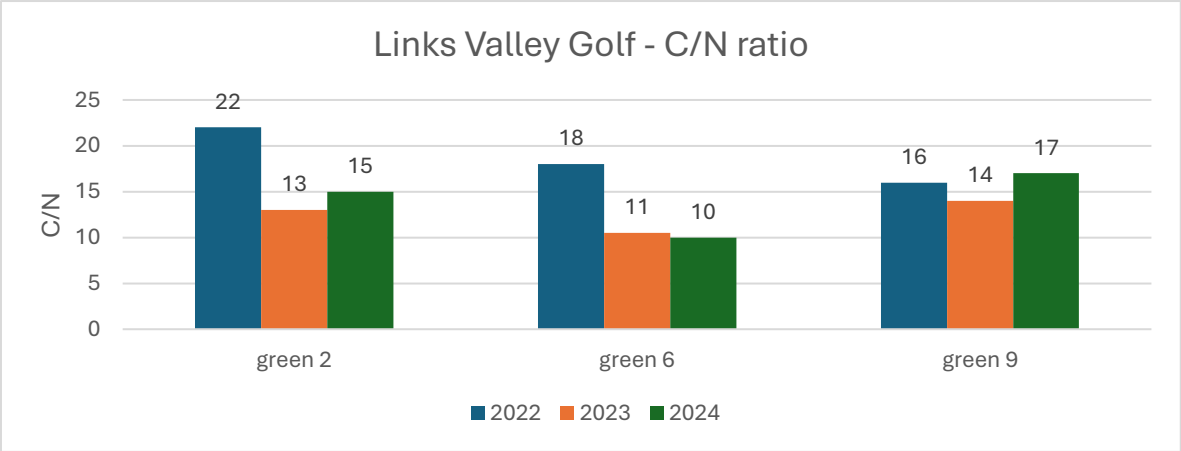


Figure 116: C/N ratios

The pH remained stable for greens 2 and 6 (5.2 and 5.4 respectively). Green 9, however, increased from pH 4.7 in 2022 to pH 5.4 in 2024.

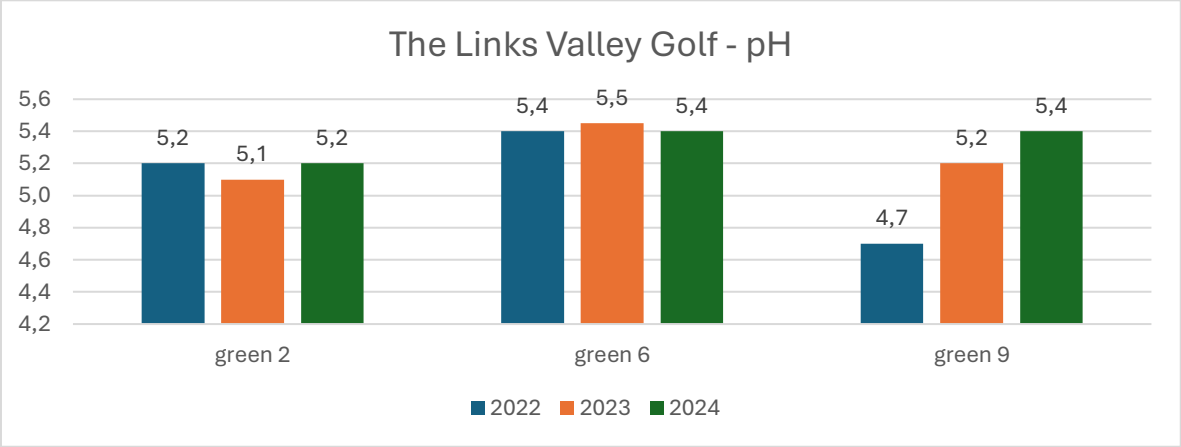


Figure 117: pH development

C. Turf Composition and Overseeding

The turf sward consists of a mix of *Festuca rubra* spp. (fine fescue) and *Agrostis capillaris* spp. (colonial bentgrass). On average, the ratio is approximately 45% fine fescue and 55% bentgrass. *Poa annua* fluctuates between 2% and a maximum of 4%.

Links Valley applies an intensive overseeding programme which also includes *Festuca trachyphylla* (hard fescue). This species—specifically the selected cultivar "Hardtop"—is particularly tolerant under increasingly frequent extremes of drought and heat.

Figure 118 presents the development of turf composition over the years. Appendix 4 contains the full overseeding programme and grass seed mixtures used.

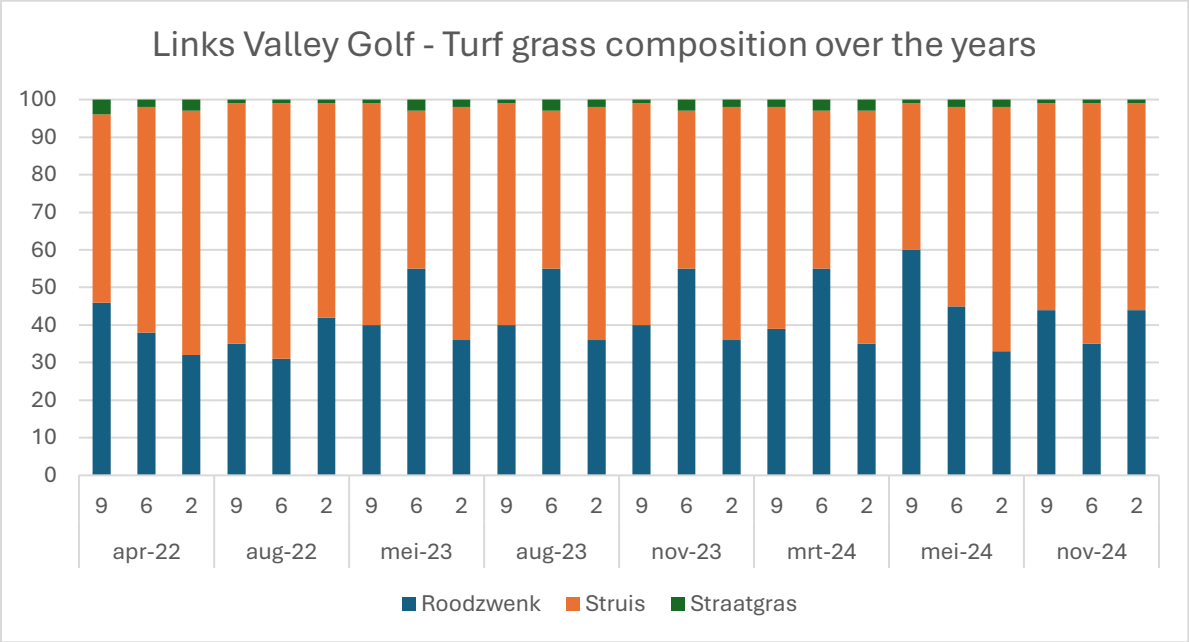


Figure 118: Development turf grass composition

D. Nitrogen and Iron Sulphate Fertilisation

The average nitrogen input applied at Links Valley is above the national average (12 courses) in all years. Except for 2022, the average dollar spot level is lower than the national benchmark.

Table 43. Nitrogen inputs in relation to dollar spot pressure at The Links Valley Golf

Year	Total N (kg/ha) Links Valley	National average N	Avg. DS pressure	National avg. DS
2022	108	79	1.3	1.0
2023	98	76	1.1	1.8
2024	165	88	0.9	1.5

Across the years, a pattern emerges of regular nitrogen applications combined with low dollar spot infection levels. Even during the most dollar spot-sensitive period (from autumn 2023 through autumn 2024), infections—and especially damage—remain limited. In 2024, nitrogen rates were increased to stimulate growth and recovery, with the explicit aim of preventing more severe and damaging outbreaks.

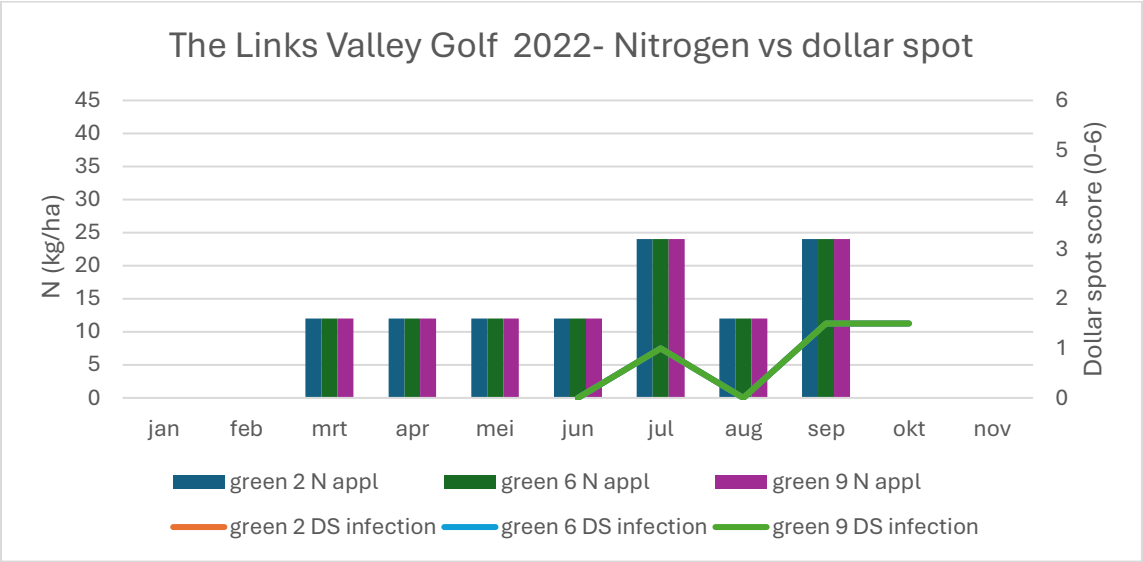


Figure 119: Nitrogen applications vs. dollar spot progression (2022)

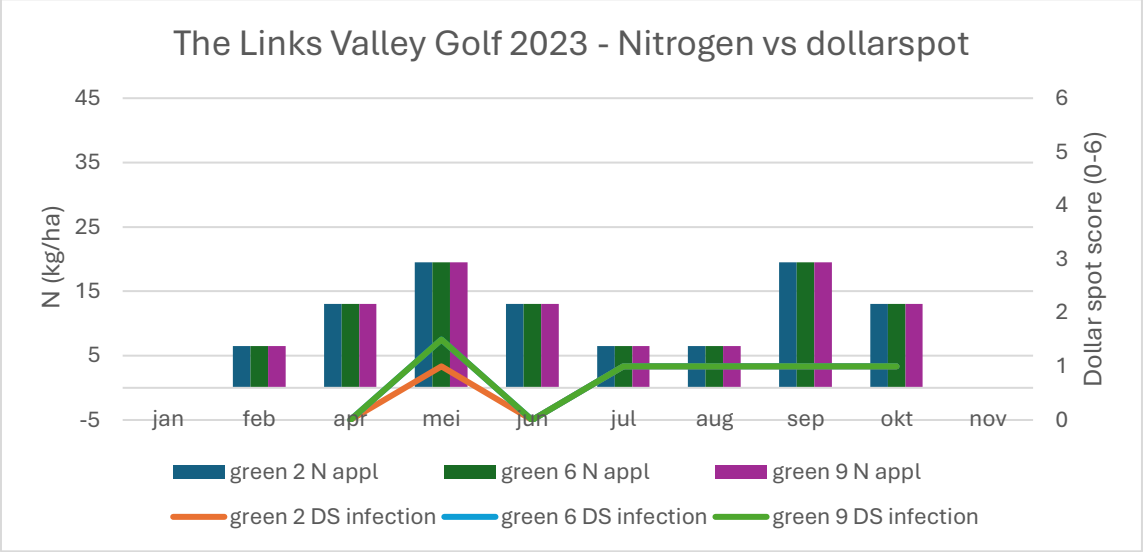


Figure 120: Nitrogen applications vs. dollar spot progression (2023)

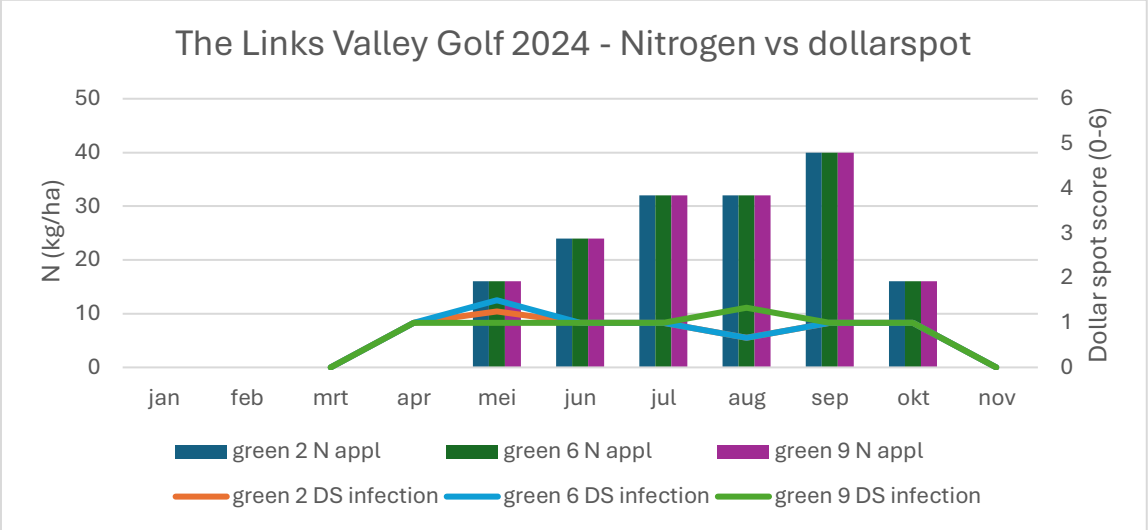


Figure 121: Nitrogen applications vs. dollar spot progression (2024)

Iron sulphate use was lower than the national average in 2022 and 2023. In 2024, Links Valley increased iron use in response to Smith-Kerns forecasts.

Table 44. Iron sulphate use in relation to dollar spot pressure at The Links Valley Golf

Year	Total Fe (kg/ha) Links Valley	National average Fe	Avg. DS pressure	National avg. DS
2022	32	48	1.3	1.0
2023	21	47	1.1	1.8
2024	53	38	0.9	1.5

Split applications throughout the year appear to help reduce dollar spot pressure. Because infection peaks in 2023 and 2024 mainly occurred in September and October, iron sulphate applications were focused more strongly on that period.

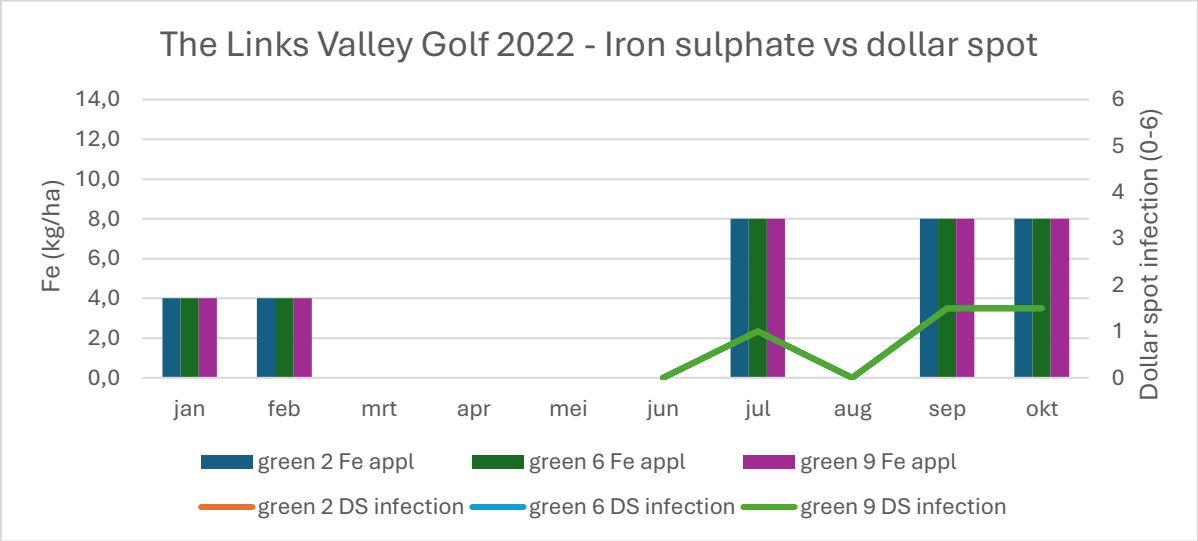


Figure 122: Iron sulphate applications vs. dollar spot progression (2022)

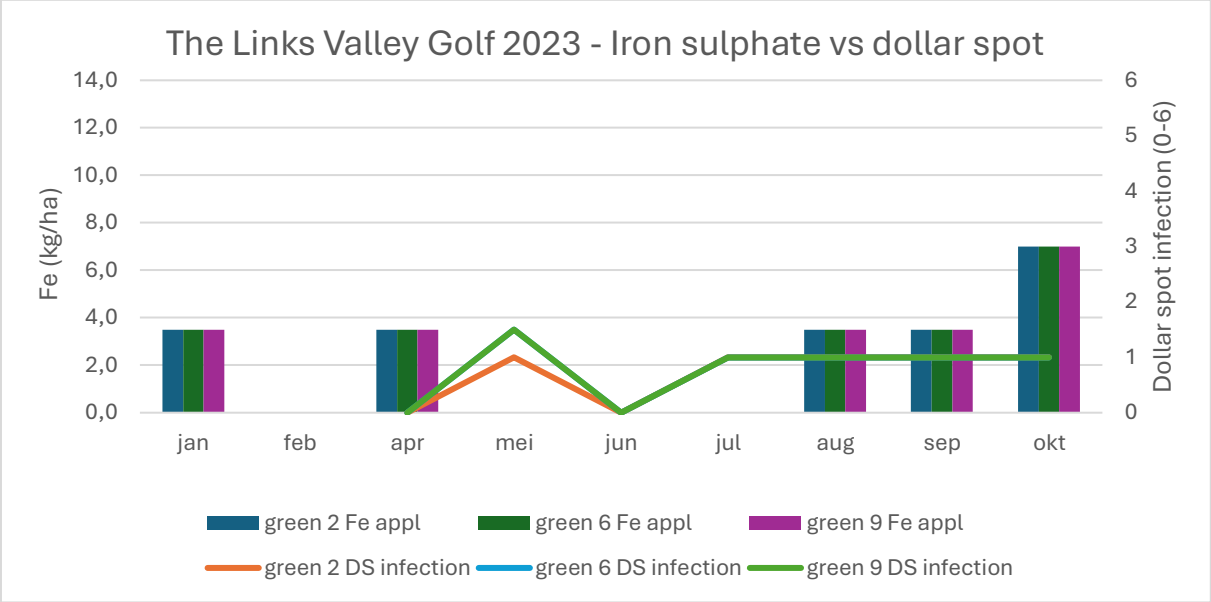


Figure 123: Iron sulphate applications vs. dollar spot progression (2023)

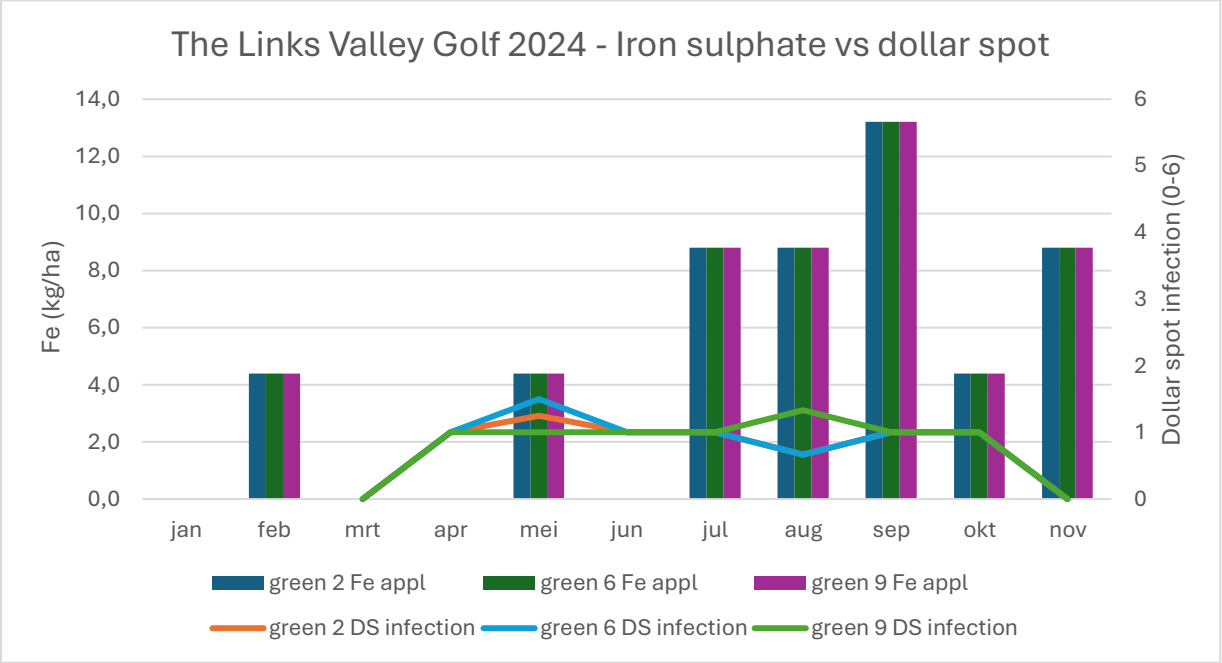


Figure 124: Iron sulphate applications vs. dollar spot progression (2024)

E. Cultural Practices: Rolling, Topdressing, Aeration and Other

The Links Valley operates an intensive management strategy involving rolling, topdressing and aeration. Given the very high infiltration capacity below roughly 4–5 cm depth, aeration is primarily focused on shallow cultivation: using Procore and Maredo operations to a maximum depth of about 5 cm, combined with topdressing with pure sand (M50 330 µm).

Rolling is considered an indispensable treatment at The Links Valley.

Table 45. Facts on rolling, topdressing and aeration

Practice	2022	2023	2024	Notes
Rolling	3× per week (24 weeks)	3× per week (29 weeks)	3× per week (24 weeks)	Essential practice
Topdressing	100 m³/ha	81 m³/ha	75 m³/ha	4.5 / 5.0 / 6.2 m³/ha per application
Aeration	8× Maredo/Procore	Same as 2022	5× Maredo/Procore + Vertidrain	Tines 6, 7 & 12 mm (max 5 cm); Vertidrain 12 mm to 10 cm

Links Valley also uses a broad set of supplements alongside frequent nitrogen fertilisation, including trace elements, biostimulants and plant health enhancers.

Playing Quality

Clegg measurements for greens 2, 6 and 9 generally fall within the target range of 80–100 gravimeters. There is insufficient stimp and trueness data to draw conclusions regarding relationships with dollar spot.

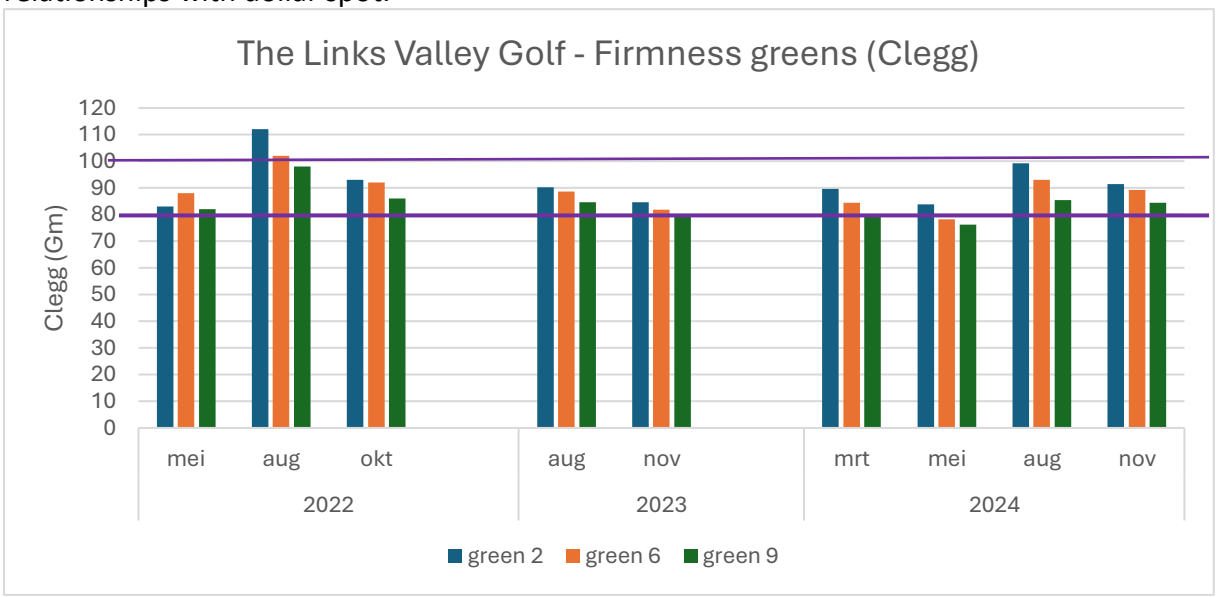


Figure 125: Clegg values

F. Snow mold (*Microdochium nivale*)

No significant Microdochium patch (or summer fusarium) was observed during the monitoring seasons.

G. Conclusions

With dollar spot scores of approximately 0.8–0.9 across the monitored greens, The Links Valley Golf is among the courses with very low dollar spot pressure. It is also the youngest of the 12 courses, which is clearly reflected in the green rootzone: substantial accumulation of organic matter in the upper 0–2 cm layer.

Given both the increase in organic matter and a relatively high C/N ratio, this organic layer appears persistent. Apparently, bacterial activity is still insufficient to effectively break down the resilient thatch layer.

This thatch layer—composed of organic material derived from both colonial bentgrass and fine fescue—results in very low infiltration capacity in the immediate surface zone and higher soil moisture levels compared with the layer beneath. The microclimate created within the thatch layer does not (yet) appear to favour pathogenic fungi such as dollar spot or Microdochium. More fundamental research is needed to better understand this mechanism.

The pathogen *Clarireedia bennetti* is indeed present, but the turf remains sufficiently resilient and vital to avoid severe infection. This is notable because several conditions that are often associated with dollar spot susceptibility are present: low moisture at 6–12 cm, low organic matter at 2–4 and 4–6 cm, and strong organic accumulation at the surface due to limited bacterial breakdown.



Dollar spot activity just outside green 2.

As the photo illustrates, rolling appears to be a prerequisite to literally keep dollar spot outside the green. The thatch layer is compressible, which can lead to anaerobic conditions that restrict gas exchange and slow down decomposition processes. Adequate drainage remains essential, and the current strategy of shallow aeration and topdressing is functioning well as an effective management practice.

9. Utrechtse Golfclub ‘de Pan’



Extreme drought and heat at De Pan, June 2023 *(photo: M. Lampe)*

Dollar Spot Development

Utrechtse Golfclub De Pan shows a mixed pattern of infection levels. Of the three monitored greens, green 17 is known for increased dollar spot sensitivity. Measurements and observations confirm that it is indeed sensitive, but it does not perform worse than green 2. Green 16 performs best on average and scores below the national average in all seasons. The other greens generally score above average for dollar spot infection, with the exception of 2024 (see Table 46).

In 2023, De Pan applied fungicides (Signum) because the damage threshold had been exceeded. In 2024, fungicides were used again, but not on the monitored greens.

Table 46. Average level of dollar spot infection at De Pan in 2022, 2023 and 2024

Year	Green 2	Green 16	Green 17	National average DS
2022	1.1	0.6	1.2	1.0
2023	2.1	1.7	1.9	1.8
2024	1.2	1.2	1.1	1.5
Average	**1.4**	**1.1**	**1.3**	

In 2022, infection and subsequent damage remained limited until early autumn. After that, an outbreak with damage occurred across all greens. In 2023, spring forecasts were favourable for dollar spot, and severe infections indeed occurred in June—first on greens 2 and 17, and later also on green 16. In 2024, the pathogen became active early and continued smouldering throughout the season, causing relatively limited damage.

A. Water Management

Soil moisture trends of the three monitored greens show that in 2022 green 17 deviated compared with greens 2 and 16. Moisture levels at both 0–6 cm and 6–12 cm remained below the desired minimum of 20%, after which dollar spot became active and later caused damage. However, similar dollar spot patterns were also visible on greens 2 and 16. Although green 17 is known as drought- and dollar spot-sensitive, it did not show more activity or damage than the other monitored greens during the study period.

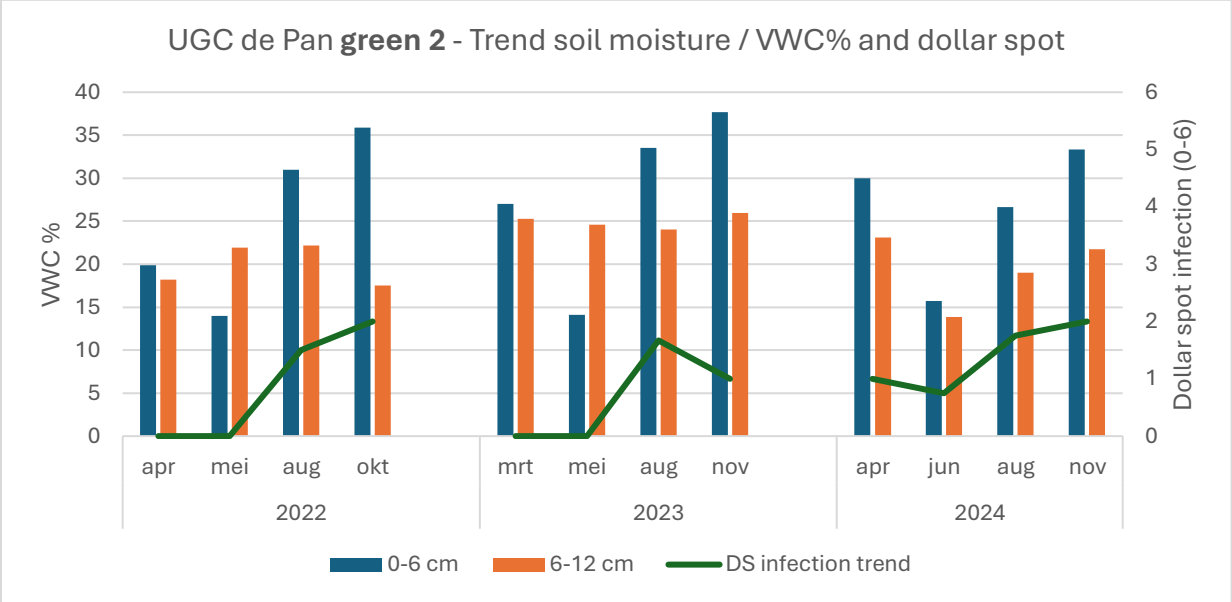


Figure 126: Soil moisture vs. dollar spot infections – green 2

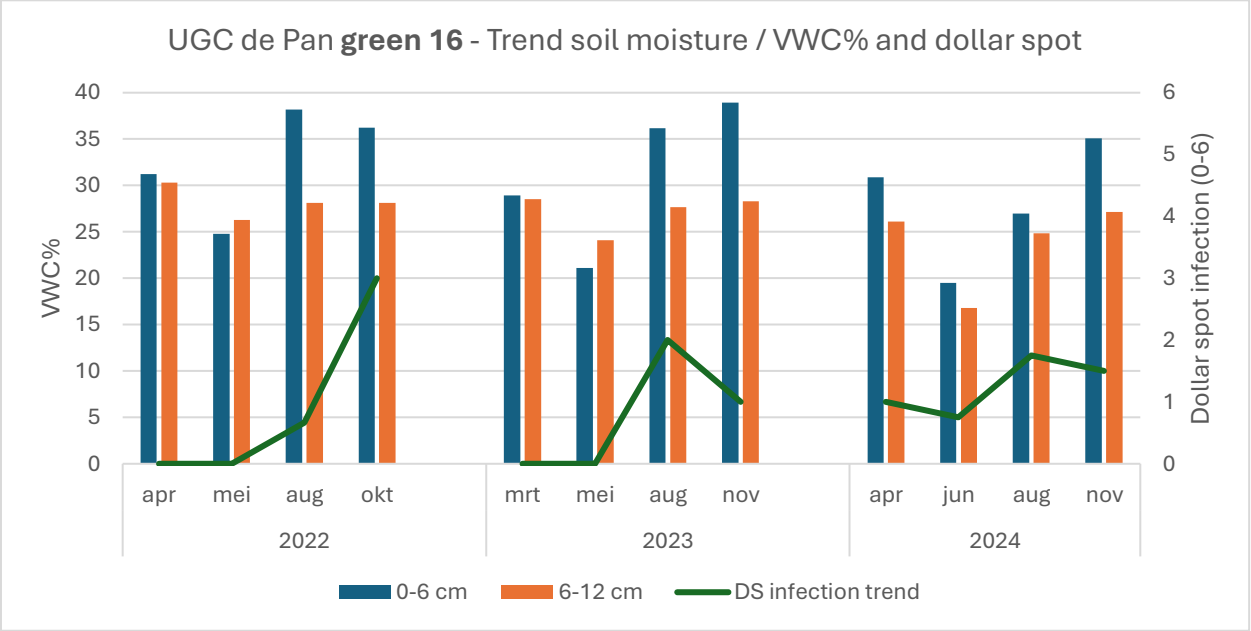


Figure 127: Soil moisture vs. dollar spot infections – green 16

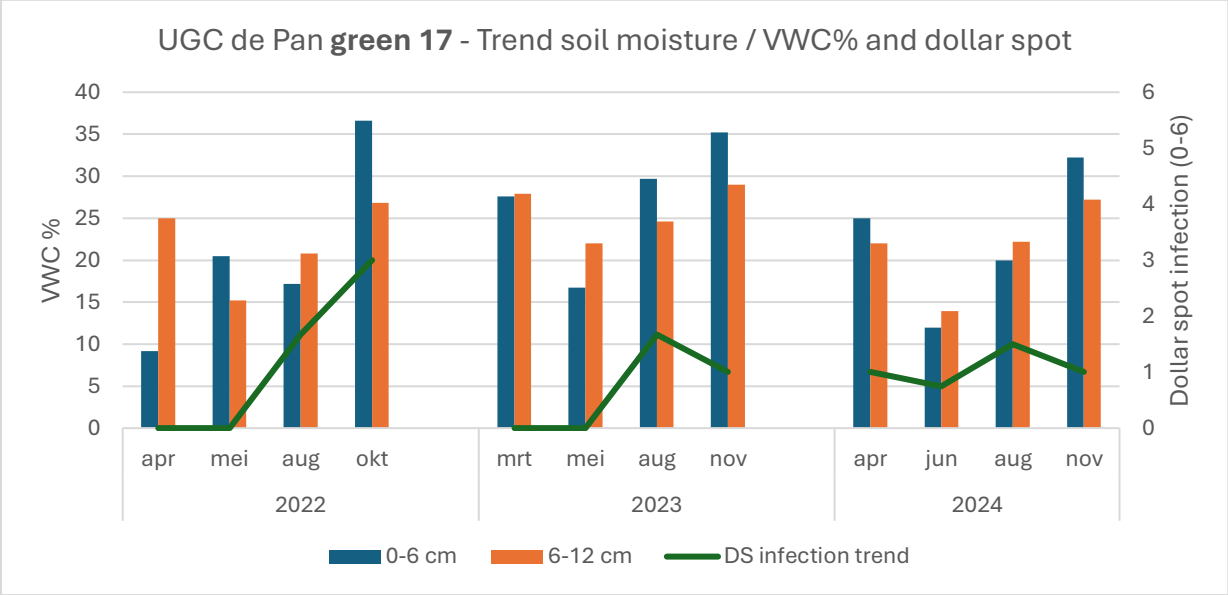


Figure 128: Soil moisture vs. dollar spot infections – green 17

Infiltration capacity is good in the 0–6 cm layer. At 6 cm depth, infiltration rates were relatively low. A likely explanation for limited drainage capacity is the high organic matter content, combined with the natural hydrophobicity of the sandy soil at De Pan.

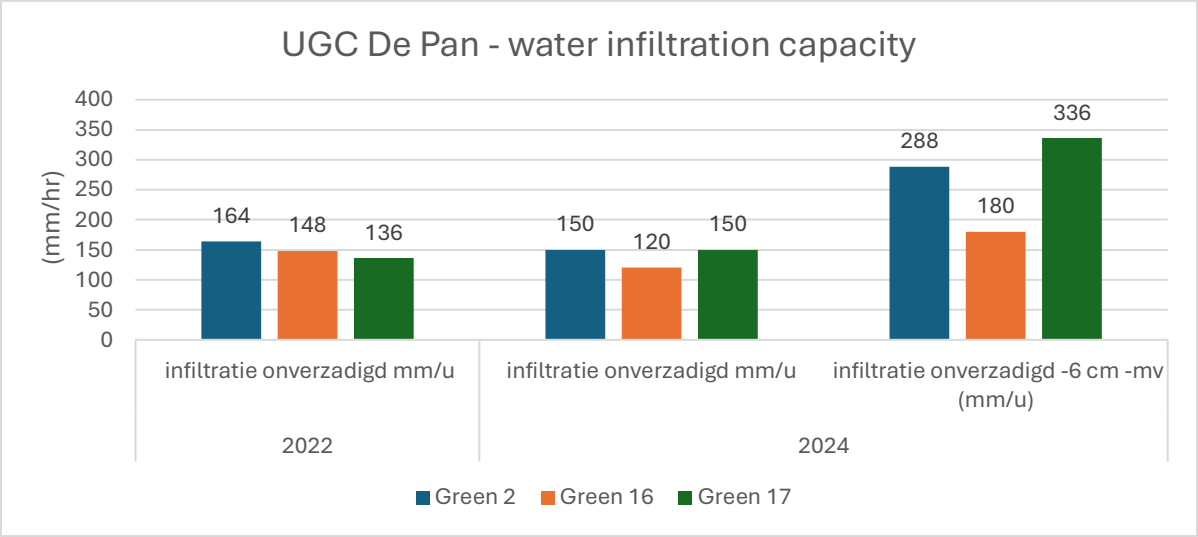


Figure 129: Average water infiltration capacity in years 1 and 3

B. Organic Matter, C/N Ratio and pH

All greens have high to very high organic matter content in the 0–6 cm layer (up to 7.8%). Organic matter levels are also high in the underlying layers (up to 5.0%).

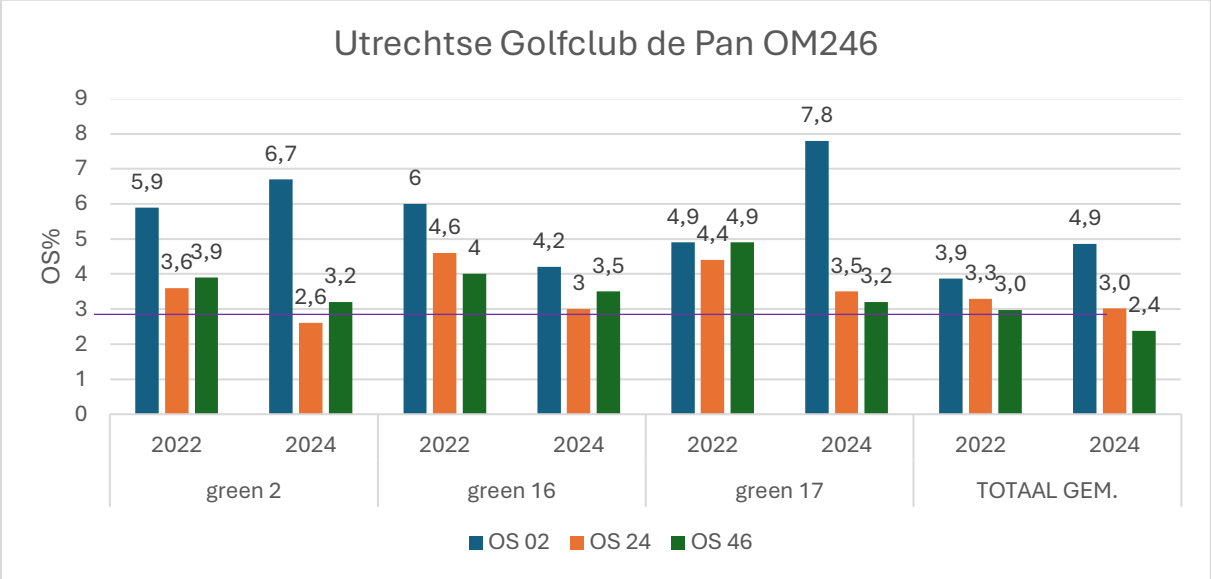


Figure 130: OM2-4-6 development in years 1 and 3



Root zone plug of green 2; the effect of Graden Sand Injector treatment is clearly visible

The C/N ratio is variable. Green 16 is an outlier, reaching a C/N of 20 in 2024. Green 17, in contrast, remains relatively stable with a C/N ratio of 11–12 across three seasons—unexpected given the high organic matter levels. Apparently, bacterial activity is sufficient to enable decomposition and transformation of organic matter.

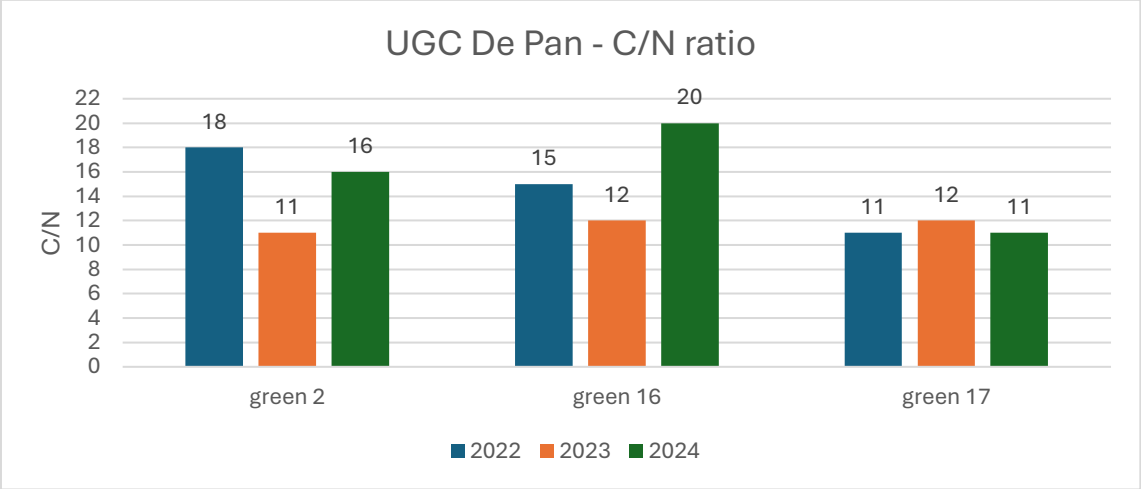


Figure 131: C/N ratios

All greens show a (very) low pH, averaging slightly above pH 4 across the seasons.

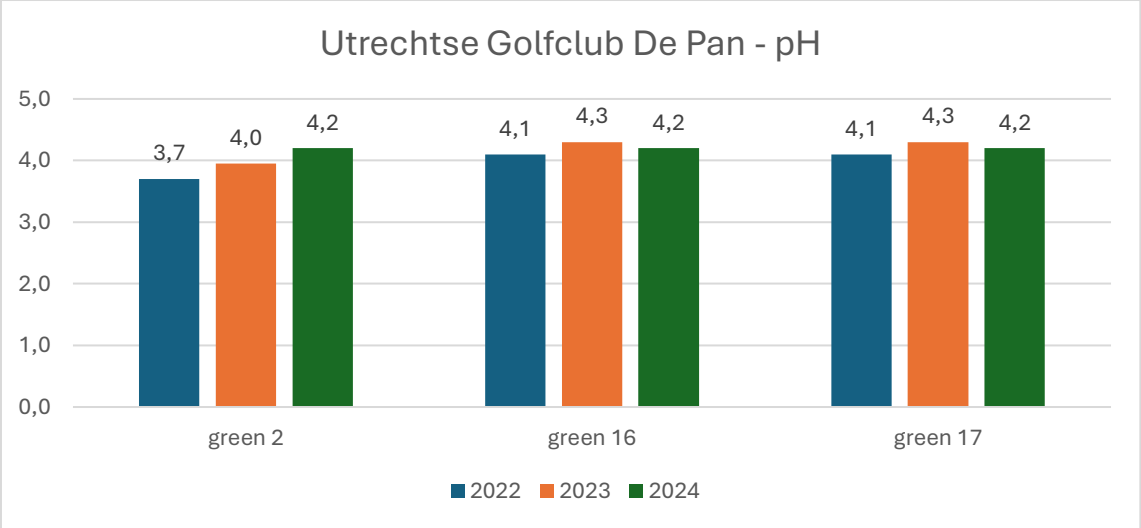


Figure 132: pH development

C. Turf Composition and Overseeding

The turf has long been dominated by *Agrostis capillaris* (colonial bentgrass), and this stable pattern is shown in Figure 133.

De Pan does not operate an intensive overseeding regime. In 2022, overseeding was performed twice with 100% colonial bentgrass—once using the Maredo, and once through the sand using the Graden. In 2023 and 2024, overseeding was carried out once per year, again with 100% colonial bentgrass. For the full overview, see Appendix 4.

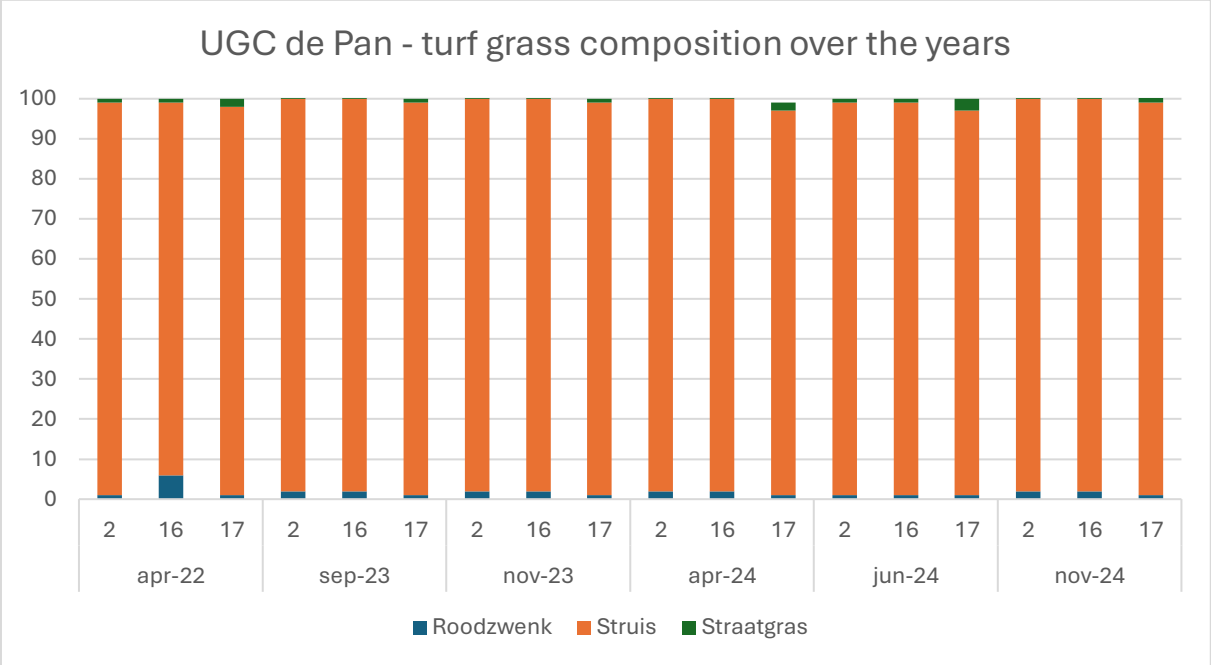


Figure 133: Development of turf grass composition

D. Nitrogen and Iron Sulphate Fertilisation

UGC De Pan maintained a consistent nitrogen regime across the three study years, with applied amounts slightly above the national average.

Table 47: General facts on nitrogen inputs in relation to dollar spot pressure at UGC De Pan

	Total N (kg/ha) De Pan	National average N (kg/ha)	Average DS pressure (0–5)	National DS pressure
2022	90	79	0.9	1.0
2023	85	76	1.9	1.8
2024	96	88	1.2	1.5

Nitrogen was applied in four split applications from March/April through summer. After August, no further fertilisation was applied. Nitrogen sources included urea and ammonium sulphate.

In the wet spring of 2023, nitrogen was sprayed twice. Shortly thereafter, dollar spot pressure rose sharply, especially on greens 2 and 17. Green 16 showed less infection. A combination of weather conditions, a leaching-prone soil, the low nitrogen-supplying capacity of the rootzone, and a pH around 4 means much of this nitrogen may not have benefited the turf plant. The lower the pH, the less able the plant is to absorb nutrients; on green 2, a pH of 3.8 was even measured. Under suboptimal conditions, stress can develop rapidly.

Green 16 likely avoided severe infection partly due to slightly higher moisture retention in the upper rootzone (one side of the green remains wet longer than the other).



Rootzone green 16 under wet conditions, November 2023

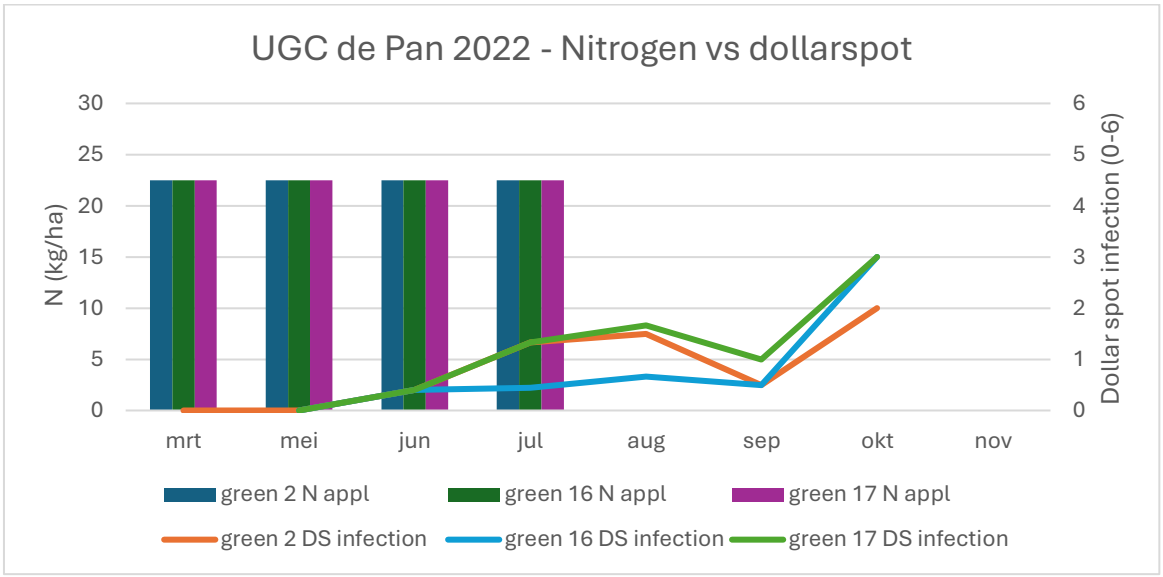


Figure 134: Nitrogen applications vs dollar spot infections (2022)

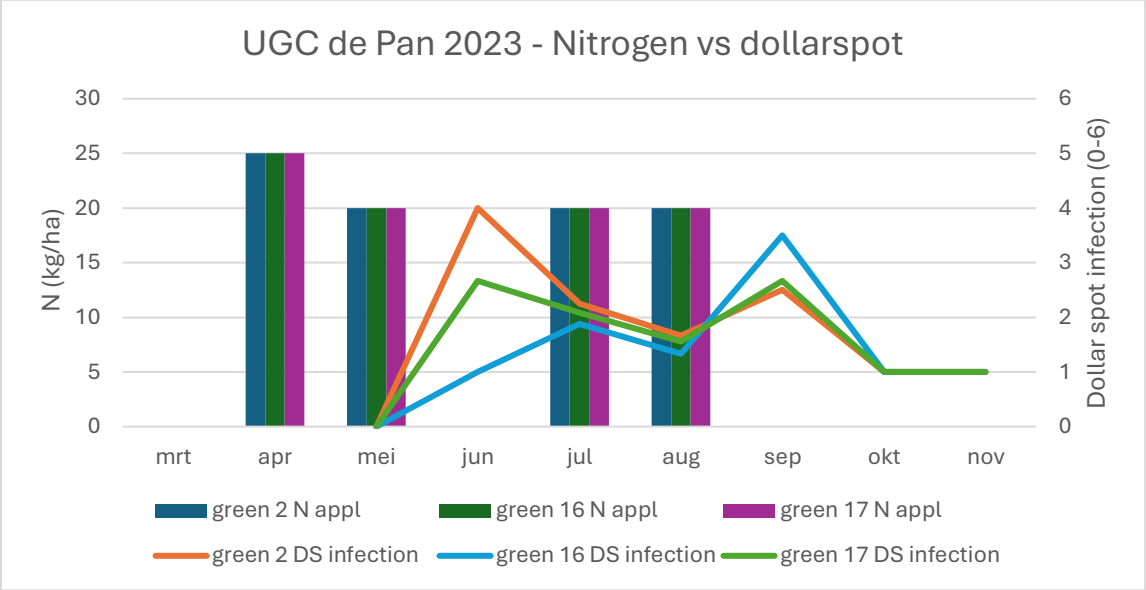


Figure 135: Nitrogen applications vs dollar spot infections (2023)

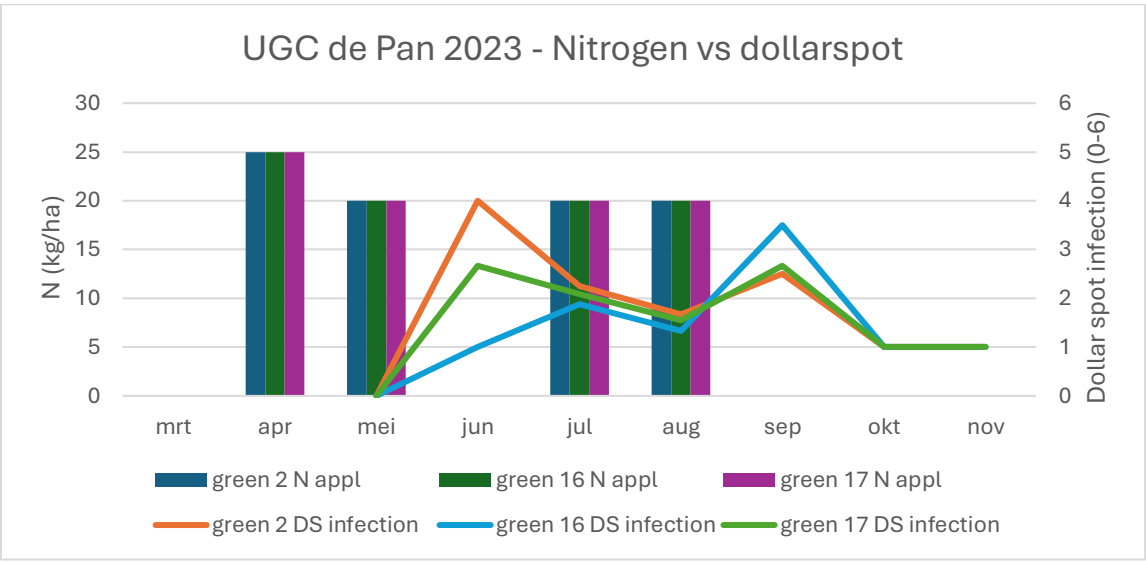


Figure 136: Nitrogen applications vs dollar spot infections (2024)

Iron sulphate use at De Pan fell well below the national average after 2022, while dollar spot infections increased in 2023 and 2024. In 2023, fungicide use partly replaced iron sulphate as a control measure. In 2024, other factors likely contributed to keeping the pathogen under control (infections remained below level 2).

Table 48: Iron sulphate use in relation to dollar spot pressure at UGC De Pan

	Total Fe (kg/ha) De Pan	National average Fe (kg/ha)	Average DS pressure	National DS pressure
2022	38	48	0.9	1.0
2023	15	47	1.9	1.8
2024	8	38	1.2	1.5

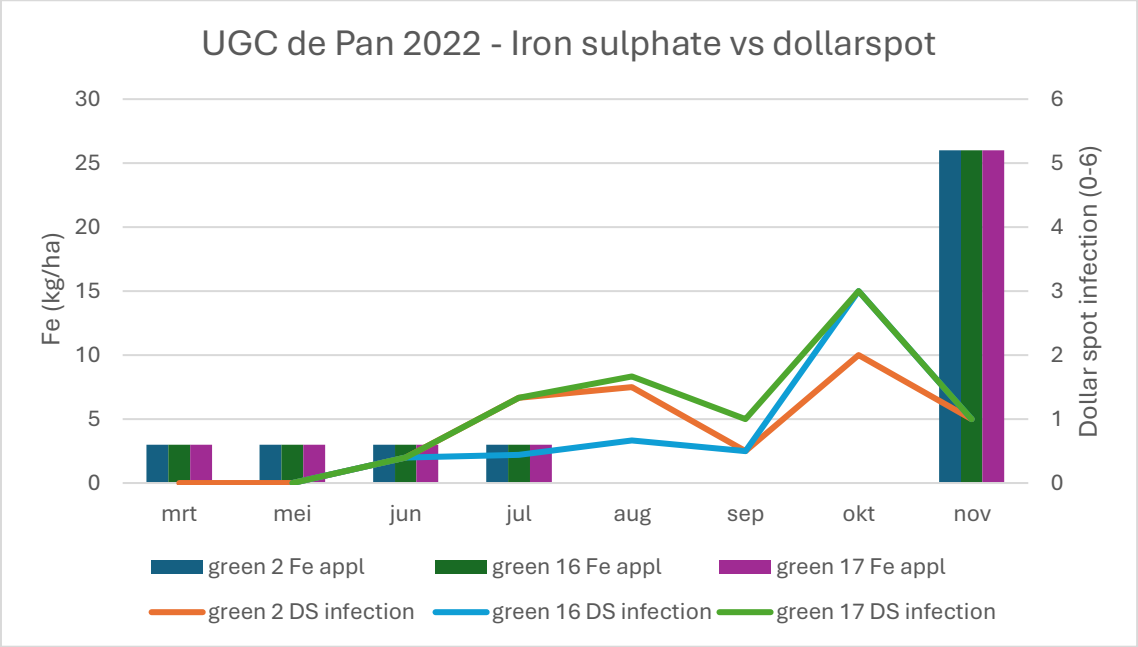


Figure 137: Iron sulphate applications vs dollar spot infections (2022)

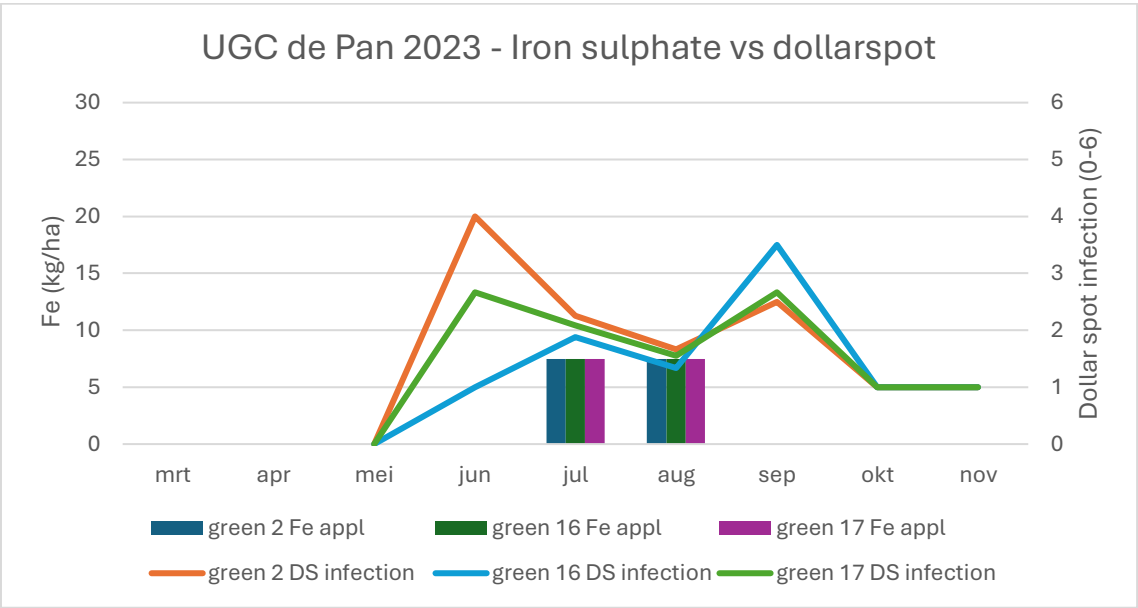


Figure 138: Iron sulphate applications vs dollar spot infections (2023)

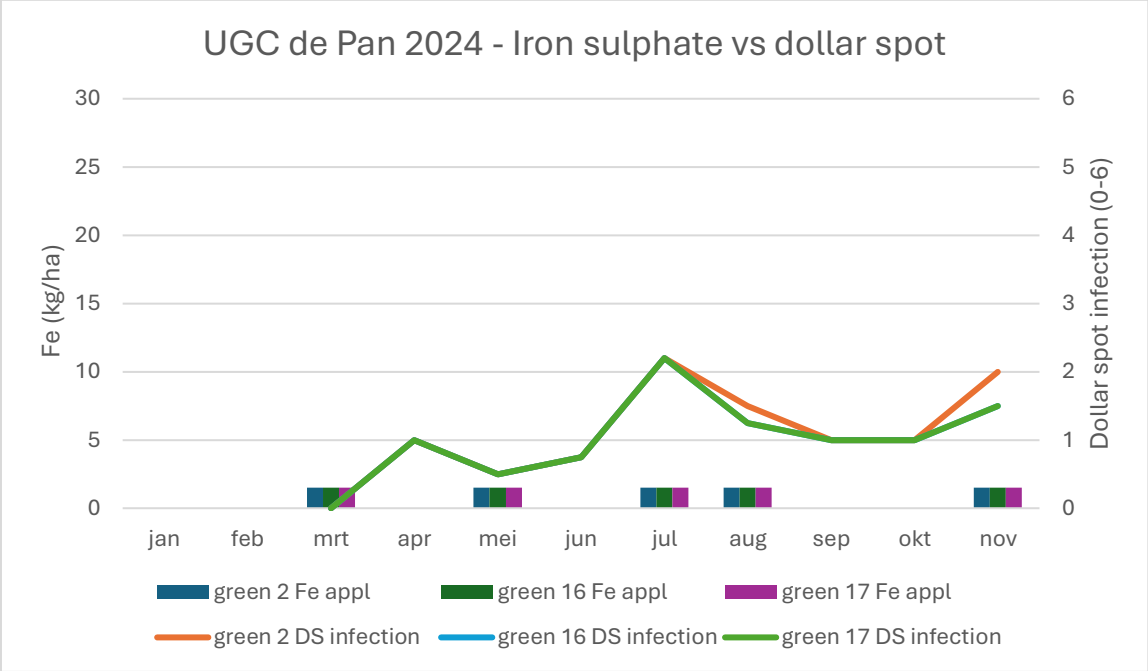


Figure 139: Iron sulphate applications vs dollar spot infections (2024)

E. Cultural Practices: Rolling, Topdressing, Aeration and Other

In 2022 and 2023—and to a lesser extent in 2024—the greens were rolled intensively and frequently. In 2023, rolling took place every 2–3 weeks, with approximately 14 rolling passes per green. Since after August almost no nitrogen and iron inputs were applied, dollar spot control can largely be attributed to the beneficial effect of rolling.

Table 49: Facts on rolling – topdressing – aeration

	Frequency	Remarks
Rolling 2022	4.6	25
Rolling 2023	1.4	17
Rolling 2024	1.0	7
Topdressing 2022	30 m³/ha	7.5 m³ per application + 18 m³ via Graden
Topdressing 2023	39 m³/ha	13 m³ per application
Topdressing 2024	42 m³/ha	14 m³ per application
Aeration 2022	6× per year	5×8 mm (15 cm), 1×12 mm (20 cm)
Aeration 2023	4× per year	3×8 mm (15 cm), 1×12 mm (25 cm)
Aeration 2024	5× per year	3×15 mm (15 cm), 8 mm hollow (5 cm), 12 mm (18 cm)

F. Playing Quality

Clegg values generally fall within the target range of 80–100 gravimeters. Correlation analysis indicates a moderate negative correlation between hardness and dollar spot across all greens: a strong indication that higher Clegg values correspond with less dollar spot. In other words, at De Pan, rolling appears to have a measurable effect.

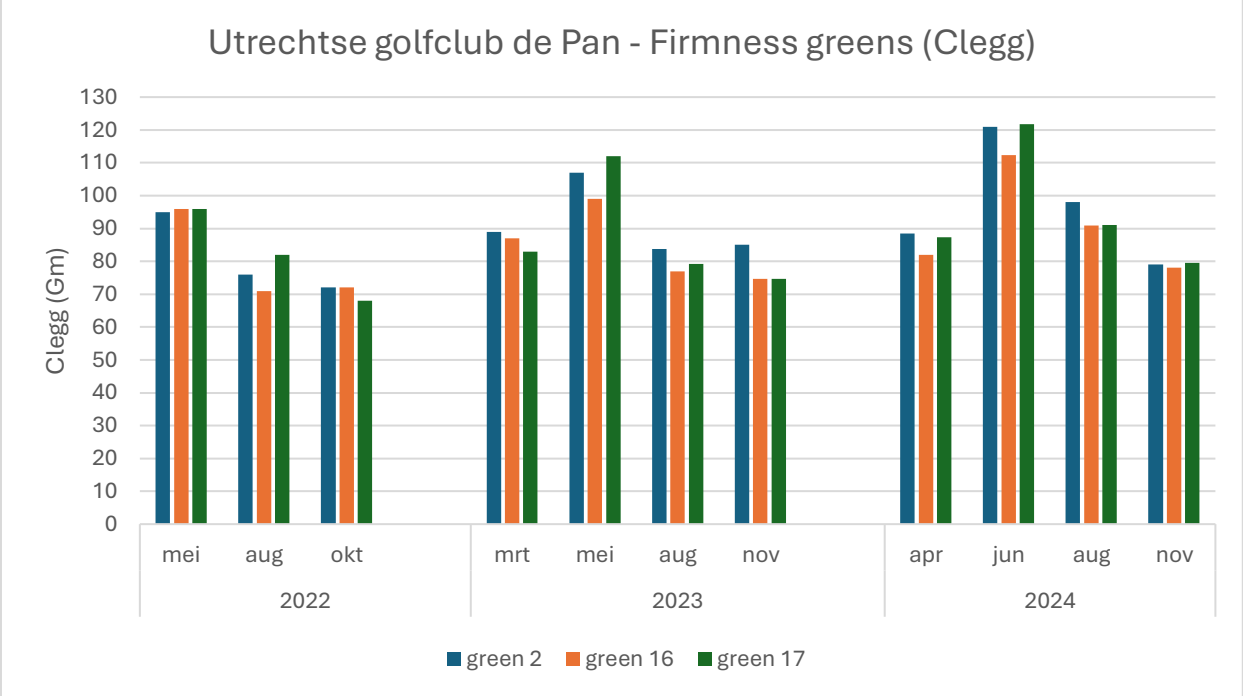


Figure 140: Clegg values over the years

G. Microdochium Patch (*Microdochium nivale*)

The greens showed very little Microdochium activity. Green 16 may require some attention in principle because it remains locally wetter for longer and is more sheltered, potentially increasing susceptibility.

H. Conclusions

De Pan is the only one of the 12 courses where all monitored greens are located in shade and sheltered conditions, and are therefore potentially more sensitive to dollar spot. Nevertheless, shade and shelter do not appear to be the main trigger, given the moderate average scores: 1.5 for green 2, 1.2 for green 16 and 1.4 for green 17.

A quality shift occurred between early 2022 and late 2024: green 17 moved from “poor” to “average to good”, while green 2 shifted from “average” towards “poor”. Both greens remain heavily shaded; no trees were removed during the study period. Green 16 performed

best and can now effectively share that position with green 17. Green 2 suffered significant dollar spot pressure particularly in 2023.

In summer 2023, Signum was sprayed across all greens. That this represented a short-term fix became clear in spring 2024, when dollar spot became active early again. Ultimately, the regular maintenance programme was resumed and recovery gradually followed.

Green 17 is known as “the dollar spot-sensitive green” at De Pan. Soil moisture measurements also show the lowest moisture percentages compared with greens 2 and 16. Yet across the monitoring period, it was not more severely affected than the others. By increasing (manual) irrigation particularly in 2024, dollar spot pressure on green 17 decreased substantially, with rolling also contributing.

10. Sallandse Golfclub “De Hoek”

Overview of Dollar Spot Infections

At Sallandse Golfclub, the monitored greens were treated with fungicides twice annually throughout the research period. In 2022 and 2023, applications took place in mid-June and early September; in 2024, fungicides were applied in early June and late July. The fungicide applications temporarily halted fungal activity but did not eradicate the pathogen. Especially on green 17, dollar spot re-emerged on previously affected, insufficiently recovered areas despite two treatments.



Persistent dollar spot on green 17, May 2023.

Table 50. Average level of dollar spot infection at Sallandse Golfclub in 2022, 2023 and 2024

Year	Green 1	Green 5	Green 17	National average DS
2022	0.3	0.3	0.3	1.0
2023	1.6	1.7	1.9	1.8
2024	2.3	2.3	3.3	1.5
Average	**1.6**	**1.6**	**1.9**	

In 2022, fungicide application proved effective when used preventively, and no significant dollar spot outbreaks occurred during the remainder of the season. In subsequent years, fungicides were applied only after dollar spot activity and damage had already developed,

resulting in a far more limited effect—partly due to renewed activity on previously damaged turf.

Note: Because fungicides were applied, the influence of other parameters on turf quality cannot be clearly isolated.

A. Water Management

Green 17 is the most severely affected by dollar spot, followed by green 5. Both greens show large differences in soil moisture (%) between the 0–6 cm and 6–12 cm layers.

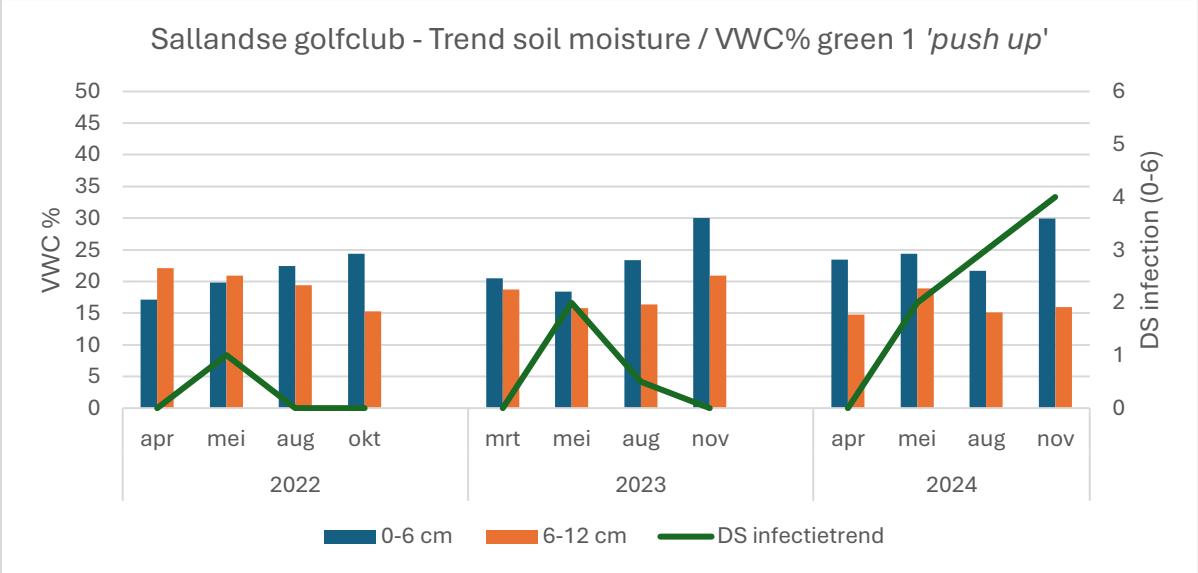


Figure 141: Soil moisture trend – dollar spot infections for green 1

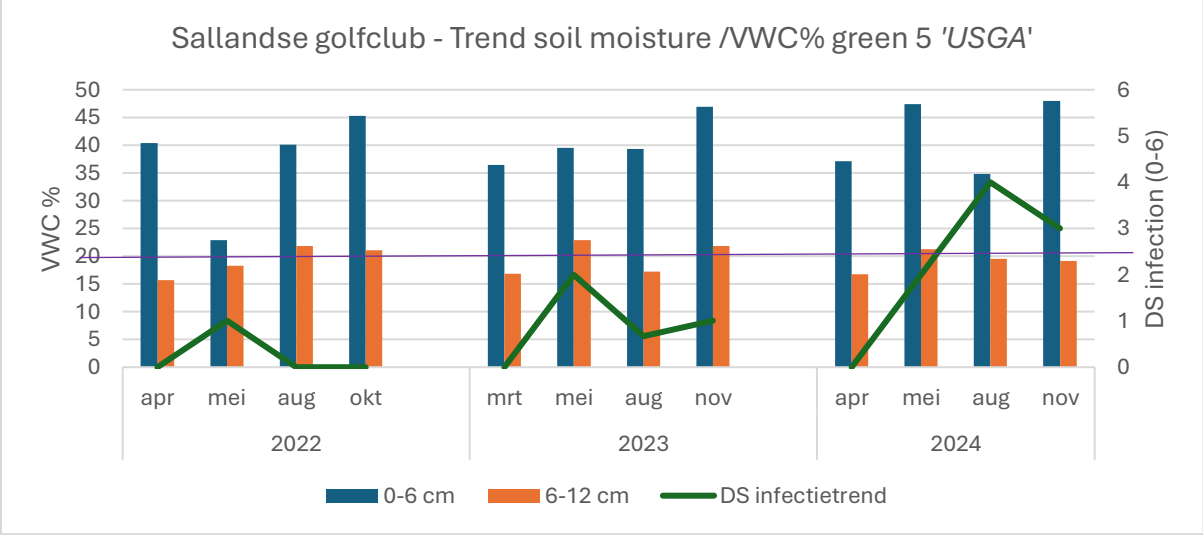


Figure 142: Soil moisture trend – dollar spot infections for green 5

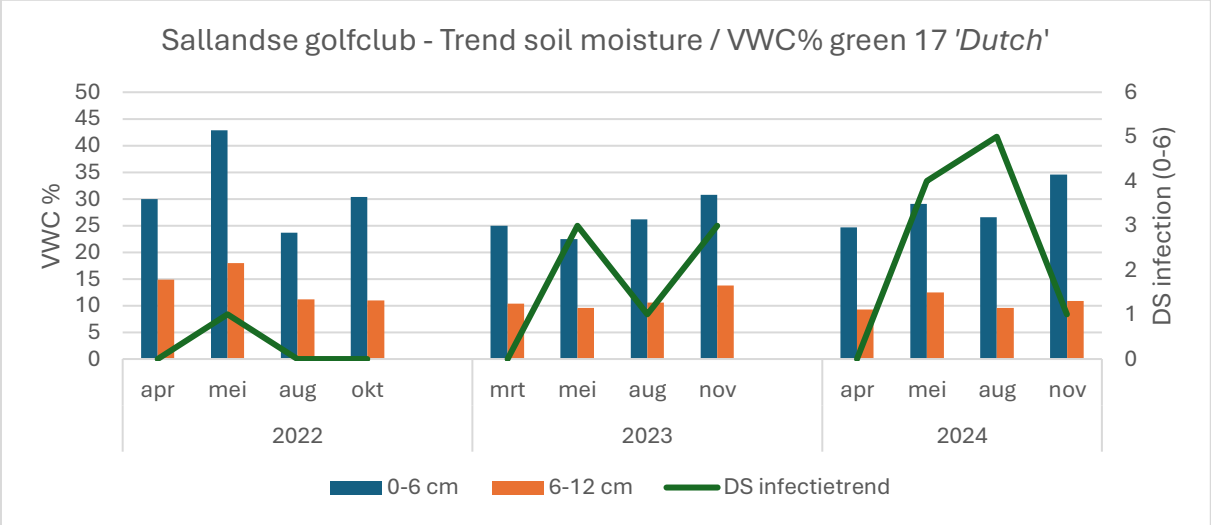


Figure 143: Soil moisture trend – dollar spot infections for green 17

Infiltration capacity also differed substantially between greens. Particularly notable were the low infiltration rates recorded in 2024. Only the push-up green allowed water to drain effectively. Green 5 showed infiltration rates of approximately 60 mm/hour, reflected in extremely high soil moisture values of up to 45%. Measurements at 6 cm below the surface again identified push-up green 1 as the most freely draining green. Green 17 also performed well at over 1,000 mm/hour, whereas the USGA-constructed green 5 lagged behind at approximately 540 mm/hour.

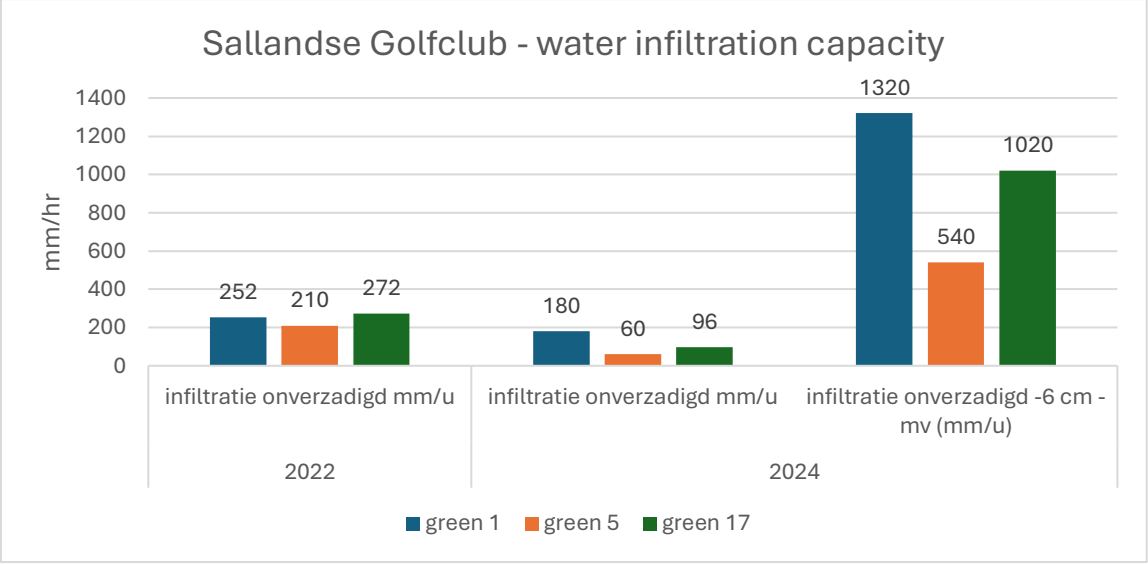


Figure 144: Average water infiltration capacity in year 1 and 3

B. Organic Matter, C/N Ratio and pH

Organic matter content within the top 6 cm varied considerably on green 17 (Dutch construction). At 4–6 cm depth, organic matter levels were particularly low compared with

the 0–2 cm and 2–4 cm layers. These low values constitute a clear trigger for dollar spot development.

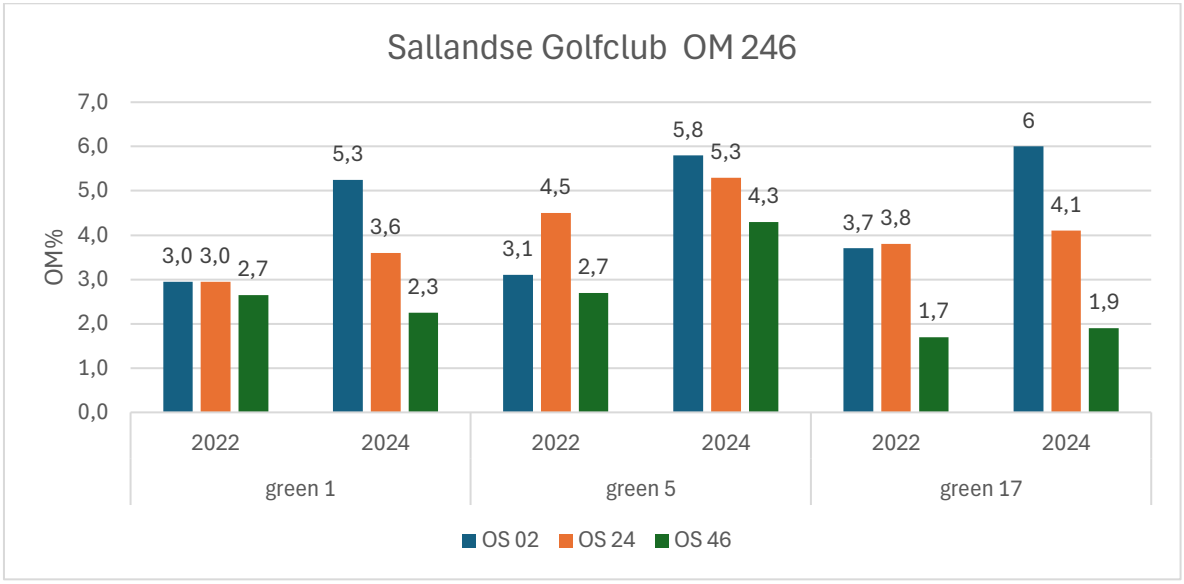


Figure 145: OM 2–4–6 development in year 1 and 3

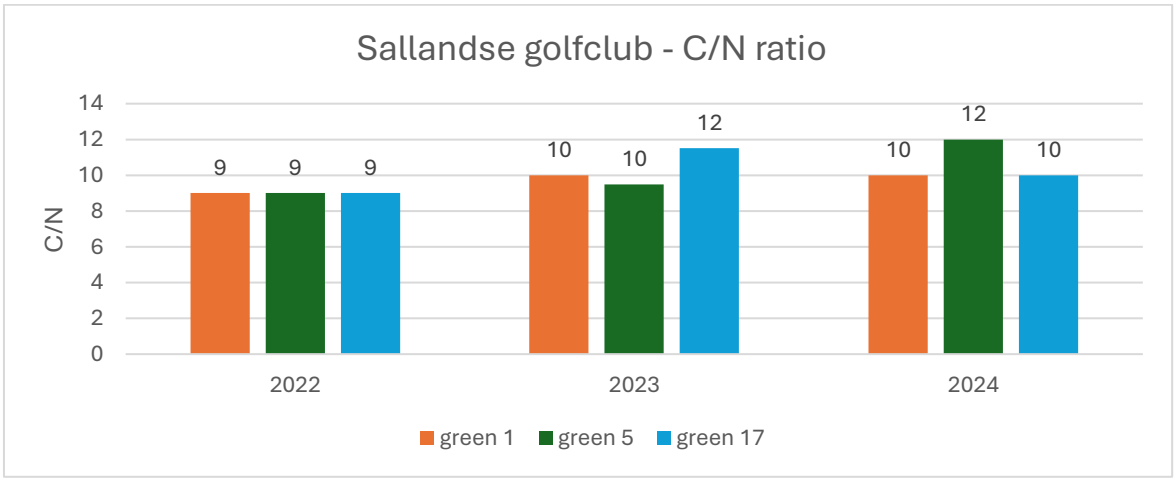


Figure 146: C/N ratios

The pH values across the monitored greens were relatively uniform (5.6–5.8), with a slight decline observed in 2024. Overall, the greens tend towards the alkaline side for the dominant turf species *Agrostis capillaris* and *Agrostis stolonifera*.

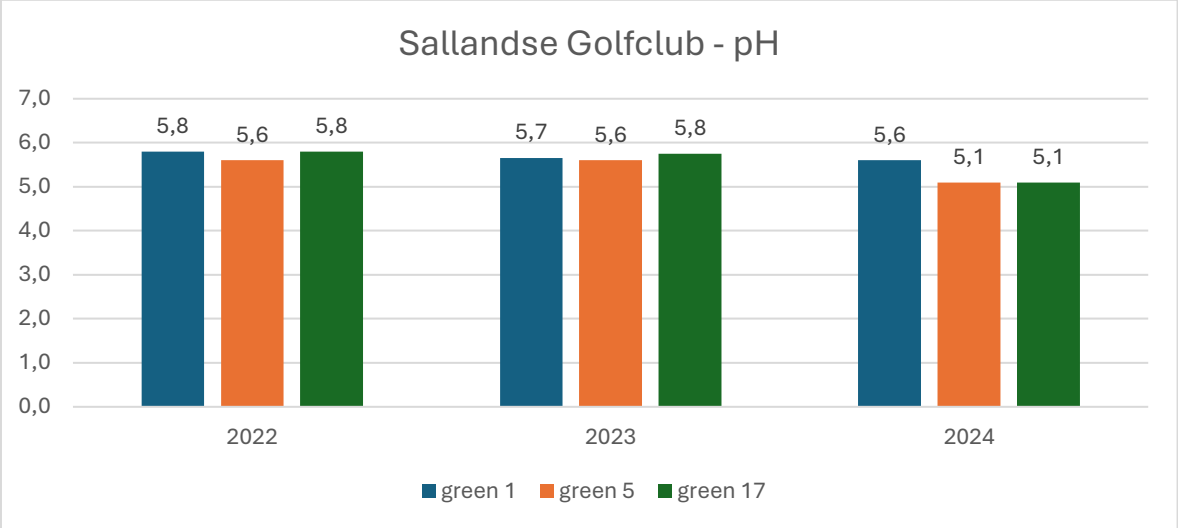


Figure 147: pH trend

C. Turf Composition and Overseeding

The dominant turf species are *Agrostis capillaris* (colonial bentgrass) and *Agrostis stolonifera* (creeping bentgrass). Changes in turf composition over the monitoring period are shown in Figure 148. Percentages are estimates, and no distinction was made between colonial and creeping bentgrass.

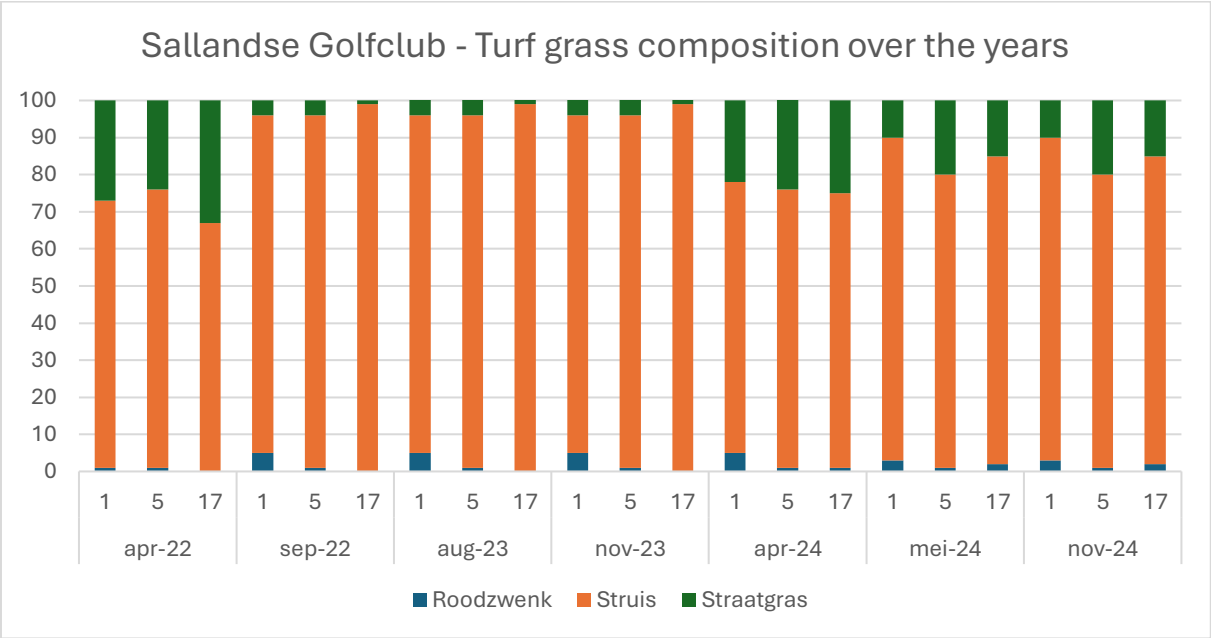


Figure 148: *Turf grass composition development*

Overseeding is carried out 5–6 times per year using 100% colonial bentgrass and 100% creeping bentgrass. Colonial bentgrass is overseeded in spring and autumn, creeping bentgrass in summer, both at seeding rates of 15 kg/ha. The full overseeding programme is provided in Appendix 4.

D. Nitrogen and Iron (Sulphate) Fertilisation

Greens are fertilised primarily with an autumn fertiliser containing 6% iron, applied in small doses at high frequency. Total nitrogen inputs are well above the national average but are considered appropriate for the dominant turf species at Sallandse.

Table 51. Nitrogen inputs in relation to dollar spot pressure at Sallandse Golfclub

Year	Total N (kg/ha)	National average N	Avg. DS pressure	National avg. DS
2022	140	79	0.3	1.0
2023	108	76	1.7	1.8
2024	150	88	2.6	1.5

The effect of nitrogen fertilisation on dollar spot suppression is difficult to assess due to fungicide use. However, nitrogen clearly contributed to faster turf recovery and supported the success of frequent overseeding.

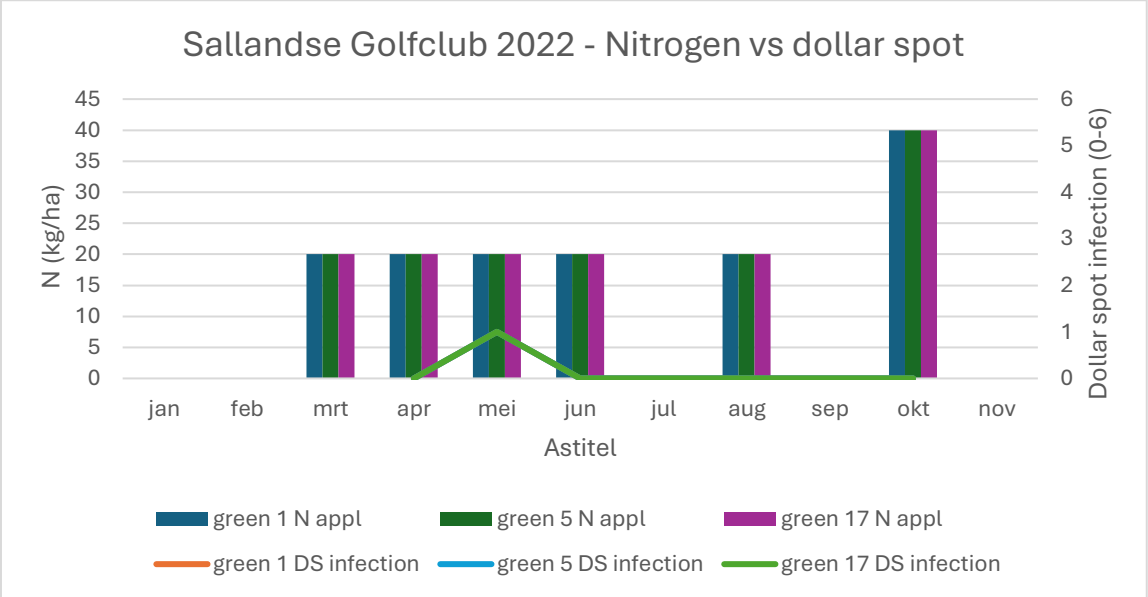


Figure 149: Nitrogen applications vs. dollar spot infections in 2022

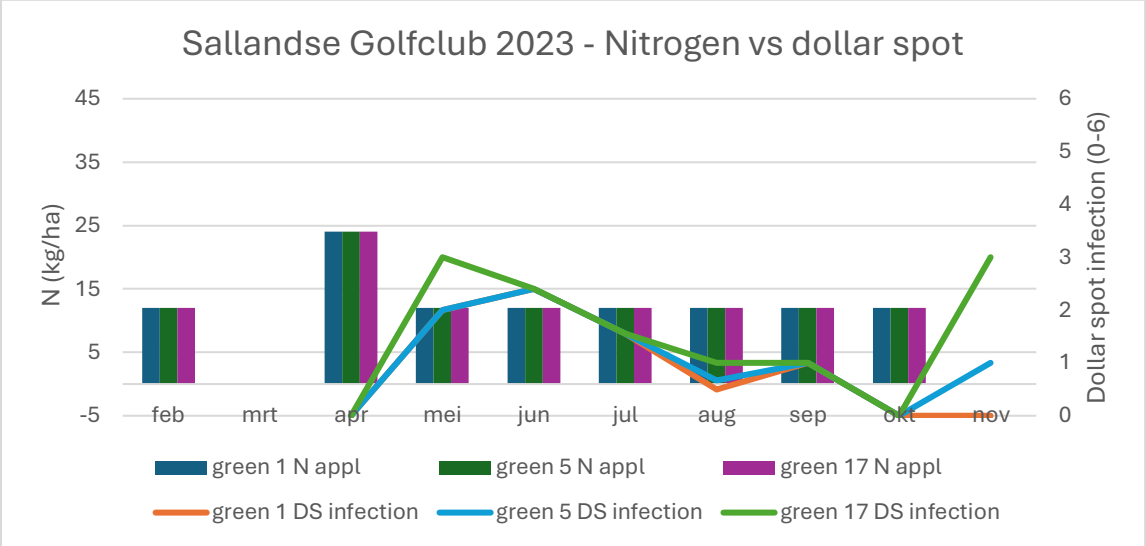


Figure 150: Nitrogen applications vs. dollar spot infections in 2023

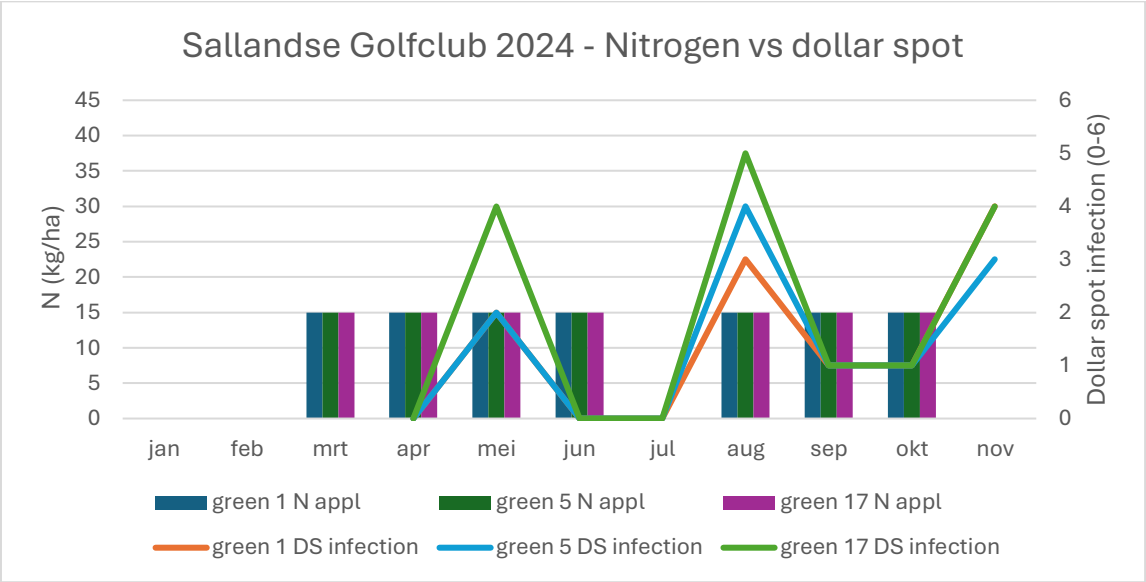


Figure 151: Nitrogen applications vs. dollar spot infections in 2024

Iron sulphate inputs varied considerably between years. In 2022, high iron inputs coincided with minimal dollar spot pressure, although the fungicide Signum was also applied. In 2023, iron use was significantly reduced, while infection levels increased. In 2024, iron inputs increased again but failed to suppress dollar spot development.

Table 52: Iron (sulphate) use in relation to dollar spot pressure at Salland Golf Club

	Total Fe (kg/ha) Salland	National average Fe (kg/ha)	Average DS pressure	National DS pressure
2022	82	48	0.3	1.0
2023	26	47	1.7	1.8
2024	43	38	2.6	1.5

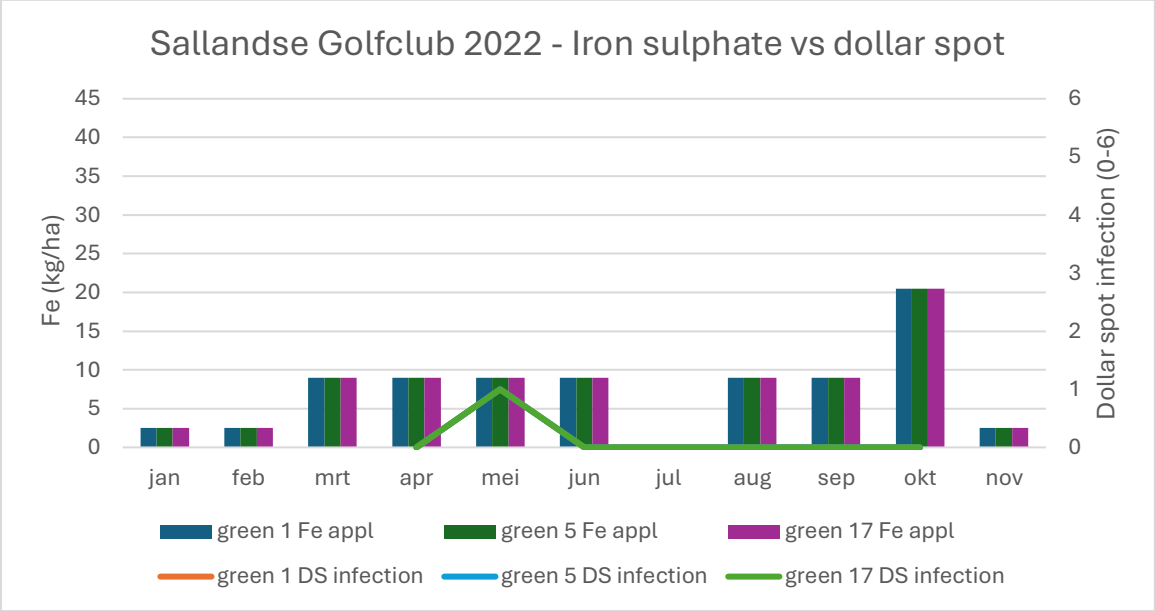


Figure 152: Fe applications vs. dollar spot infections in 2022

In 2023, iron fertilisation was limited. Dollar spot was already active from April and controlled with fungicides in early July. A second application later in the season reduced infection levels. Iron did not play a significant role.

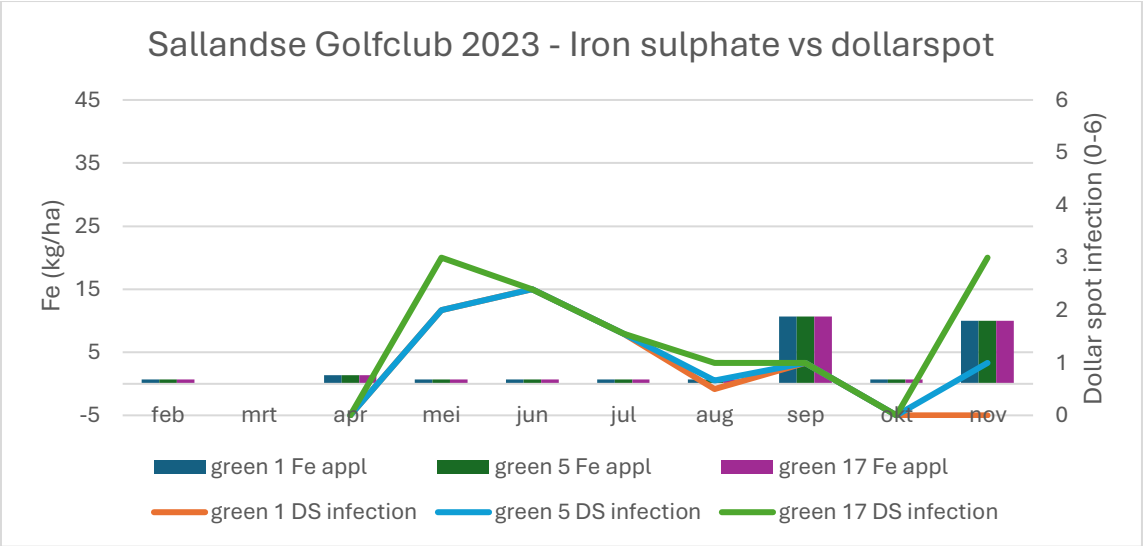


Figure 153: Fe applications vs. dollar spot infections in 2023

In 2024, severe dollar spot activity occurred again, with two Signum applications (July and September).

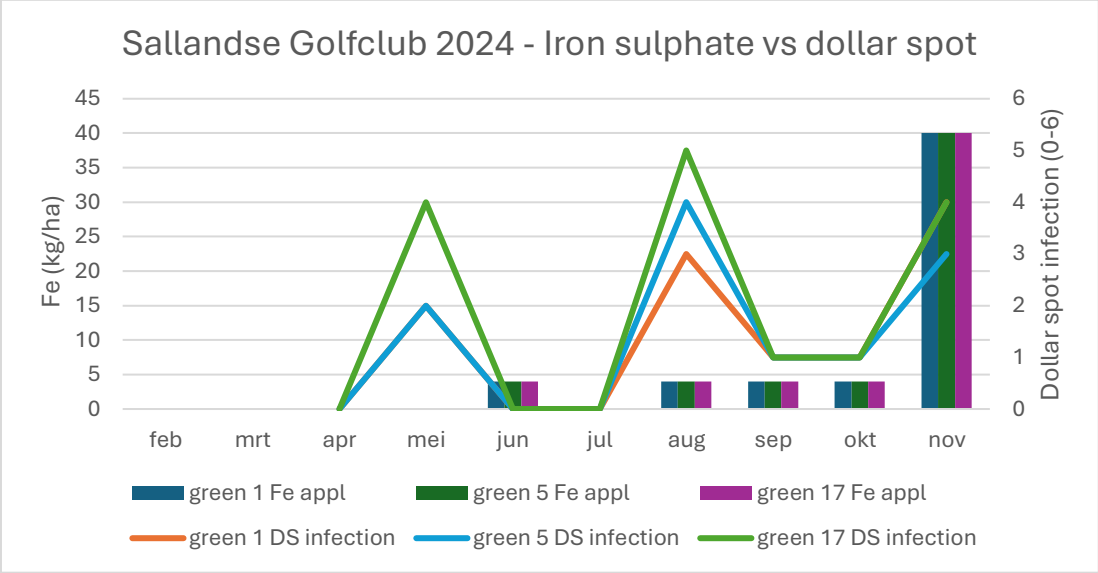


Figure 154: Fe applications vs. dollar spot infections in 2024

E. Cultural Practices: Rolling, Topdressing and Aeration

In the first years of the study, greens were rolled approximately twice per month. In 2024, rolling frequency increased substantially to several times per week.

Table 53: Rolling – topdressing – aeration

	Frequency	Remarks
Rolling 2022	0.5 per week	29
Rolling 2023	0.5 per week	20
Rolling 2024	3.1 per week	27
Topdressing 2022	85 m³/ha	5 × 17 m³/ha
Topdressing 2023	120 m³/ha	6 × 20 m³/ha
Topdressing 2024	120 m³/ha (?)	6 × 20 m³ (?)
Aeration 2022	6× per year	8 mm solid tine
Aeration 2023	7× per year	1× 12 mm deep; rest solid tine
Aeration 2024	7× per year	1× 12 mm deep; rest solid tine

Throughout the seasons, iron was primarily applied via the fertiliser Autumn 6-5-10 +6Fe. Only in 2022 was additional iron sulphate applied, resulting in markedly higher total iron inputs. In 2023, iron applications were reduced and later partly compensated by lawnsand (Black and Green) applications. Persistently wet conditions from mid-October 2023 onwards hampered effective maintenance operations.

F. Playing Quality

Appendix 5 presents stimp, trueness and firmness (Clegg). Below, Clegg values for greens 1, 5 and 17 are shown, with a target range of 80–100 Gm.

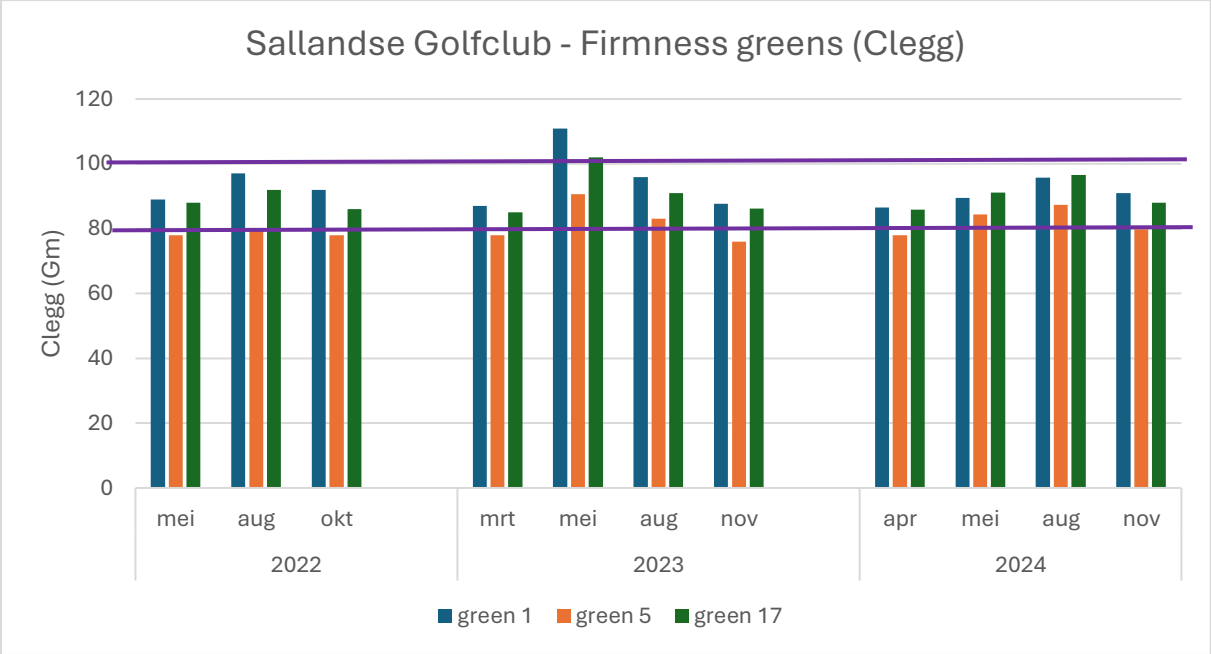


Figure 155: Clegg values over the years

Clegg hammer measurements for greens 1, 5 and 17 generally fell within the target range of 80–100 gravimeters. Correlation analysis revealed no relationship between surface hardness and dollar spot incidence on any of the greens. Based on measured data and field observations, rolling did not contribute to dollar spot reduction at Sallandse; other parameters played a more decisive role.

Insufficient data were available to assess relationships between stimp speed, trueness and dollar spot occurrence.

G. Snow mold (*Microdochium nivale*)

During both spring and autumn of 2022 and 2023, the greens were affected by Fusarium diseases. In autumn, symptoms were most likely summer Fusarium, while in early spring (March) Microdochium patch occurred. Green 5 proved particularly susceptible. Frequent and intensive topdressing combined with regular overseeding reduced Fusarium pressure. It is unknown whether additional fungicides were applied for Fusarium control.



Microdochium patch on green 5.

H. Conclusions

With average dollar spot scores of 1.6, 1.6 and 1.9 for greens 1, 5 and 17, Sallandse Golfclub shows moderate overall susceptibility. However, when considering 2024 alone, scores for greens 1 and 5 increased to 2.3, while green 17 was severely affected with a score of 3.3.

In the dry year 2022, the application of Signum effectively suppressed peak dollar spot activity, resulting in near-zero damage. In contrast, during the wet and highly variable 2024 season, the effect of Signum was marginal, as reflected in the extensive damage—particularly on green 17.

The diversity in green construction types makes Sallandse Golfclub particularly interesting. Soil moisture levels varied strongly between greens: green 1 maintained approximately 20% VWC year-round, with limited fluctuation. Green 5 recorded 0–6 cm values around 35%, while Dutch-constructed green 17 ranged between 25 and 30%.

Organic matter levels on greens 1 and 5 were around or above 3% and are considered adequate. On green 17, organic matter at 4–6 cm was too low. Nutrient supply was generally adequate.

The primary causes of high dollar spot pressure appear to be turf composition (excessive creeping bentgrass resulting in prolonged leaf wetness), reactive rather than preventive management, and reduced plant vitality due to repeated fungicide use.

11. Veluwse Golf Club



Drought conditions at Veluwse Golf Club, June 2023

Overview of dollar spot incidence

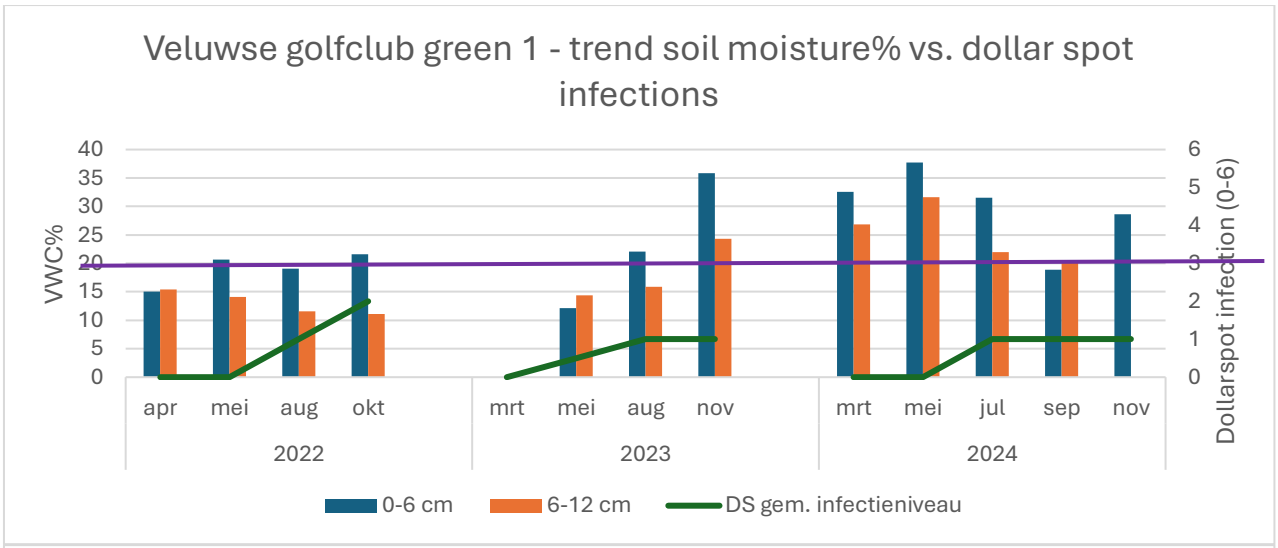
In 2022, dollar spot pressure at Veluwse Golf Club followed a relatively calm pattern. Only a few recurring spots were observed on greens 7 and 3. The situation changed markedly in the summer of 2023, when a sudden and aggressive dollar spot outbreak caused substantial damage. The tolerance threshold was exceeded and, in October of that year, the club decided to apply chemical control. Recovery was relatively rapid, allowing the greens to enter the wet winter of 2024 in reasonably good condition.

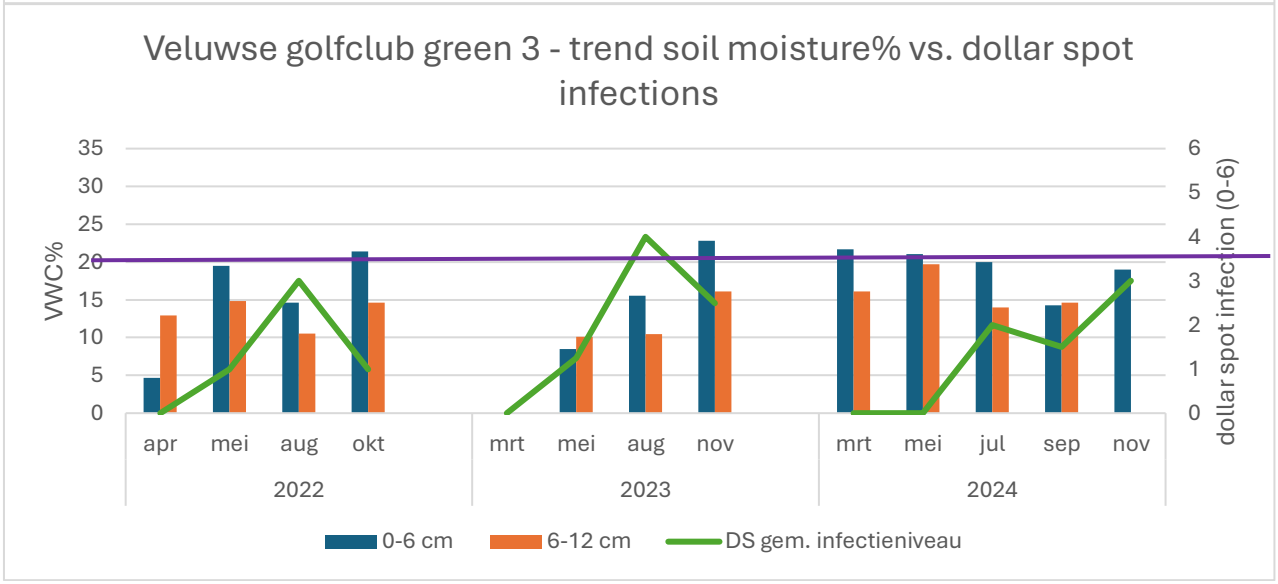
Table 54. Average level of dollar spot infection at Veluwse Golf Club in 2022, 2023 and 2024.

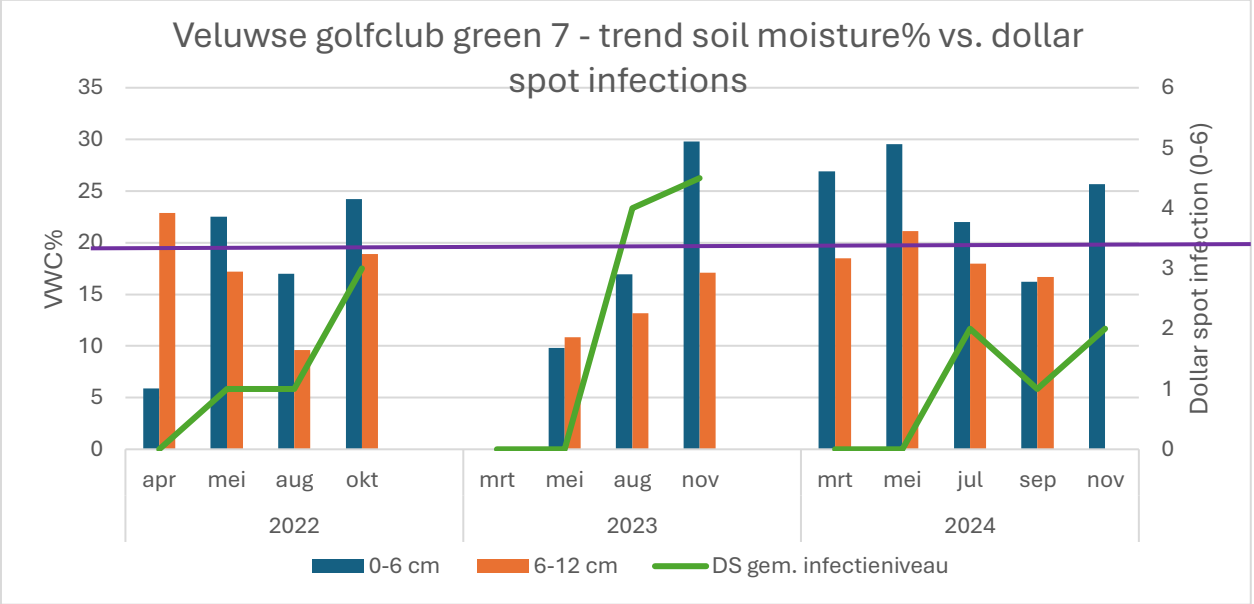
	Green 1	**Green 3**	**Green 7**	**National average DS severity**
2022	0.5	0.8	1.3	1.0
2023	0.5	2.3	3.7	1.8
2024	0.6	1.6	1.0	1.5
Average	**0.5**	**1.9**	**2.8**	

A. Water management

Green 1 differs significantly from greens 3 and 7. Green 1 is a relatively moist push-up green with low susceptibility to dollar spot. Greens 3 and 7, by contrast, are sand-based and drought-prone, as evidenced by the low soil moisture contents measured in 2022 and 2023.







Figures 156–158: Soil moisture trends and dollar spot incidence for greens 1, 3 and 7.

During the 2023 and 2024 seasons, the target value of at least 20% moisture in the 0–6 cm layer was not achieved on greens 3 and 7. The rootzone dried out, became hydrophobic and showed reduced water infiltration. This is further illustrated by infiltration measurements: for greens 3 and 7, infiltration rates were substantially lower than for green 1 (although still acceptable). Notably, at 6 cm below surface, green 1 showed the lowest infiltration rate, likely caused by deeper-lying soil compaction.

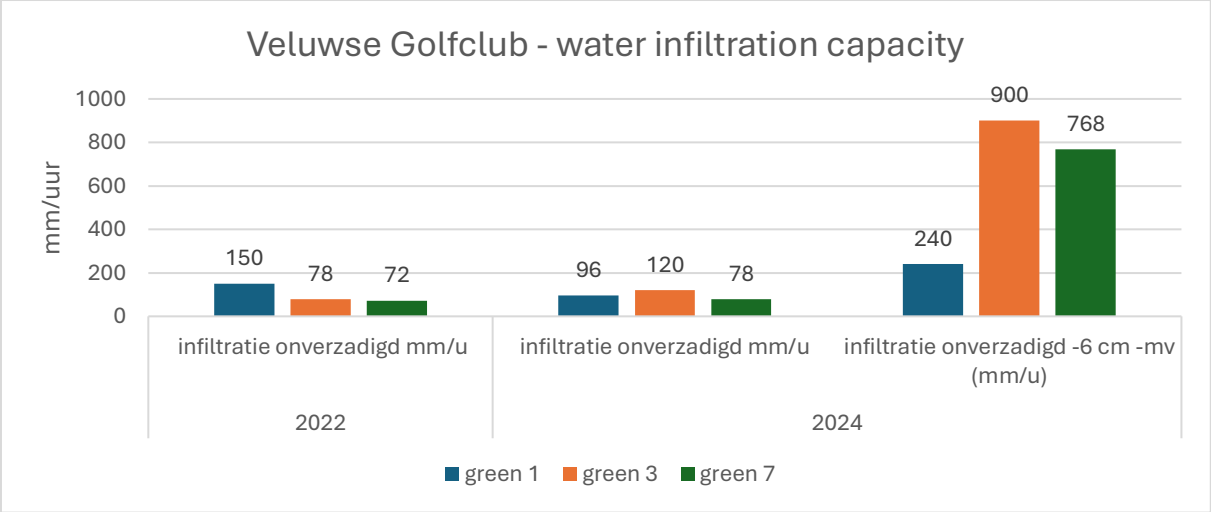


Figure 159: Average water infiltration capacity in year 1 and year 3.

B. Organic matter, C/N ratio and pH

Figure 160 shows that the organic matter content of greens 3 and 7 in the 2–4 cm and 4–6 cm layers is very low compared with the 0–2 cm layer. This partly explains the low soil moisture contents at these depths and the associated drought sensitivity. During prolonged

dry periods with high temperatures, both greens experience drought stress more readily, which acts as a strong trigger for dollar spot.

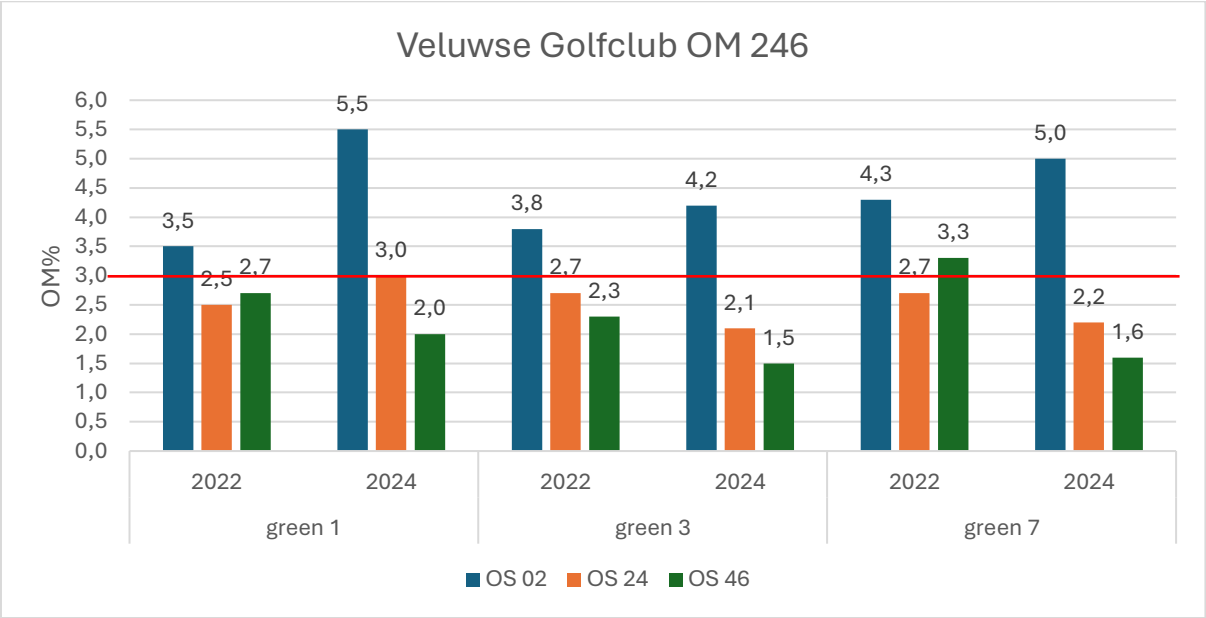


Figure 160: Organic matter (0–2, 2–4 and 4–6 cm) development in year 1 and year 3.

The C/N ratio fluctuates considerably and is highest for green 7 when averaged over the three years. A striking observation is the strong decline in the C/N ratio of green 1, from 16 to 6.

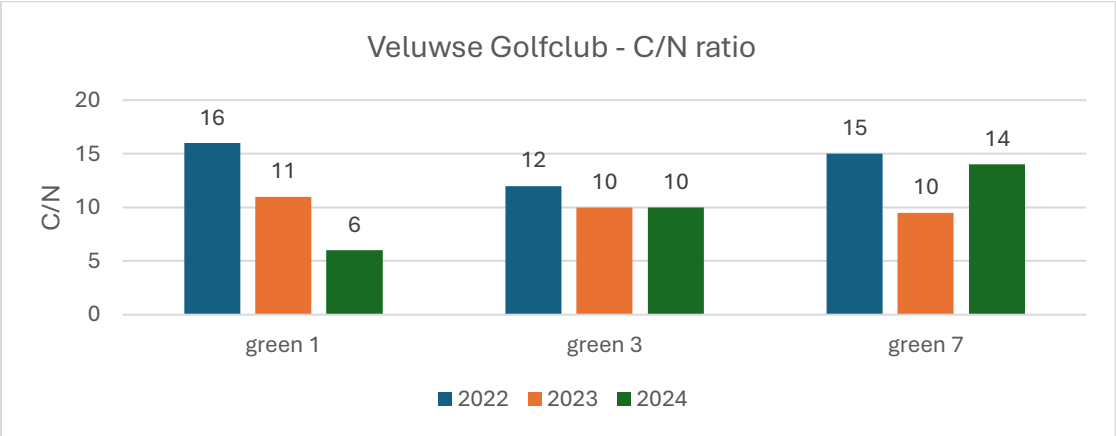


Figure 161: C N ratios.

Soil pH remained fairly constant throughout the project. Typical for a woodland course, pH values were low, ranging between 4.1 and 4.5 for all greens.

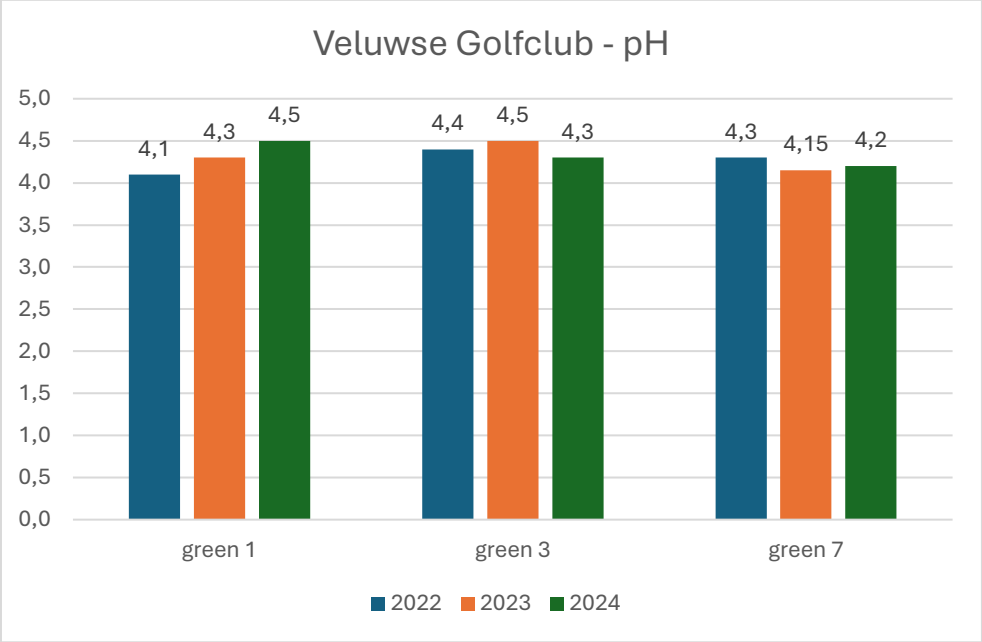


Figure 162: pH trends.

C. Turf composition and overseeding

Browntop bentgrass (*Agrostis capillaris*) is the dominant turf species on all greens. Figure 163 illustrates changes in turf composition over time. Each year, overseeding is carried out after hollow-tine aeration using mini-tines. Seed mixtures consist of bentgrass and red fescue; however, based on the turf composition over the years, establishment of red fescue has been largely unsuccessful.

See Appendix 4 for the full overseeding programme and seed mixtures.

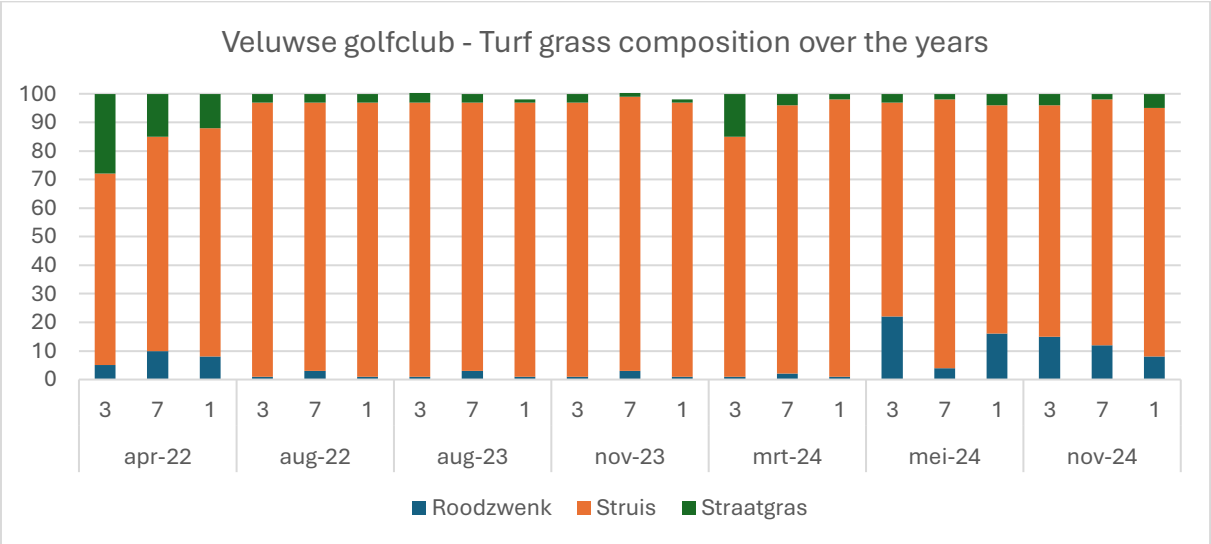


Figure 163: Turf composition over time.

D. Nitrogen and iron (sulphate) fertilisation

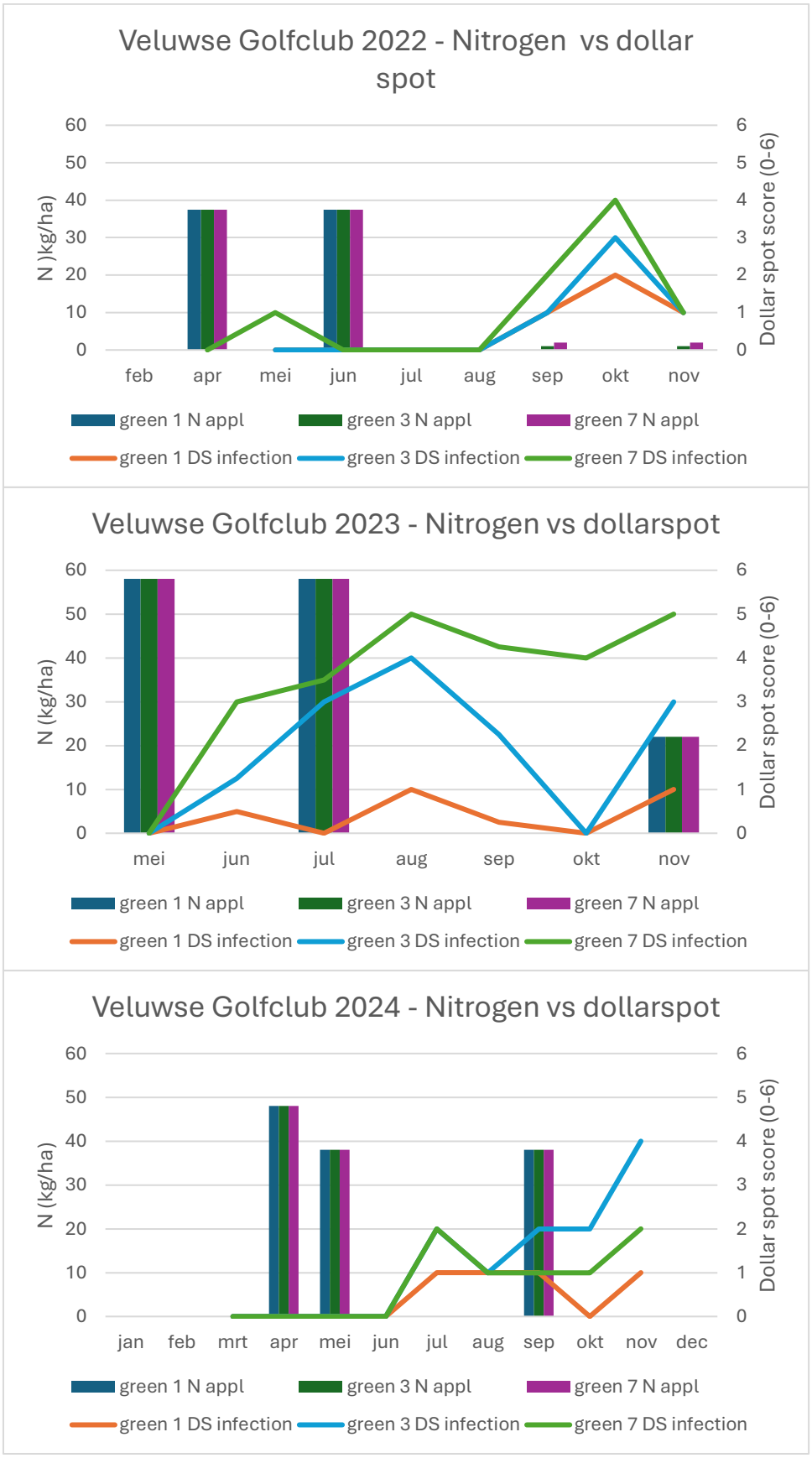
In 2022, fertilisation levels at Veluwse Golf Club were broadly in line with national averages. In the two subsequent years, higher nitrogen inputs were applied. Fertilisation is carried out two to three times per year, mainly in spring. Nitrogen is applied exclusively in granular form, using fertilisers such as 12-0-12 and 16-0-16, supplemented with magnesium and 2% iron. Applications are made in two to three relatively large doses; no frequent low-rate adjustments are made in response to turf demand.

Table 55. Nitrogen inputs in relation to dollar spot pressure at Veluwse Golf Club.

	Total N (kg/ha)	National average N (kg/ha)	Avg. DS severity	National avg. DS
2022	75	79	0.8	0.9
2023	138	76	2.2	1.7
2024	124	88	1.1	1.6

In 2022, the final major nitrogen application was already made in June. No further nitrogen was applied later in the season, including around the time when dollar spot developed in autumn. In 2023, two large nitrogen applications were made, yet dollar spot was already active early on greens 3 and 7, resulting in severe damage on green 7. The damage threshold was exceeded and fungicides were applied late in the season. With an extremely wet winter ahead, this chemical intervention proved beneficial for turf recovery. Combined with mechanical practices and overseeding, playability was quickly restored.

In 2024, nitrogen inputs were again relatively high and had a reasonably positive effect on dollar spot pressure. Disease activity persisted, but did not result in severe damage. Plant protection products (Signum) were applied, though not on the monitored greens.



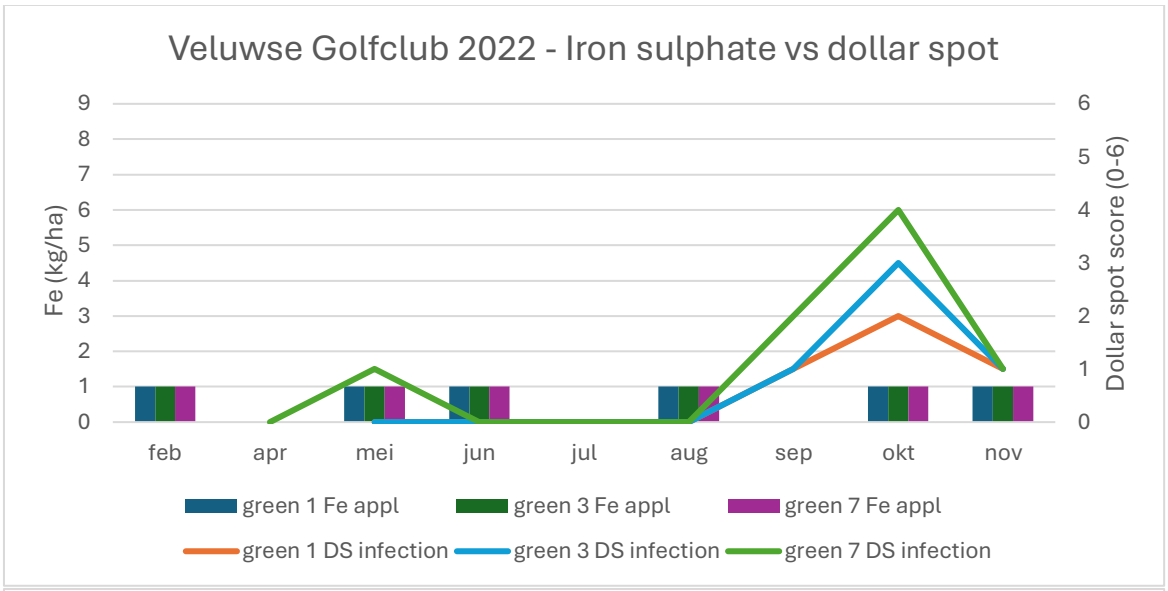
Figures 164–166: Nitrogen applications versus dollar spot development in 2022–2024.

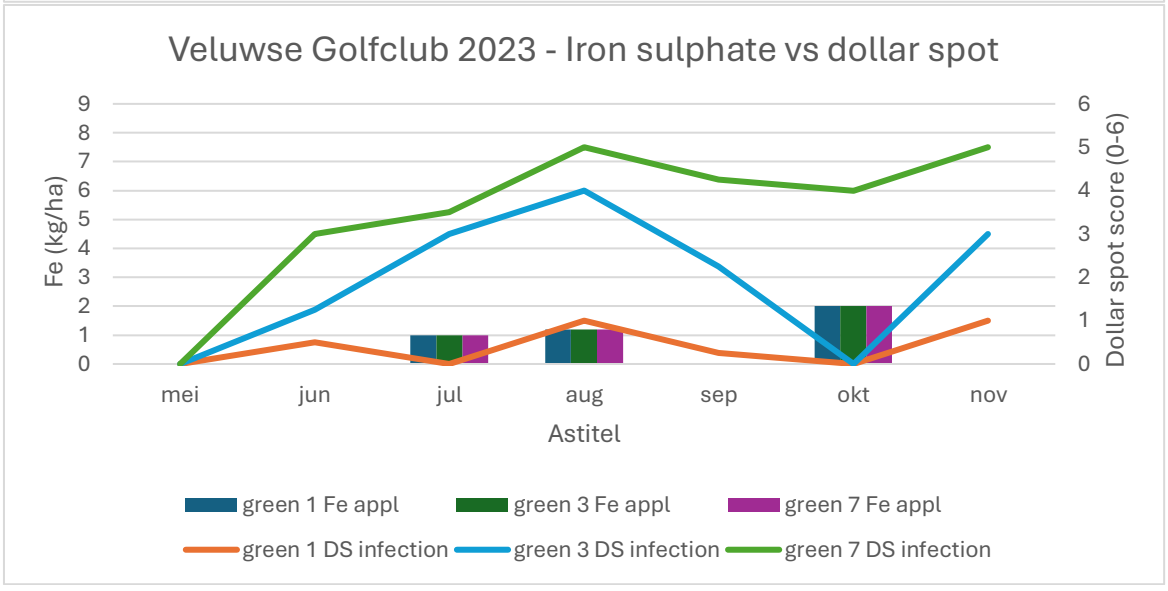
Only limited amounts of iron sulphate were applied to the greens. Table 56 shows that with less than 10 kg/ha of pure Fe in 2022 and 2023, iron inputs were exceptionally low compared with national averages.

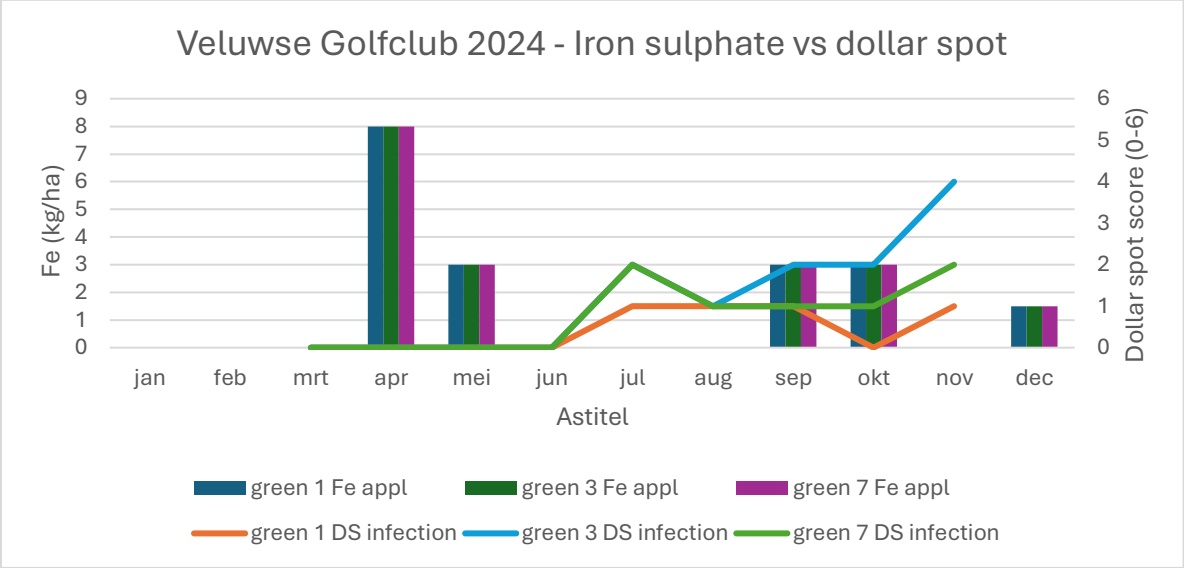
Table 56. Iron sulphate use in relation to dollar spot pressure at Veluwse Golf Club.

	Total Fe (kg/ha)	National average Fe (kg/ha)	Avg. DS severity	National avg. DS
2022	6	48	0.8	0.9
2023	4	47	2.2	1.7
2024	18	38	1.1	1.6

Iron sulphate was applied sporadically in 2022 and 2023. Following the severe dollar spot outbreak in 2023, the greenkeeper decided to slightly increase iron use in 2024, although overall application rates remained low.







Figures 167–169: Iron applications versus dollar spot development.

E. Cultural practices: rolling, topdressing, aeration and other measures

Table 57. Summary of rolling, topdressing and aeration practices.

Practice	Year	Frequency	Remarks
Rolling	2022	≤1×/week	As required, depending on growth rate
	2023	≤3×/week	Based on growth rather than mowing
	2024	≤1×/week	As required
Topdressing	2022	90 m³/year	15 m³ per application; first pass combined with vertical mowing
	2023	~90 m³/year	5 applications (~1.5 m³ per green)
	2024	Same as 2023	Same
Aeration	2022	Monthly	8 mm & 6 mm solid tines; 1× hollow tines with mini-tines
	2023	1×	Deep aeration 12 mm in July; selective hollow-tining and overseeding
	2024	2×	8 mm solid and 6 mm hollow tines

In addition to nitrogen fertilisation with 12-0-12 and 16-0-16, supplementary trace elements and seaweed products were applied in 2023.

F. Playing quality parameters

Appendix 5 provides an overview of playing quality parameters: Stimpmeter speed, trueness (holing-out test) and firmness (Clegg hammer). Figure 170 presents Clegg values for greens 1, 3 and 7, using a target range of 80–100 gravimeters.

Correlation analysis revealed only a weak negative correlation between firmness and dollar spot occurrence on green 7, suggesting a tentative indication that higher firmness may reduce dollar spot on this green. Continued rolling and Clegg measurements are recommended to confirm this relationship. No correlation was found for greens 1 and 3.

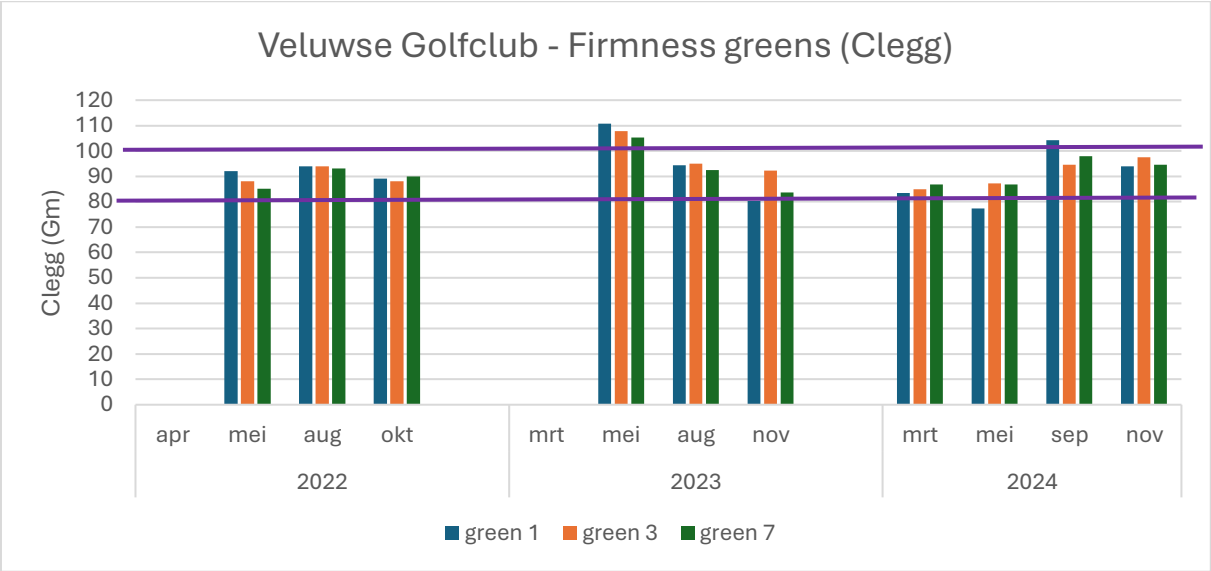


Figure 170: Clegg values over time.

Insufficient data are available for Stimp and trueness to assess any relationship with dollar spot.

G. Snow mold (*Microdochium nivale*)

Only in the 2022 season did all greens show moderate snow mould infection (score 2). No notable infections were observed thereafter.

H. Conclusions

For many years, Veluwse Golf Club managed fungal diseases without the use of chemical plant protection products. In 2023, however, fungicide application became unavoidable. In hindsight, this could likely have been prevented.

Differences in disease severity between the greens are substantial. Green 1 consistently maintained scores of 0.5–0.6, whereas green 3 increased from 0.8 to 2.3 in 2023, and green

7 rose from 1.3 in 2022 to 3.7 in 2023. In 2024, control over disease pressure appeared to be partially restored.

Key findings include:

- Organic matter content at 4–6 cm depth on greens 3 and 7 is well below 2.0%. The overlying layer is also low. These levels are insufficient to provide resilience against diseases such as dollar spot.
- Water infiltration capacity at 6 cm below surface is high, resulting in low water retention in the upper profile and high drought susceptibility. Late-season deep aeration is therefore strongly discouraged.
- During May–August 2023, repeated measurements (including additional site visits) showed soil moisture contents on greens 3 and particularly 7 dropping well below 15% at both depths. This is undesirable given the increasing dollar spot pressure at that time, especially as green 7 was already known to be more susceptible.
- Soil pH on all greens remained below 4.5, consistent with expectations for a woodland course. Given the consistently good quality of green 1, pH was not a determining factor for dollar spot.
- In 2023 and 2024, relatively high nitrogen inputs were applied. However, frequent heavy rainfall events likely resulted in leaching and runoff losses, reducing nitrogen availability to the turf. Limited buffering capacity (low organic matter) led to nutrient deficiencies and plant stress.
- Higher iron sulphate application rates could likely have prevented the aggressive expansion of dollar spot.



12. Golf Club ’t Zelle



Dew (with webs) on green 8 after a clear night, Golf Club ’t Zelle, April 2023.

Dollar spot development

As on other golf courses, dollar spot pressure at ’t Zelle was still relatively low in 2022 and could be managed well in day-to-day greenkeeping. Weather conditions—especially early in the year—were favourable: dry and cold, meaning fungal activity did not develop into visible damage.

In 2023, dollar spot struck all monitored greens in July—somewhat later than on other courses—but pressure persisted until late in the season. In particular, green 18 entered the wet winter in poor condition, with the familiar dollar spot damage still present. As a result, new symptoms appeared early in spring 2024 on old damage areas. Even the relatively healthy green 8 experienced more dollar spot than usual in 2024.

The table below shows the annual mean scores per green. Except for green 8 in 2023, all greens performed above the national level with regard to average dollar spot severity.

Table 58. Average level of dollar spot infection at Golf Club ’t Zelle in 2022, 2023 and 2024.

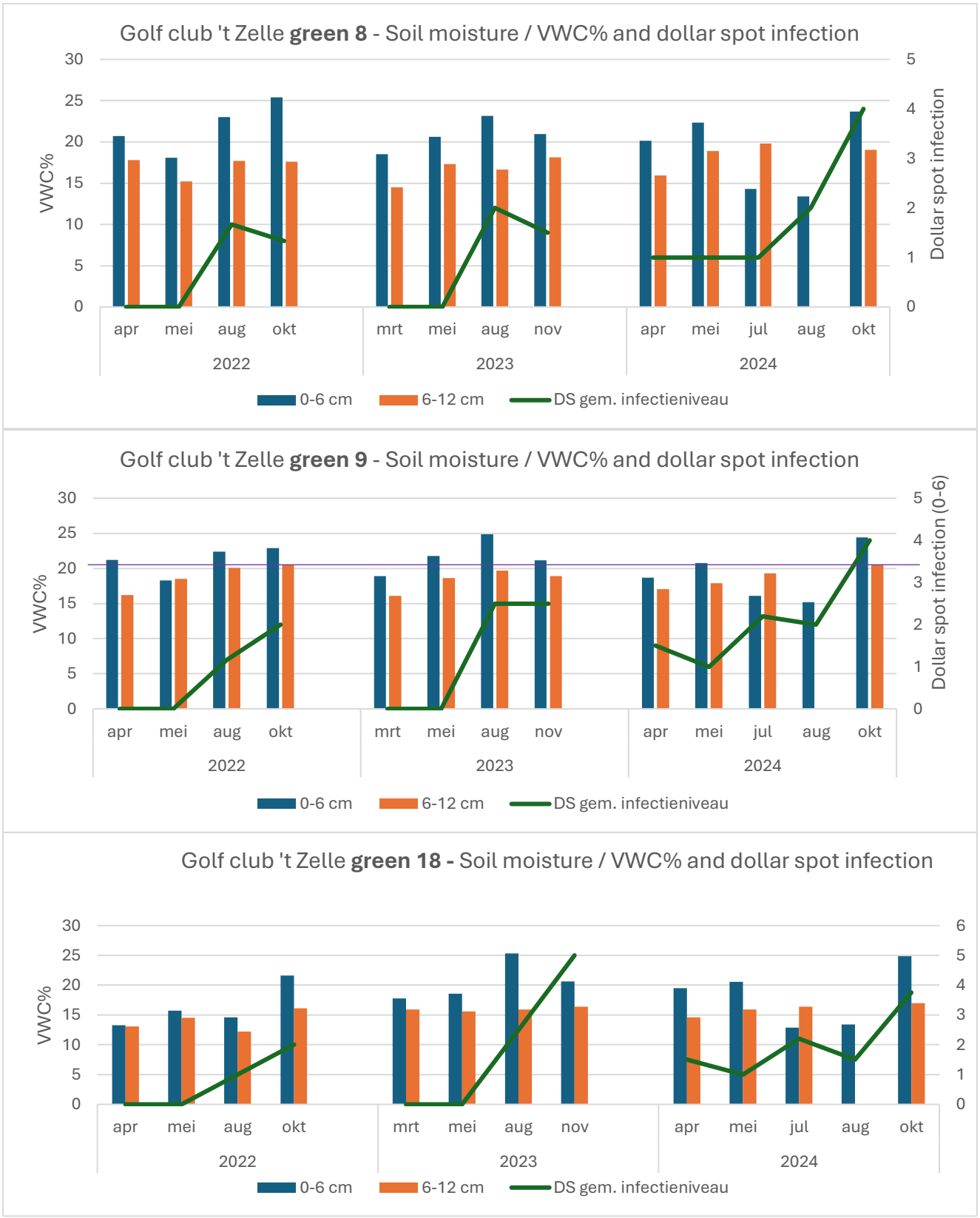
	Green 8	Green 9	Green 18	National average DS severity
2022	1.4	1.2	1.2	1.0
2023	1.5	2.4	2.7	1.8
2024	1.8	2.4	1.8	1.5
Average	**1.6**	**2.1**	**2.1**	

See Appendix 3 for the Smith Kerns forecasts per green plotted against the actual infection levels on the monitored greens at Golf Club ’t Zelle.

A. Water management

Soil moisture management plays an important role in the greenkeeping strategy at ’t Zelle. Using soil sensors, moisture percentages are monitored intensively. The aim—given the specific rootzone top layers—is to maintain 15–20% volumetric water content (VWC) at 6 cm depth. During the assessment rounds, measurements on greens 8 and 9 generally fall within this range. Moisture values on green 18, however, occasionally drop below 15% at both 0–6 cm and 6–12 cm.

Low moisture levels are not necessarily problematic when meteorological parameters such as relative humidity and mean daily temperature are also low. Under those conditions, dollar spot is usually less active (although still present). This helps explain the limited dollar spot pressure in 2022. The year 2023 was characterised by stronger extremes, such as cold and wet periods followed abruptly by prolonged drought and heat. Especially during drought, the turf requires sufficient water buffering capacity in the upper rootzone. For that reason, the target band shown in the graphs below has been raised to 20%.



Figures 171–173: Soil moisture trends and dollar spot incidence for greens 8, 9 and 18.

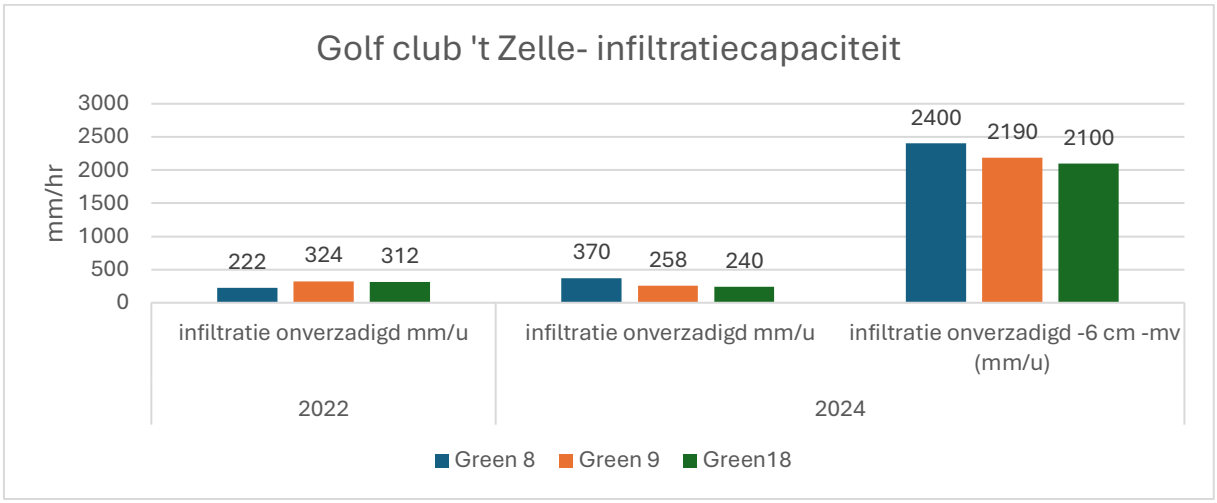


Figure 174: Average water infiltration capacity in year 1 and year 3.

Infiltration rates are very good. Measured at the surface, infiltration is well above 200 mm per hour, and at 6 cm depth even exceeds 2000 mm per hour.

B. Organic matter, C/N ratio and pH

Organic matter levels (0–2, 2–4 and 4–6 cm) are shown below. The line at 3% indicates the (minimum) target value. The measured values are nicely around or above this line. Low organic matter levels therefore do not appear to be the trigger for dollar spot at ’t Zelle.



Figure 175: Organic matter (0–2, 2–4 and 4–6 cm) development in year 1 and year 3.

The C/N ratio was determined annually and shows that the most dollar-spot-sensitive green (18) has a distinctly lower C/N than greens 8 and 9. Apparently, more conversion (mineralisation) takes place in the upper rootzone of green 18 and less organic matter is being built up than in greens 8 and 9.

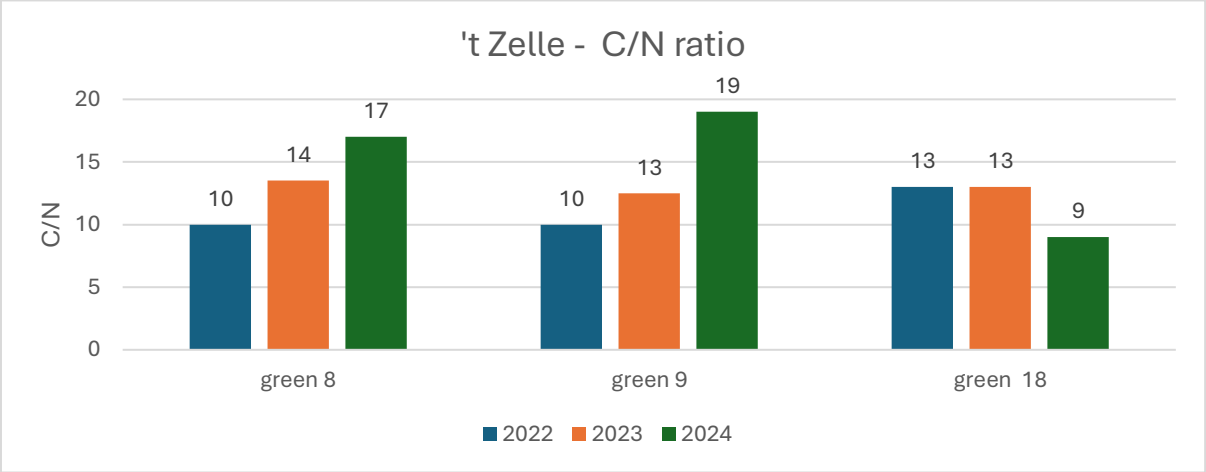


Figure 176: C/N ratios.

Soil pH is high. In 2022 and 2023, pH values for all greens were around 6, but in 2024 green 18 stands out with a pH of 7.2. In general, higher pH is associated with more active soil biology.

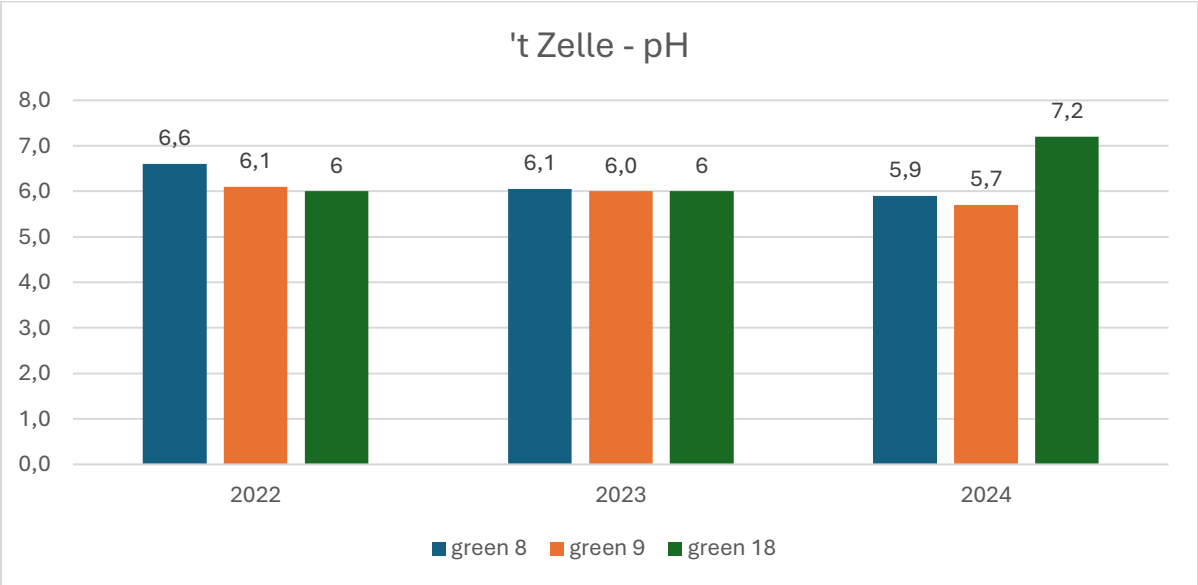


Figure 177: pH trends.

C. Turf composition

The sward consists of a mix of bentgrass and red fescue, plus a small proportion of annual meadow-grass (*Poa annua*). In the final year, bentgrass became more dominant. Green 8 contains the highest proportion of red fescue. Overseeding is carried out several times each

year, alternating between 100% browntop bentgrass and 100% red fescue. In 2022, overseeding was performed three times per year; in 2024 this increased to five times. Appendix 4 contains the overseeding programme, including the seed mixtures used.

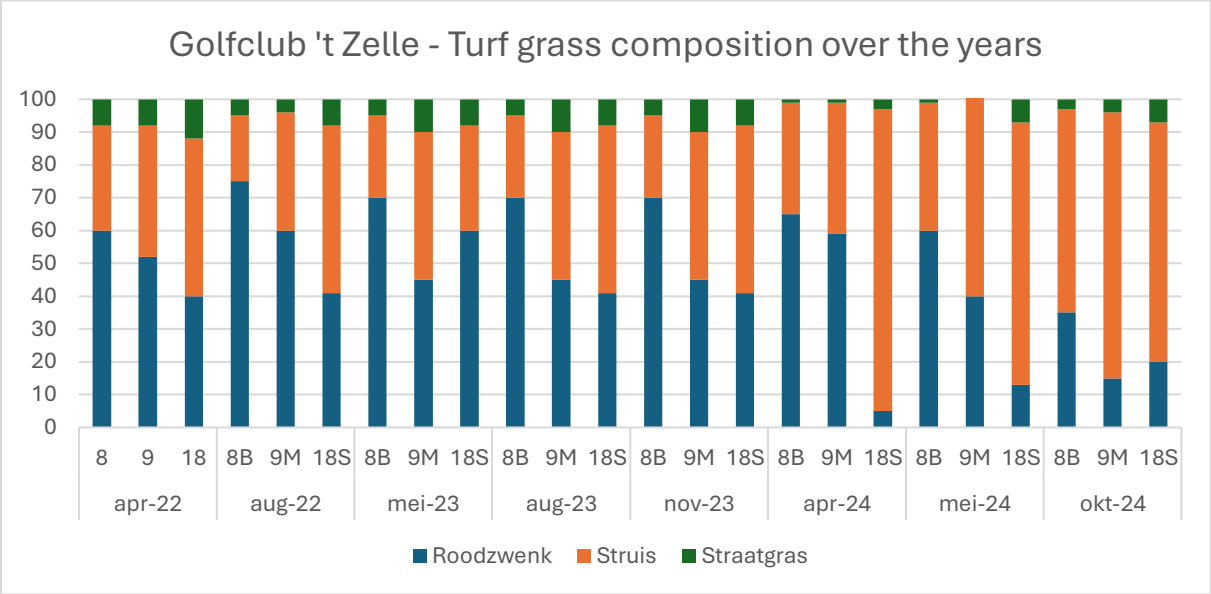


Figure 178: Turf grass composition development.

D. Nitrogen and iron (sulphate) fertilisation

Nitrogen was applied mainly as ammonium sulphate. In 2022 and 2024 it was applied early in the season; in 2023 not until June due to poor (wet) conditions. Total nitrogen inputs were lower in all years than the national average amount applied (granular and spray).

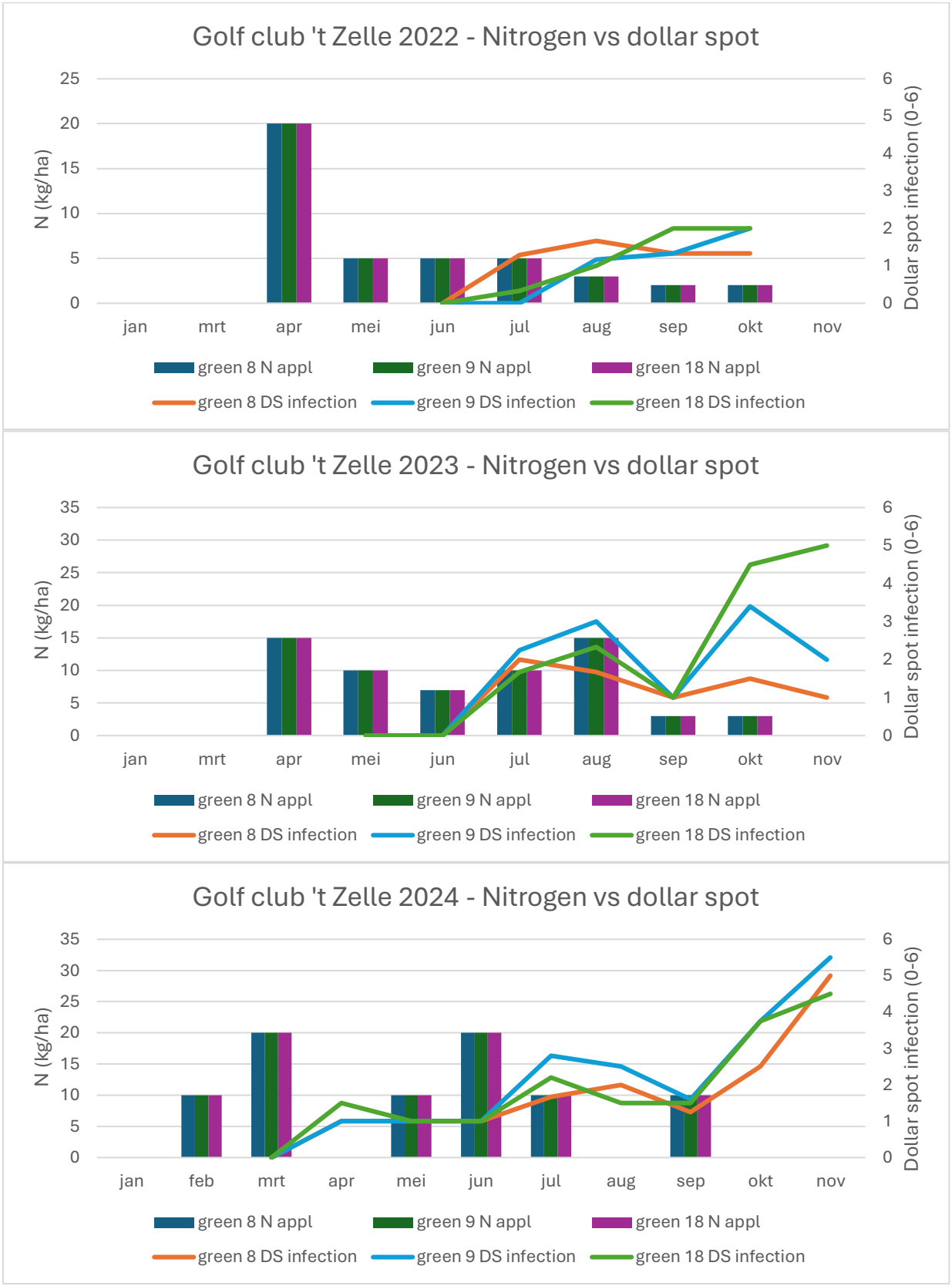
Table 59. Nitrogen inputs in relation to dollar spot pressure at Golf Club 't Zelle.

	Total N (kg/ha) – 't Zelle	National average N (kg/ha)	Avg. DS severity (0–6)	National avg. DS
2022	40	79	1.2	1.0
2023	62	76	2.2	1.8
2024	80	88	2.1	1.5

In 2022, weather conditions remained favourable into summer. Dollar spot infections occurred on all greens, but—unlike subsequent years—did not expand further. In 2023 and 2024, disease pressure (including fusarium) was high.

Nitrogen is applied in small amounts in various forms across all greens, but the greens respond very differently. The core fertiliser programme at 't Zelle consists of one or two granular applications per year, with all remaining inputs applied as liquids through a range of products. Section E (Cultural practices) lists formulations and products. The full programme is also included in the appendix "Forms Golf Club 't Zelle". The diversity—and overall

intensity—of the programme makes it difficult to assess whether nitrogen rates and timing are optimal. Part 4 will address this in more depth under “diagnosis”.



Figures 179–181: Nitrogen applications versus dollar spot development in 2022–2024.

The table below shows total iron (sulphate) inputs. With increasing dollar spot pressure, iron sulphate use also increased.

Table 60. Iron (sulphate) use in relation to dollar spot pressure at Golf Club 't Zelle.

	Total Fe (kg/ha) – 't Zelle	National average Fe (kg/ha)	Avg. DS severity (0–6)	National avg. DS
2022	28	48	1.2	1.0
2023	44	47	2.2	1.8
2024	50	38	2.1	1.5

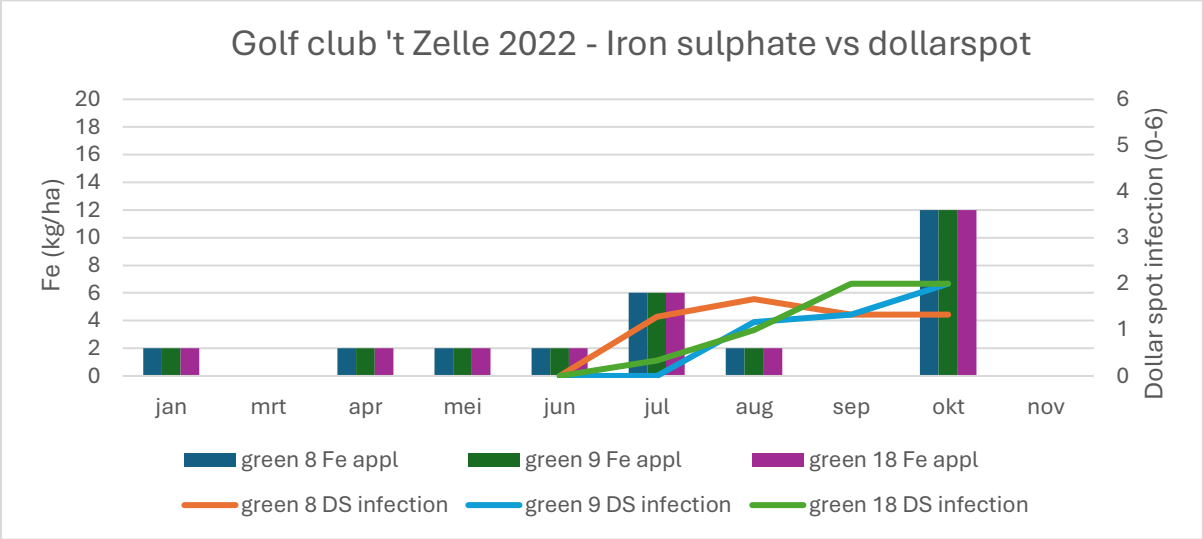


Figure 182: Iron applications versus dollar spot development in 2022.

In 2022, a dry, cold spring kept dollar spot pressure low across all greens. Small amounts of iron sulphate helped protect the turf. Here, iron sulphate mainly acted as a foliar feed and helped protect leaf tissue against potential infections. In the second half of summer, dollar spot activity increased, but damage remained very limited.

In early 2023, iron inputs during the cold, wet spring were a response to widespread snow mould on greens 9 and especially 18. With rising temperatures, humidity and increasing Smith Kerns forecast curves, dollar spot developed strongly from June onwards and caused damage (score 3 on green 9). Despite a lawnsand application in October (too late?), dollar spot struck again in a more aggressive form, also driven by the warm, humid autumn that year.

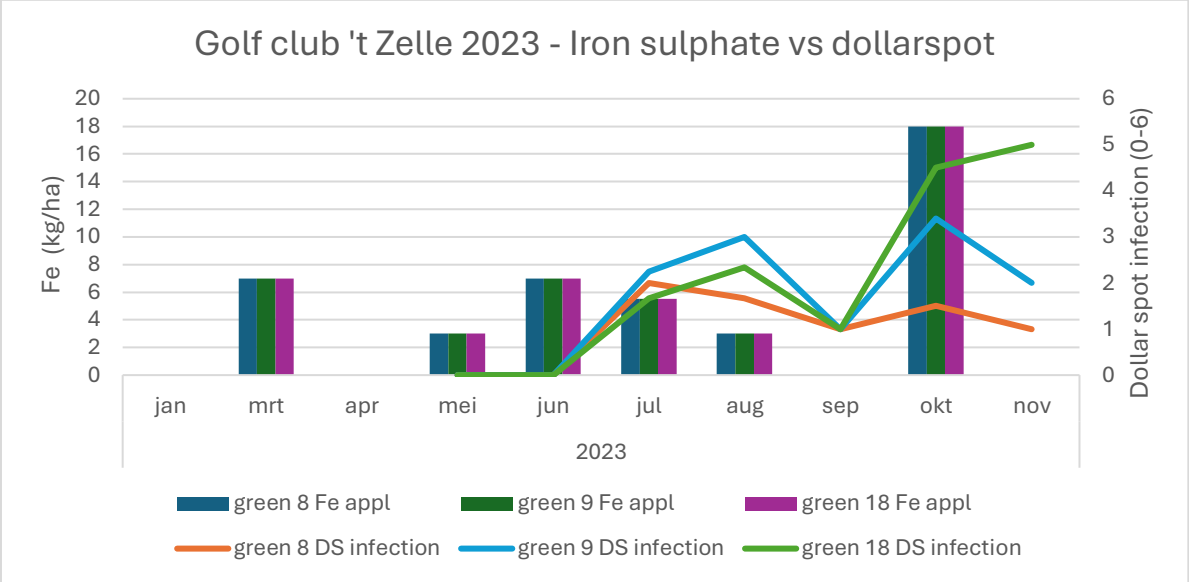


Figure 183: Iron applications versus dollar spot development in 2023.

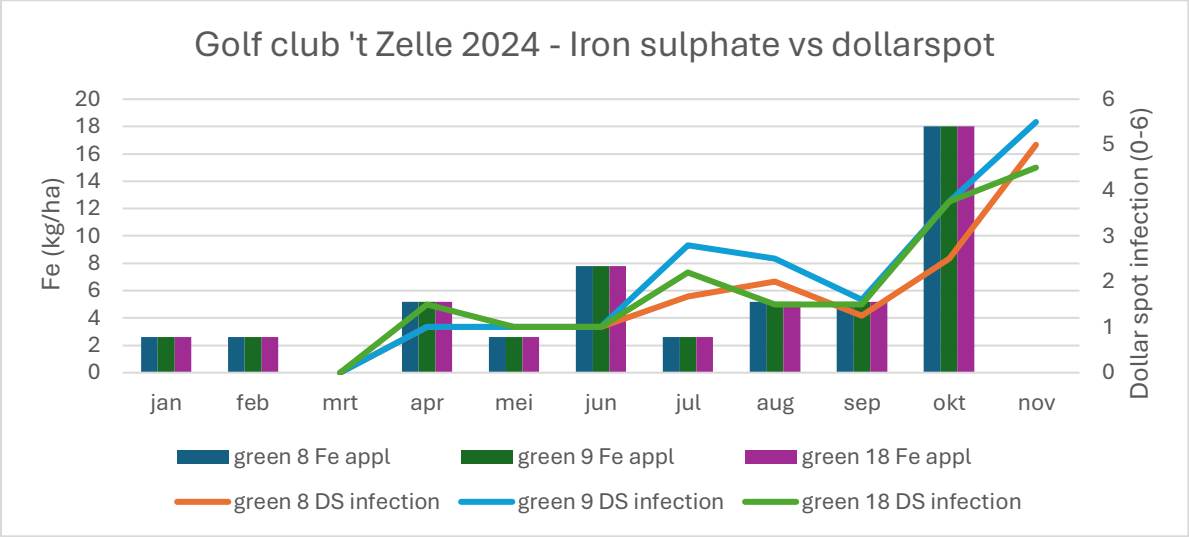


Figure 184: Iron applications versus dollar spot development in 2024.

In 2024, recovery did not occur; the slightly higher iron total (50 kg Fe) did not lead to reduced dollar spot. Damage from the 2023 autumn outbreak and the subsequent wet winter of 2023/2024 did not heal sufficiently, leaving turf susceptible to fungal infection. Even the normally more vigorous green 8 experienced a major dollar spot attack in autumn 2024. Here too, lawnsand appears to have been insufficient—possibly also a matter of timing.

E. Cultural practices: rolling, topdressing, aeration and other measures

Golf Club ’t Zelle operates an extensive treatment programme for its greens. The underlying approach is to stimulate soil biology in the upper rootzone layers, aiming to produce more robust and vital greens. In addition to base fertilisation with ammonium sulphate and

granular organo-mineral nitrogen (including products from Melspring), supplementary fertilisers, biostimulants, seaweed products and wetting agents are also used. These products are often applied in combination—i.e., mixed together in the same tank mix.

On top of this, mechanical practices are carried out. The table below summarises rolling, topdressing and aeration. For a graphical overview of topdressing volumes per year, see Appendix 6.

Table 61. Rolling, topdressing and aeration practices.

Practice	Year	Frequency	Remarks
Rolling	2022	2.0× per week	38 rolling weeks
	2023	1.0× per week	20 rolling weeks
	2024	2.5× per week	27 rolling weeks
Topdressing	2022	100 m³	5×
	2023	66 m³	6×
	2024	180 m³	10×
Aeration	2022	3×	Verti-drain 8 mm / 20 cm + Maredo 6 mm / 4 cm + ProCore 10 mm / 3–5 cm
	2023	5×	Verti-drain 8 mm / 20 cm; 3× Maredo 6 mm / 4 cm + ProCore 10 mm / 3–5 cm
	2024	4×	Same as 2023 for Verti-drain; 3× Maredo 4 mm / 3–4 cm

As dollar spot activity increased, an increase is also seen in the frequency of rolling, topdressing and aeration. In 2024, almost three times more pure sand was applied than in the year before.

F. Playing quality parameters

Appendix 5 provides the playing quality parameters: Stimpmeter speed, trueness (holing-out test) and firmness (Clegg hammer). The Clegg values for greens 8, 9 and 18 are shown in a column chart, using a target range of 80–100 gravimeters.

Correlation analysis indicates that none of the greens show a correlation between firmness and the occurrence of dollar spot. Based on measured data and the information collected, rolling at ’t Zelle had little to no effect on reducing dollar spot. Other parameters played a more decisive role.
Insufficient data are available for Stimp and trueness to assess any relationship with dollar spot.

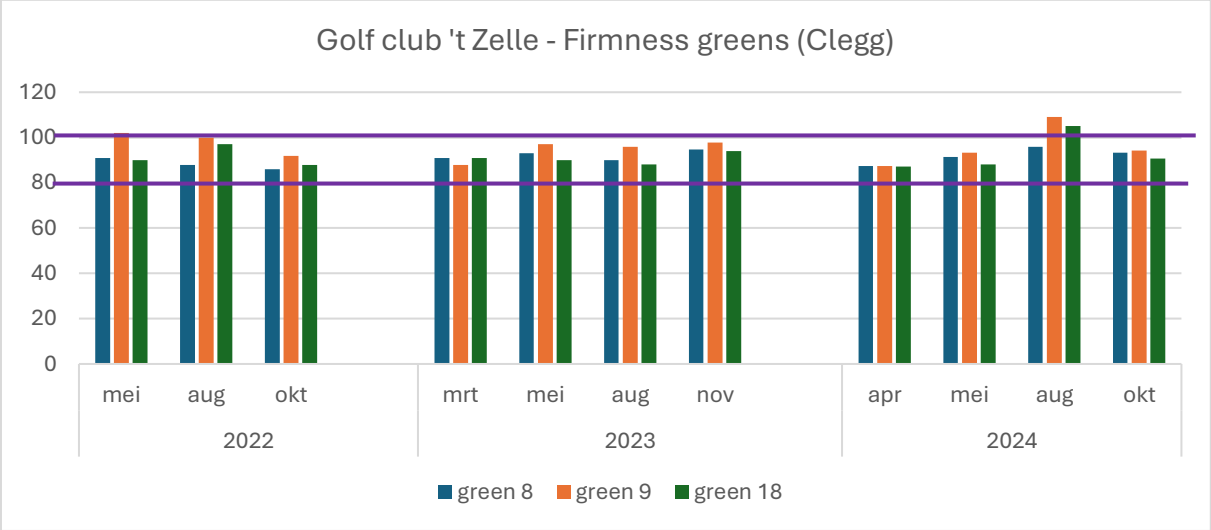


Figure 185: Clegg values over time.

G. Snow mold (*Microdochium nivale*)

Greens 9 and 18 had moderate to severe snow mould infection during the autumn and winter season 2022/2023. Afterwards, the disease was managed well, but by late 2024 a significant infection (score 5) occurred again on green 9.



Snow mold on green 18, March 2023.

H. Conclusions

At Golf Club ’t Zelle, the number of dollar spot infections has increased since the start of the study—not only in frequency, but also in severity. Green 18, and to a slightly lesser extent green 9, suffered heavily from aggressive dollar spot and snow mould attacks in spring and autumn. The 2023/2024 season was particularly extreme. Nevertheless, from a playing-quality perspective, the damage threshold was not exceeded, although the club was leaning towards applying fungicides from summer 2024 onwards. Despite the damage observed, there is certainly no need to use Signum in 2025:

- Of all participating golf courses, ’t Zelle is the only one that records data intensively on a large scale. The club operates a weather station equipped with sensors that record not only meteorological data (rainfall, temperature, evapotranspiration) but also soil (physical) parameters such as soil moisture (%), matric potential (suction), and soil temperature. The goal is doing green management based on or supported by these data—for example, determining irrigation timing based on measured moisture levels.
- With regard to data driven management, a target range of 15–20% volumetric water content at 6 cm depth has been used to date. In practice, this range appears too low for the monitored greens during the most disease-sensitive period of the year (June–September) to keep the turf sufficiently resilient against dollar spot.
- In addition, infiltration capacity on all three greens is extremely high, meaning less moisture is retained and sensitivity to drying is high. Moreover, frequent topdressing increases porosity, leading to high air exchange and increased conversion processes. If deep aeration is also performed to at least 15 cm, it becomes logical that snow mould can gain an opportunity to infect the greens.
- Soil pH values are around or above 6. On green 18, a pH of 7.2 was even measured in 2024. An excessively high pH can disrupt soil biological functioning and nutrient transformations in the upper rootzone.
- Organic matter levels are sufficient.
- Although sufficient amounts were applied in 2023 and 2024, nitrogen and iron (sulphate) did not sufficiently limit dollar spot damage. The explanation likely lies in timing of application and possibly in product interactions. Because many products are applied together in a single operation, it is not possible to determine which product contributed (or did not contribute) to improved green quality.

PART 4: MANAGEMENT STRATEGIES (BMP) – THE "CONTROL LEVERS"

4.1 Best Management Practices – course profile

In this section, a profile is described for each golf course, based on three seasons of measurements, field assessments, and knowledge of the existing maintenance programme. The profiles focus on the **Best Management Practices (BMPs)** applied by each course that have proven effective in controlling dollar spot (and, in particular, limiting damage caused by dollar spot). The guiding principle is not to use plant protection products—or to use them as little as possible, and only incidentally.

To this end, we refer back to the characterisation of course and greens using a number of BMP "control levers" (management strategies).
Note: within a single course, different strategies may apply to the three monitored greens. Each course is unique, and variation also exists within a course: greens can differ substantially.

Figure 186 shows the change in qualification per green since the start of the study in April 2022. The monitored greens were reclassified based on their dollar spot resilience. Changes were observed at Amsterdamse Golfclub, Edese Golfclub, Sallandse Golfclub, Golfclub 't Zelle, Utrechtse Golfclub De Pan, and Veluwse Golfclub. At the remaining courses, the "best", "average", and "poor" greens retained their 2022 classification. The question is what did—or did not—change that caused greens to remain stable in quality or shift towards a better or poorer category.

Banen	mrt-22 B/M/S	dec-24 B/M/S
AGC 18	B	S
AGC 3	S	B
AGC 6	M	M
A'weerd 11	S	S
A'weerd 18	B	B
A'weerd 4	M	M
Bentwoud 4A	S	S
Bentwoud 4B	M	M
Bentwoud 4C	B	B
Domburg 7	B	B
Domburg 8	S	S
Domburg 9	M	M
Ede 14	S	S
Ede 5	B	M
Ede 9	M	B
Geijs 17	B	B
Geijs 6	M	M
Geijs 8	S	S
Lauswolt 11	S	S
Lauswolt 17	M	M
Lauswolt 4	B	B
Links Valley 2	S	S
Links Valley 6	M	M
Links Valley 9	B	B
Salland 1	S	B
Salland 17	B	S
Salland 5	M	M
t Zelle 18	M	S
t Zelle 8	B	B
t Zelle 9	S	M
UGC 16	B	B (M)
UGC 17	S	M (B)
UGC 2	M	S
VGC 1	M	B
VGC 3	S	M
VGC 7	B	S

Figure 186: change in quality classification per monitored green.

The profile of each golf course outlines the approach to greenkeeping—without needing fungicides.

Cultural practices

Each profile describes the approach based on the following focus areas:

1. **Nutrient management** (including the use of iron and other trace elements)
2. **Organic matter management**
3. **Water management**
4. **BMP operations** such as rolling, topdressing, aeration, and (dew) irrigation
5. **Turfgrass composition**

A potential number 6 would be **“plant vitality”** and/or **“soil biology”**. This theme was only included at the end of the multi-year project and there is (still) insufficient data. Part 5 touches briefly on this topic.

Green construction and construction type are fundamentally important in each profile and are treated here as a given baseline condition.

Playability and performance

Ultimately, this is about the golf game and supporting the golfer. Ball roll speed, trueness, and surface firmness are key conditions for optimal putting (holing out). The relative importance assigned to these aspects differs per course and depends on factors such as the club's mission and status, the tournament schedule, and the intensity of play (rounds per year).

The impact of dollar spot (damage) varies by course. The point at which the **damage threshold** is considered exceeded differs by course and by time of year. The competition and tournament calendar can be decisive in this.

In addition, it is highly desirable for clubs to develop a growing awareness of the **living playing surface** (turf) and the sustainability considerations that come with it. Knowledge transfer to the club is a key prerequisite. Conversely, it is equally important that players communicate their expectations to the greenkeeping team.

In summary, **playing quality, acceptance, awareness, and knowledge transfer/sharing** are just as essential to BMP as cultural practices. The common denominator is **communication**.

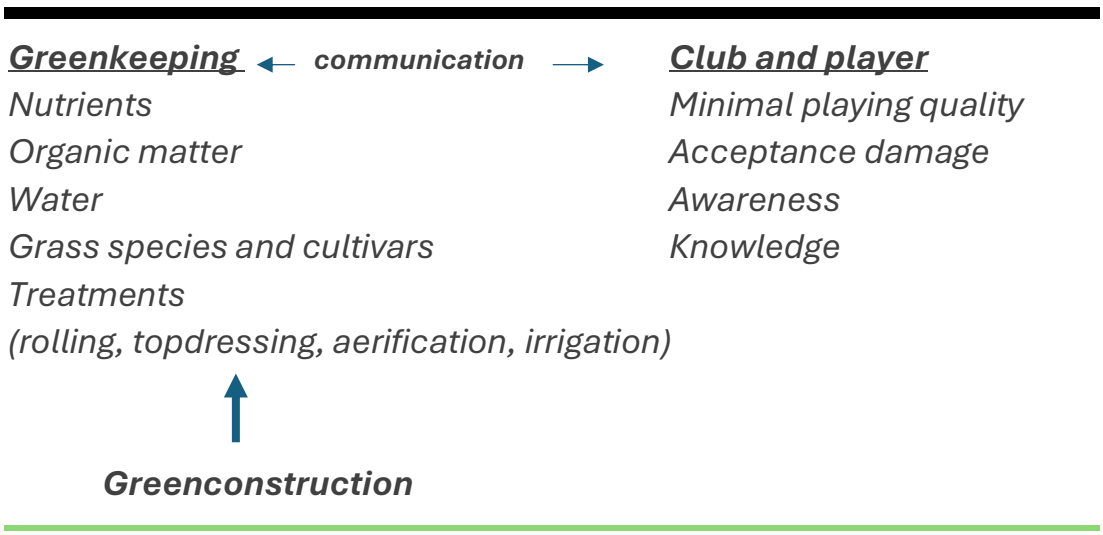


Figure 187: route to successful Best Management Practices.

4.2 Course profiles



1. Utrechtse Golfclub Amelisweerd

Dollar spot susceptibility

Amelisweerd shows a **moderate to severe** dollar spot pattern, with **green 11** most heavily affected. **Green 18** is the best of the three monitored greens. By the end of the study, visible damage had decreased across all greens, but damage remained present.

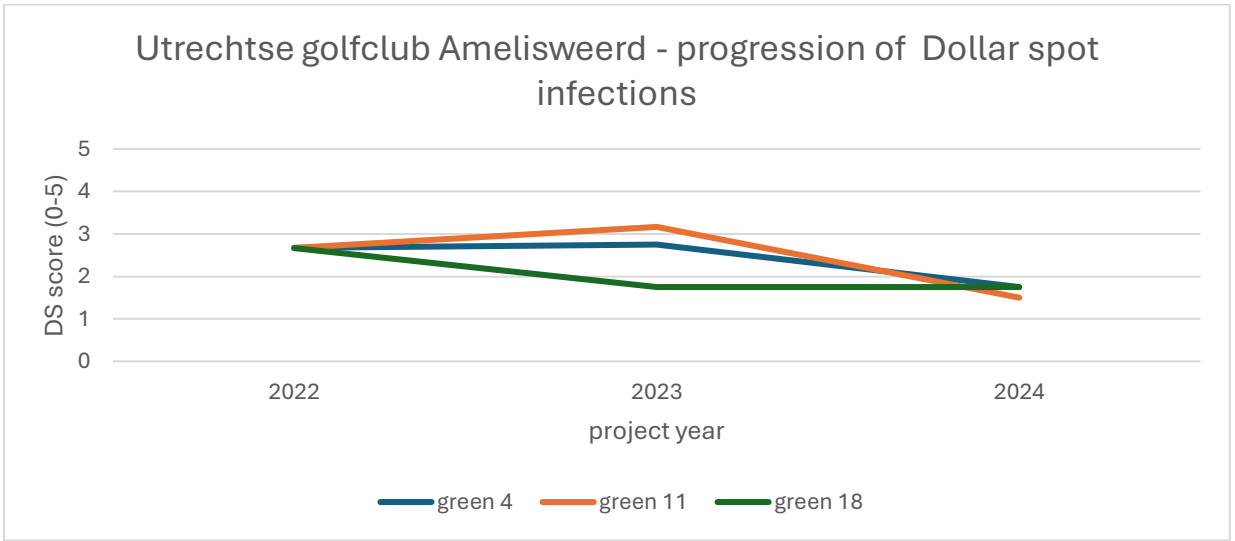


Figure 188: progression of dollar spot symptoms/damage.

Management approach

Management is **intensive**, focused on playability targets (stimp and firmness), year-round usability, and explicit control of turf diseases without chemical plant protection products.

Current programme

Green management is characterised by frequent operations and treatments. Rolling, topdressing, and aeration are performed regularly and at relatively high intensity. Rolling occurs up to six times per week, topdressing 6–12 times per year, and aeration 4–5 times per year. In addition, frequent applications of iron sulphate and nitrogen are made throughout the year. While the total amounts are below the national average, the application frequency is far above it.

Dollar spot symptoms—starting with mycelium ("webbing")—are addressed with an iron sulphate application, sometimes combined with topdressing. To maintain growth and facilitate recovery after infection, nitrogen is applied frequently (liquid), and regular overseeding with colonial bentgrass (Agrostis capillaris) is also part of the programme.

This dynamic approach keeps dollar spot under control, but the system is relatively fragile: deviating from the programme or "doing less" can quickly trigger renewed activity.

Adjustments that could stabilise the system

The following management levers could lead to a more stable, dollar spot (and fusarium) resilient system:

- **Organic matter management:** topdress not with pure sand but with an **80/20 sand mix** (same M50 specifications). Infiltration rates are very high, providing room to maintain adequate drainage while improving buffering of water and nutrients during drought stress.
- **Nutrient management:** maintain frequent applications, but increase total nitrogen to **90–100 kg pure N per hectare per green** (at least 2023 levels), divided across the current number of applications. Optionally add trace elements such as **Mn** and **Si** to support plant vitality. Organic fertilisers may improve buffering but require a multi-year transition before fully replacing mineral inputs.
- From Part 3 it appears that after more severe infection (score 3), **more iron** does not reduce dollar spot reliably. **Timing** is key: apply iron sulphate **before** activity starts rather than as a reaction. The Smith–Kerns forecast can support this.
- **Deep aeration in autumn** promotes (winter) fusarium. The later verti-draining occurs, the less light is available for growth and recovery, and the easier it becomes for fungi to outcompete the turf. Not only fusarium (Microdochium) but also dollar

spot can persist as long as temperatures remain high enough.



2. Amsterdamse Golfclub

Dollar spot susceptibility

The Amsterdamse greens show a **moderate to severe** dollar spot pattern. At the start, **green 3** was classified as the worst, while **green 18** was the best. By the end of the study, this was surprisingly reversed: **green 3** became the best and **green 18** the worst (highest dollar spot pressure), averaged across the three years.

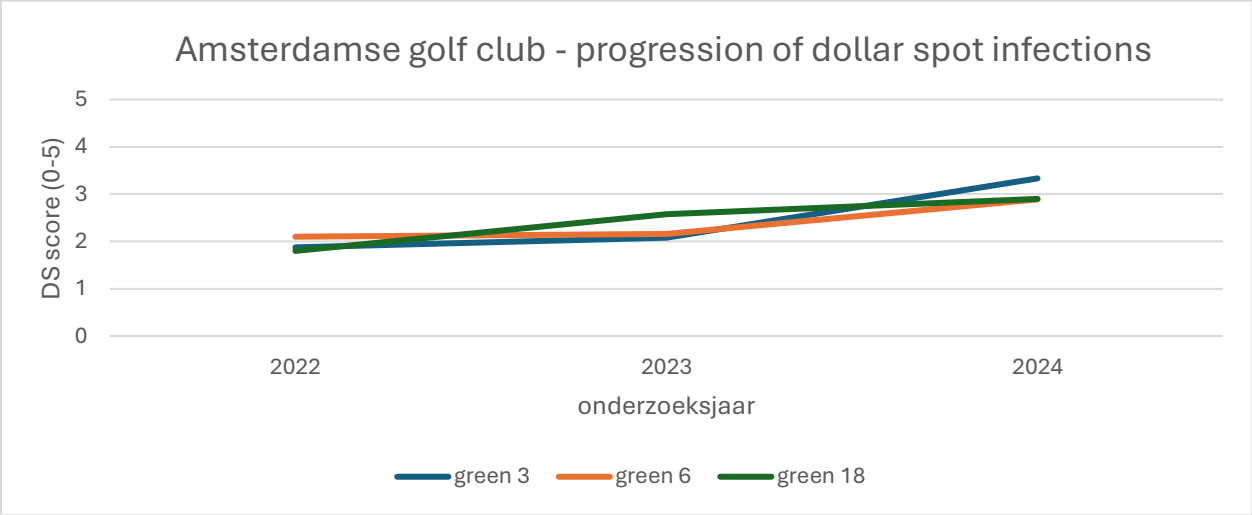


Figure 189: development of dollar spot symptoms/damage.

Management approach

Management is intensive to guarantee year-round playability on this clay-based course. **Sand, iron (sulphate), and air** are key to avoid “wet feet”. Diseases are acceptable as long as they do not negatively affect play, preferably without fungicides.

Programme

In 2022 and early 2023, the combination of frequent topdressing (**19 times**) and iron sulphate kept dollar spot acceptable and matched the broader drainage-focused management needs. At that time, green 18 was still the best monitored green.

In 2023–2024, total nitrogen levels were lower while stress increased (heat and drought alternated with intense rainfall). Despite more frequent iron sulphate applications limiting damage on greens 3 and 6, green 18 was hit hard and suffered greater damage.

Rolling (35 times in 2023) showed no effect on any green. A likely explanation is the increasingly coarse top layer due to frequent sand applications. Porosity increased, reducing compressibility of the upper centimetres—so rolling no longer creates the conditions needed

to affect disease pressure. Increased pore space also promotes air exchange during periods of higher biological activity, in which the pathogen may benefit more than the turf.

In some respects, Amsterdam's approach resembles Amelisweerd's: it is a dynamic system. However, topdressing frequency and iron sulphate rates are substantially higher.

Adjustments that could stabilise the system

Organic matter management: green 18 in particular requires improved buffering of water and nutrients. Increasing OM246 can be supported by topdressing with **90/10** and ultimately **80/20** sand/peat mixes, as infiltration continues to rise.

- **Nutrient management:** Agrostis capillaris requires an optimal nutrient strategy for recovery and competitiveness. Additional nitrogen—again particularly on green 18—can improve vitality, potentially supplemented with trace elements such as **Si** and **Mn**.
- **Proactive management:** the Smith–Kerns model should guide timing. In the current programme, iron sulphate timing often coincides with visible activity and may primarily mask damage; beyond a point, more product no longer stops the pathogen.
- **Topdressing:** topdress less often and topdress differently (e.g., sand with compost).



3. Golfbaan Bentwoud

Dollar spot susceptibility

At the start, greens 4A and 4B showed low to moderate dollar spot levels; by 2024 this had decreased to **low**. Green 4C was effectively free of dollar spot from the start.

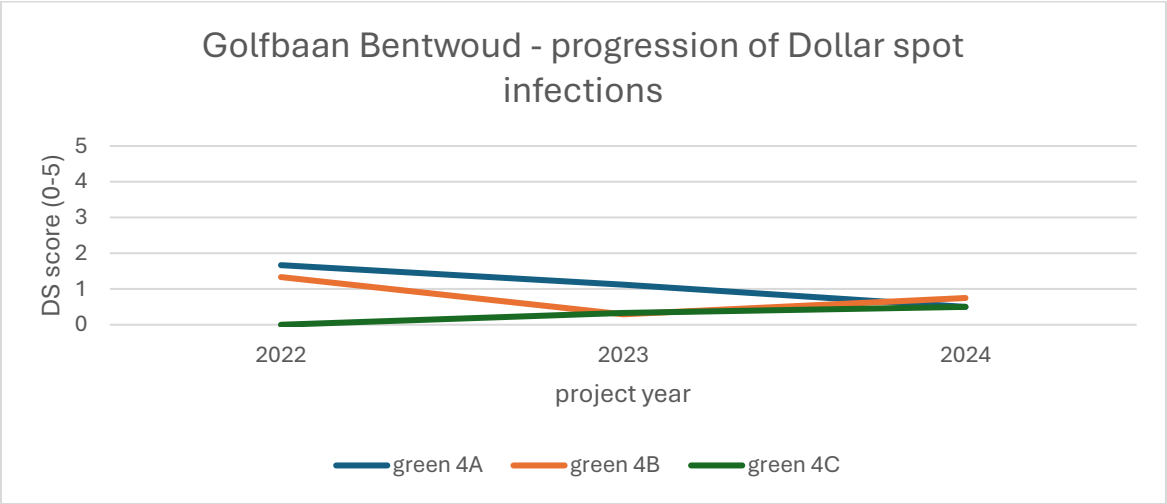


Figure 190: development of dollar spot symptoms/damage.

Management approach

Play intensity is extremely high, while maintenance is (of necessity) much more extensive. This less dynamic approach fits the **Festuca-dominant** greens very well.

Programme

The programme is fully geared towards maintaining and promoting red fescue. Greens are rolled **once per week** during the growing season. Topdressing decreased from **six** applications in 2022 to **three** in 2024 (both 8 m^3 per application). Overseeding is **once per year in August**. Compared with 2022, annual N and Fe totals decreased—and dollar spot pressure decreased as well.

The “less is more” strategy works extremely well at Bentwoud: it keeps red fescue greens in good condition and enables year-round play.

Adjustments

The foundation of this passive strategy is **organic matter/thatch management**. By keeping the thatch largely intact, dollar spot is prevented from expanding. However, creating a

connection to the very well-draining sublayer remains crucial. This can be achieved by creating “sand pillars” (e.g., with a Maredo unit). Holes do not need to exceed ~4 cm depth because organic matter is already very low from 4–6 cm.

4. Domburgse Golf Links

Dollar spot susceptibility

The monitored greens differ substantially: green 9 shows very low susceptibility, green 7 low, and green 8 low to moderate in 2024. Local conditions and green history strongly influence susceptibility. The final season (2024) brought more activity and damage.

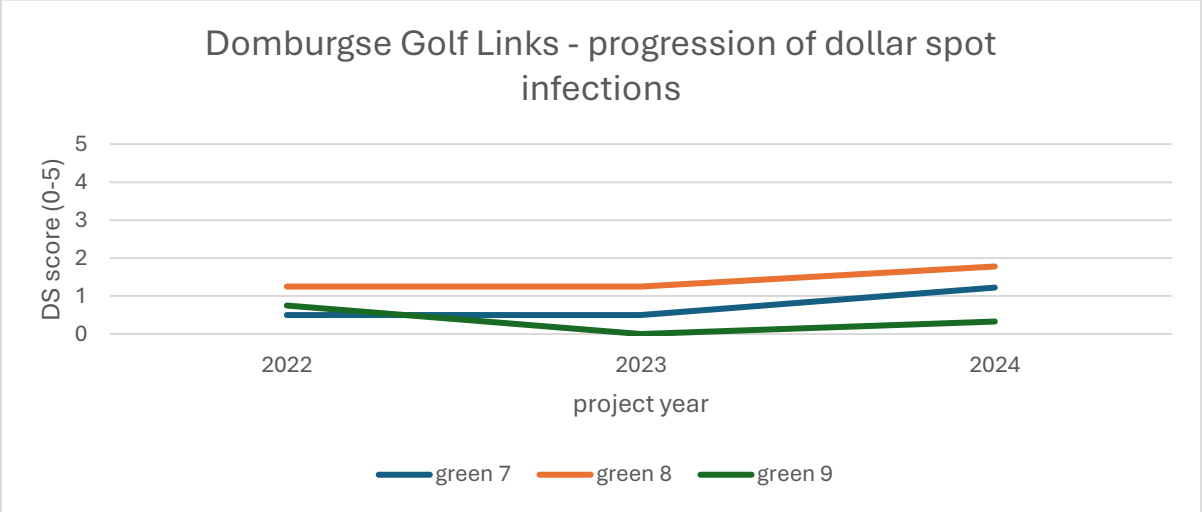


Figure 191: development of dollar spot symptoms/damage.

Management approach

Fescue-dominant greens are managed extensively. The established strategy of **low disturbance** and **low input** performed well.

Programme

Across the three years, nitrogen remained stable at ~**40 kg/ha**, fitting dune-course fescue greens. Nitrogen did not appear to drive higher/lower dollar spot. Changes in **iron** inputs did affect susceptibility on greens 7 and 8. In 2024, substantially less iron sulphate was applied than in earlier years (28 vs 77 kg/ha), and this was directly reflected in the higher scores—especially on green 8.

Regular, small iron applications are key to keeping greens clean. Rolling is also essential, as shown by more extensive disease on foregreens/approaches. Deep aeration occurs once per year; shallow aeration (Maredo) 3–4 times per year, combined with overseeding.

Adjustments

The extreme conditions in 2023 (high temperatures late in the season combined with heavy rainfall) required targeted action—preferably **before** symptoms appear. In 2024 some operations were missed due to conditions; applying additional iron sulphate on top of baseline Fe totals would likely have reduced disease progression on the susceptible green 8.



5. Edese Golfclub Papendal

Dollar spot susceptibility

2024 was the most sensitive year. All monitored greens showed increased infection from 2022 to 2024. Greens 5 and 9 were comparable (from very low to moderate), while green 14 increased from low/moderate to **very severe**.

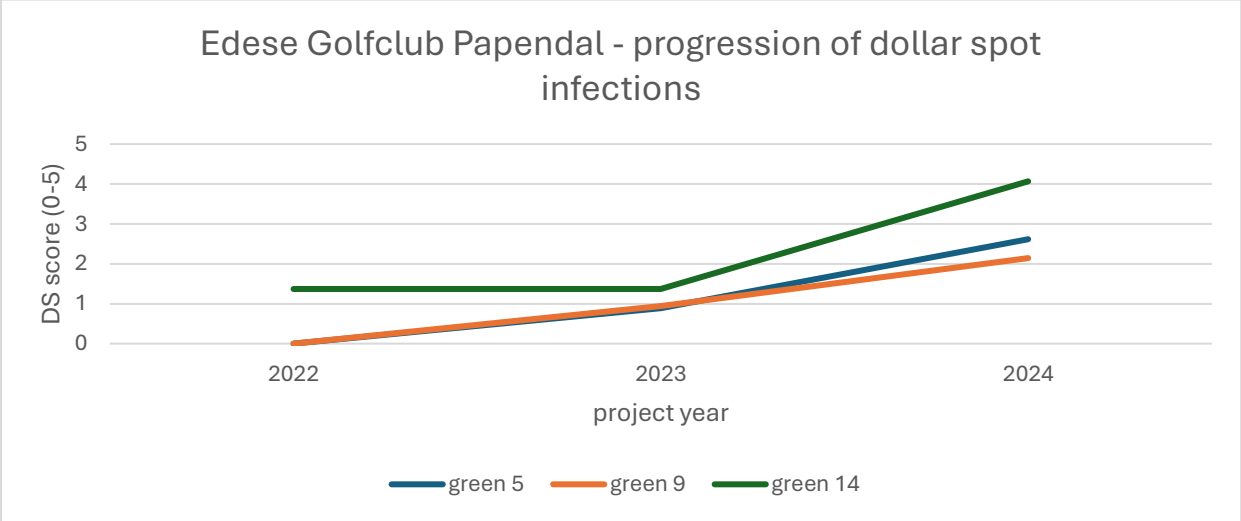


Figure 192: development of dollar spot symptoms/damage.

Management approach

The philosophy is to achieve the highest possible green quality with limited inputs, aligned with the natural setting. This results in relatively moderate mechanical intensity and nitrogen inputs—until a clear shift occurs when maintenance was taken over by a different contractor.

Programme

Before 2024, low dollar spot pressure was maintained via year-round applications of small quantities of iron sulphate. This worked well on greens 5 and 9; even green 14 remained acceptable. The relationship between total iron and dollar spot is very strong, underlining “more Fe = less dollar spot”, with **frequency (16 times)** also crucial. However, this does not fully apply to green 14.

After the contractor change in 2024, dollar spot took hold across all greens and damage on green 14 exceeded the threshold. Less iron sulphate and more nitrogen did not support recovery sufficiently; fungicide use was agreed with the club.

Until 2024, rolling was avoided due to concerns about compaction and infiltration. However, Figure 70 in Part 3 does not support this concern. Rolling was added to the programme from 2024.

Adjustments

The transition from contractor 'AHA de Man' to contractor 'Enk Groen en Golf' contributed to higher dollar spot pressure. Proactive action and timing are critical, but with a new team, staffing shortages, and highly variable weather, this proved difficult in 2024. The key challenge now is returning to a stable programme:

- Structured **nitrogen management** with trace elements such as **Si, Mn, Ca** (rates and annual distribution/frequency)
- Long-term steering of turf composition towards more tolerant bent species/variants. Agrostis canina on green 9 appears to increase thatch and water buffering, reducing dry patch and stress—potentially reducing dollar spot.
- For problem green 14, prioritise soil and plant vitality: overseeding to renew the sward combined with **80/20** topdressing and additional focus on soil biology.



Agrostis canina plugs from green 9

6. Golf- en Countryclub Geijsteren

Dollar spot susceptibility

Geijsteren had relatively high disease pressure. In 2022, fungicides were used against both Microdochium and dollar spot, explaining the low scores. Thereafter, BMPs were fully adopted; despite a flare-up in 2023 (without exceeding the damage threshold), 2024 showed relatively low damage.

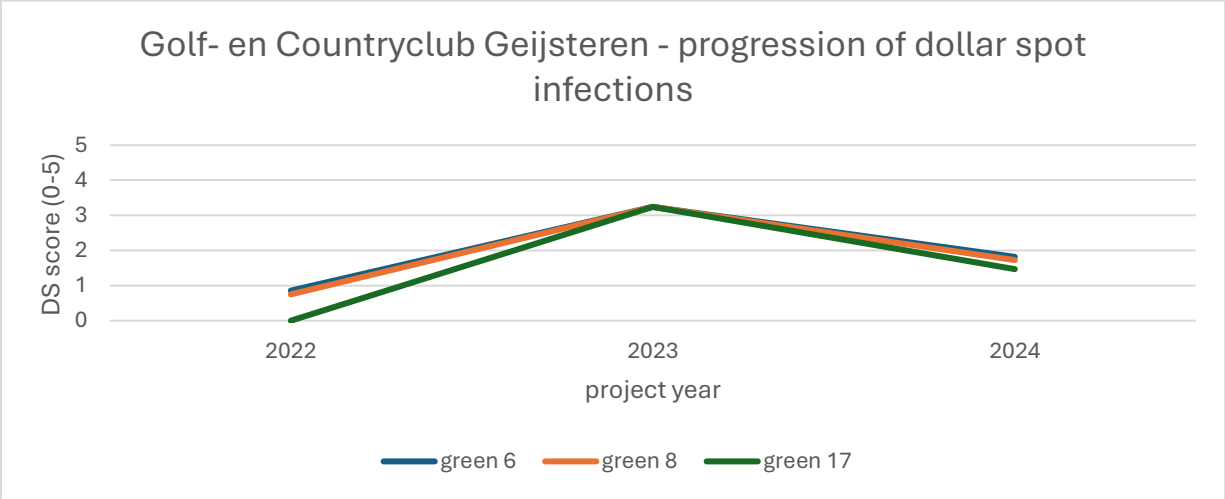


Figure 193: development of dollar spot symptoms/damage.

Management approach

The baseline is to steer playability properties for key tournaments and competitions. Despite the club's wording, management up to 2022 can still be described as fairly dynamic. From 2023 onward this shifted toward a less intensive "less is more" approach.

Programme

A dynamic approach included intensive topdressing and aeration, resulting in high infiltration and low moisture. Fungicides were used to control dollar spot and *Microdochium*. Frequent overseeding with creeping bent supported rapid cover and lower mowing heights for higher stimp.

From 2023, the strategy became more extensive: less topdressing and aeration, with nitrogen and iron sulphate taking a more steering role. Data from the club and the research team supported this shift. Introducing red fescue cultivars via overseeding, especially on the drought-sensitive greens 6 and 8, should increase resilience.

Adjustments

Key optimisation points:

- Increase organic matter more evenly across 2–4–6 cm for buffering and reduced stress; topdress with **90/10** or **80/20** rather than pure sand.
- Water management: irrigate at critical drought stress moments on greens 6 and 8—manual if needed—to prevent dry patch. Keep moisture ≥20% using measurements.
- Nutrient balance: sufficient nitrogen for bentgrass alongside preventative iron programmes.
- Turf composition: as long as creeping bent remains present, minimising leaf wetness duration is essential; early experiences with **dew irrigation** in 2024 reduced activity.
- Mechanical impact: frequent sand applications dry the surface but may also injure leaves, creating infection courts.

In short, Geijsteren requires an integrated approach because both dollar spot and Microdochium can readily occur—especially on greens 6 and 8 (and to a lesser extent 17).

7. Golf- en Countryclub Lauswolt

Dollar spot susceptibility

Lauswolt shows low susceptibility, ranging from very low to low/moderate on green 17.

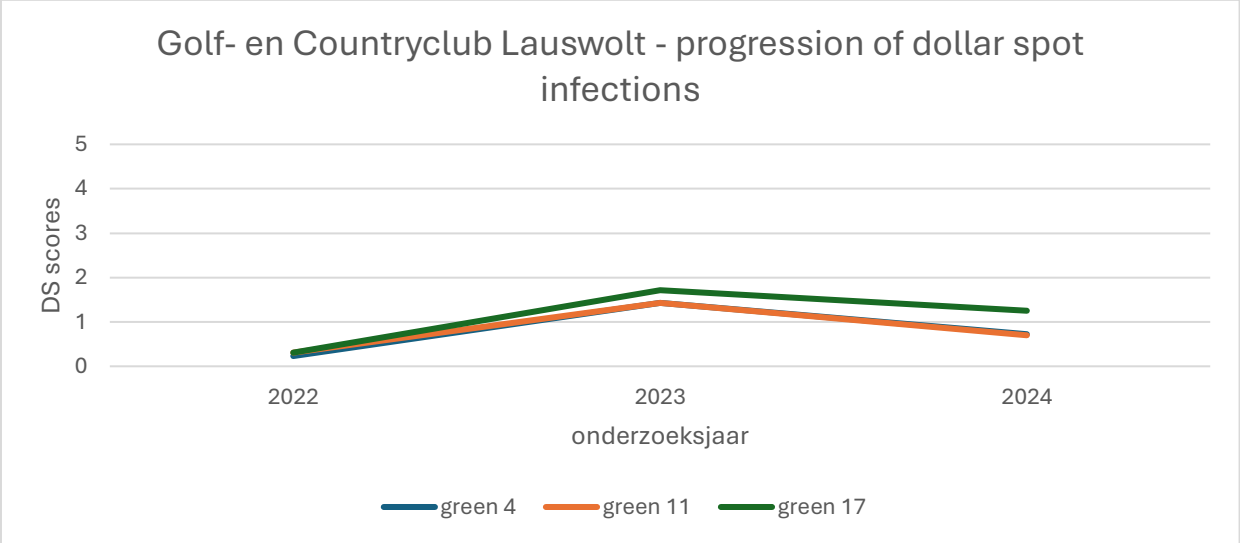


Figure 194: development of dollar spot symptoms/damage.

Management approach

Management is based on a clear vision: **"less is more"**—less topdressing, less aeration, but more rolling.

Programme

Annual sand volumes decreased by >10 m³ over the study period. Aeration reduced from 3 operations in 2022 to just 1 in 2024, adjusted using annual infiltration measurements (see green 11). The non-disturbance approach had a positive effect on susceptibility, especially when combined with proactive, frequent quality steering using small quantities of nitrogen and iron sulphate.

More frequent N and Fe applications across the year reduced infections. An N level of ~50 kg/ha yielded the best results; additional iron did not further reduce severity. This relationship was observed for all greens. Dew irrigation introduced in summer 2024 also appears beneficial.

Red fescue is developing well on greens 11 and 4, where dollar spot pressure is lower. Increasing fescue via overseeding remains a challenge but seems feasible—especially on green 4.

Adjustments

The current approach performs well; no further additions are identified (yet) after three years.

8. The Links Valley Golf

Dollar spot susceptibility

Greens 2, 6 and 9 showed very low susceptibility.

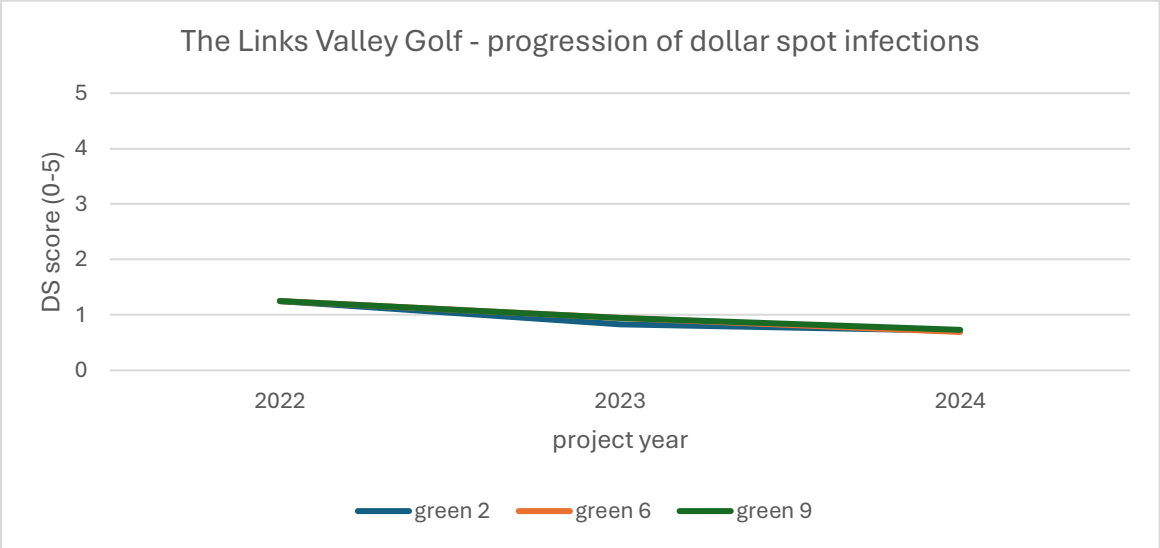


Figure 195: development of dollar spot symptoms/damage.

Management approach

The Links Valley is the youngest of the 12 courses. With a small team, the focus is year-round playability through data-driven maintenance. Management is dynamic and can be described as moderately intensive.

Programme

Core levers are organic matter (thatch/mat at 2–4–6 cm) and moisture management. Young greens accumulate organic matter rapidly in the 0–2 cm layer, reducing infiltration in the surface while infiltration at 6 cm depth exceeds 1500 mm/h. The increased surface organic matter also seems to suppress dollar spot.

Deep aeration is avoided or postponed; aeration focuses on improving permeability of the upper 4–6 cm through frequent topdressing and Maredo shallow aeration.

Success is not driven by total kg N and Fe, but primarily by the **frequency** of applications—especially nitrogen. Without rolling, activity and damage would likely be much higher, as shown by significant disease outside the green while the putting surface remains clean.



Left: damage caused by dollar spot on the aprons around green 2. The green itself was not affected (photo: M. de Bruijne, Links Valley)

Right: Effect of shallow aeration using the Maredo aerator on green 2

The Links Valley is a strong practical example of optimising the “environment” while strengthening the “host” through an extensive plant health programme alongside standard N and iron inputs—the plant disease triangle in practice.

Adjustments

The current approach works well; no further additions are identified (yet).

9. Utrechtse Golfclub “De Pan”

Dollar spot susceptibility

Historically, green 17 is the most susceptible at De Pan. With small adjustments, this was no longer the case by the end of 2024: green 17 shifted into the average-to-best category among the three monitored greens. Overall, severity remains moderate; 2023 stands out.

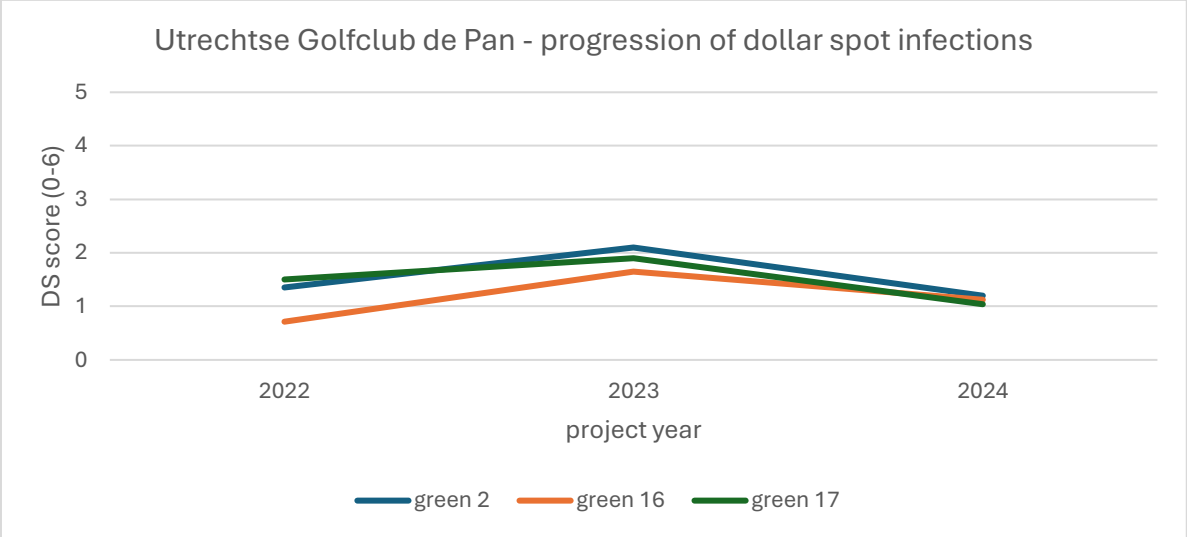


Figure 196: development of dollar spot symptoms/damage.

Management approach

De Pan also follows “less is more”, with a disciplined and stable programme and limited annual deviations.

Programme

A disciplined programme with only a few fertilisation events, aerations and topdressings (plus Graden Sand Injector every two years) and extensive use of walk mowers works well—until conditions shift substantially. In 2023, the damage threshold was exceeded and fungicide intervention occurred. Recovery was rapid, and despite higher pressure in 2024, dollar spot spread remained controlled with sufficient and frequent nitrogen applications.

Iron sulphate use in 2023 and 2024 was limited and appears not to have contributed materially. Rolling was the most successful cultural practice for damage reduction (even if not statistically significant). Additional attention to green 17 through targeted irrigation also lowered pressure and improved play quality.

Given the course's reputation, acceptance and visual quality can be decisive even if surfaces remain playable from an agronomic perspective.

Adjustments

- Organic matter is high at 0–2 cm; focus should be on C/N management to accelerate breakdown and release of organically bound nitrogen.
- Cultural practices are crucial:
    - Rolling is indispensable
    - Graden Sand Injector has major impact; disturbance requires recovery support through nutrition and overseeding
    - Targeted irrigation on susceptible greens helps significantly



UGC de Pan green 17: the originally most dollar spot susceptible green

10. Sallandse Golfclub “De Hoek”

Dollar spot susceptibility

Dollar spot severity increased over time. In 2024, greens 1 and 5 were moderate and green 17 was severe.

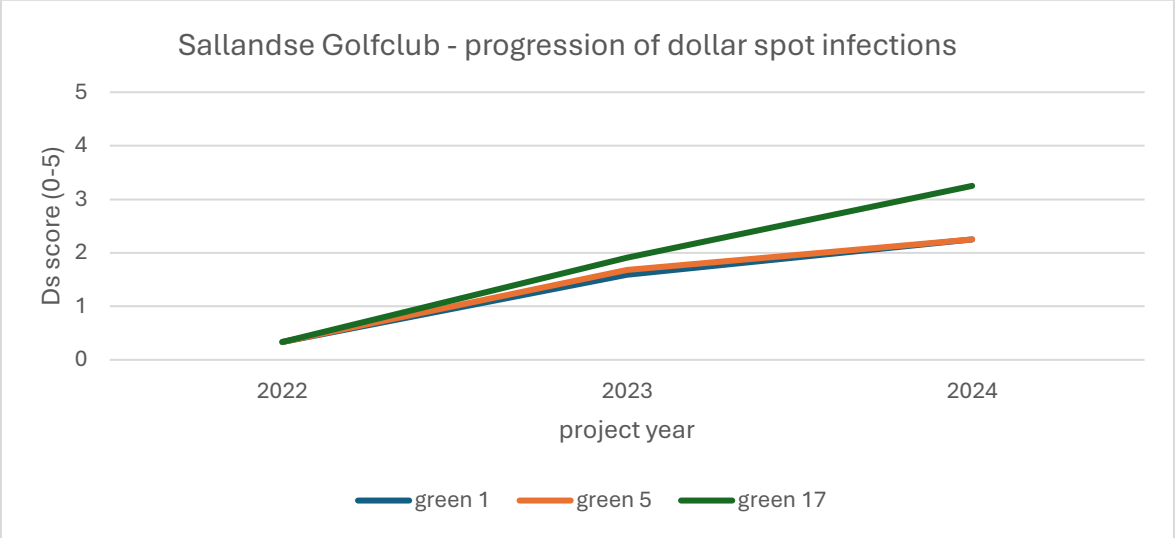


Figure 197: development of dollar spot symptoms/damage.

Management approach

Management is intensive and data-driven, but also curative. Fungicides are used twice per year.

Programme

The programme includes above-average nitrogen (>100 kg/ha) and variable iron sulphate inputs. The more N and Fe are spread through the year, the lower the severity. Aeration occurs 6–7 times annually (including one deep operation). Overseeding is intensive using blends of colonial and creeping bent. Organic matter between 0–4 cm is adequate.

Despite many “right ingredients”, severity rose above the damage threshold. Two Signum applications (preventative and curative) reduced pressure and enabled rapid recovery alongside cultural work. Notable differences exist between greens with different construction types; green 1 shifted from worst to best, likely due to buffering advantages in the push-up profile versus USGA/Dutch profiles under this management intensity.

Adjustments

- Proactively use forecast models; at first Smith–Kerns signals (12–15%) steer with Fe-containing fertiliser (e.g., Autumn-type products). Dew irrigation started in 2024 appears promising to reduce leaf wetness duration.
- In overseeding, avoid 100% creeping bent; focus on colonial bent. Creeping bent is more sensitive to drought stress and therefore dollar spot than colonial bent under current management and climate variability.
- Reduce mechanical injury from heavy topdressing.

To structurally eliminate fungicide dependence, a long-term strategy is required focusing on water management, organic matter management (80/20 topdressing on greens 5 and 17), turf composition and cultural practices.



Sallandse Golfclub green 1, January 2025

11. Veluwse Golfclub

Dollar spot susceptibility

Veluwse shows high diversity in susceptibility. After a calm start, major differences appeared in 2023: green 3 was moderate and green 7 severe to very severe. After intervention, quality improved in 2024. Green 1 remains consistently low-susceptibility and was classified as the best green by the end.

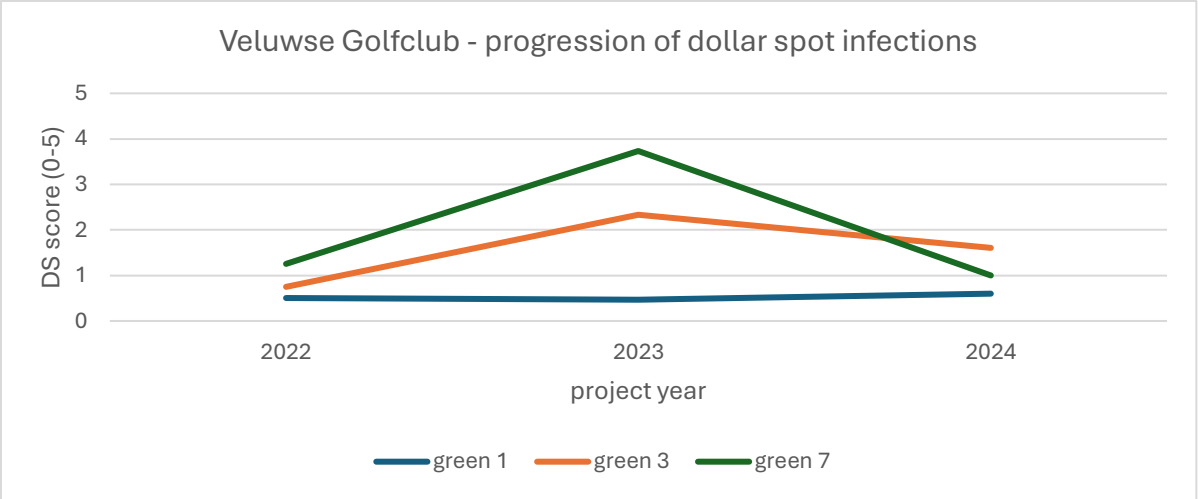


Figure 198: development of dollar spot symptoms/damage.

Management approach

Like the wooded course De Pan, Veluwse has followed “less is more”: minimal inputs (nitrogen and water) while maintaining quality. This proved sustainable for 16 years until the 2023 dollar spot year. Since then, management has become more intensive.

Programme

With almost no iron (sulphate), relatively low nitrogen for bentgrass, few spray/spread events, and one annual overseeding, Veluwse is a true low-input course. This approach fits green 1 perfectly and also worked on the other greens—until the widespread 2023 outbreak on greens 7 and 3. Fungicides halted activity, enabling recovery (after vertical mowing and overseeding).

Despite high national pressure in 2024, pressure decreased without fungicides on the monitored greens. Additional iron sulphate inputs contributed.

Adjustments

Optimisation points for greens 7 and 3:

- **Tailored moisture management:** hand watering and topdressing with **90/10 or 80/20** mixes to improve moisture buffering.
- **Nutrient management:** distribute the annual N total over more applications (more plant-demand driven).
- The same applies to iron: annual Fe could easily be tripled, but **spread** and applied based on need. Construction did not indicate adverse effects of iron on subsurface structure or infiltration.
- **Timing** is critical; use Smith–Kerns forecasting proactively.
- **Turf composition:** increase red fescue on drought-sensitive greens, while considering shade and shelter constraints for establishment.

In short, 2023 was a turning point requiring fungicide intervention due to threshold exceedance. Renewed focus on moisture, fertility, organic matter and turf vitality can improve resilience and potentially allow a return to “less is more” for greens 3 and 7.



Veluwse Golfclub green 3, May 2023

12. Golfclub ’t Zelle

Dollar spot susceptibility

Green 8 is most consistent with low to moderate susceptibility. Greens 9 and 18 have been moderate to severe since 2023. The threshold was not exceeded initially, but in 2024 exceedance was approached and plant protection use was considered.

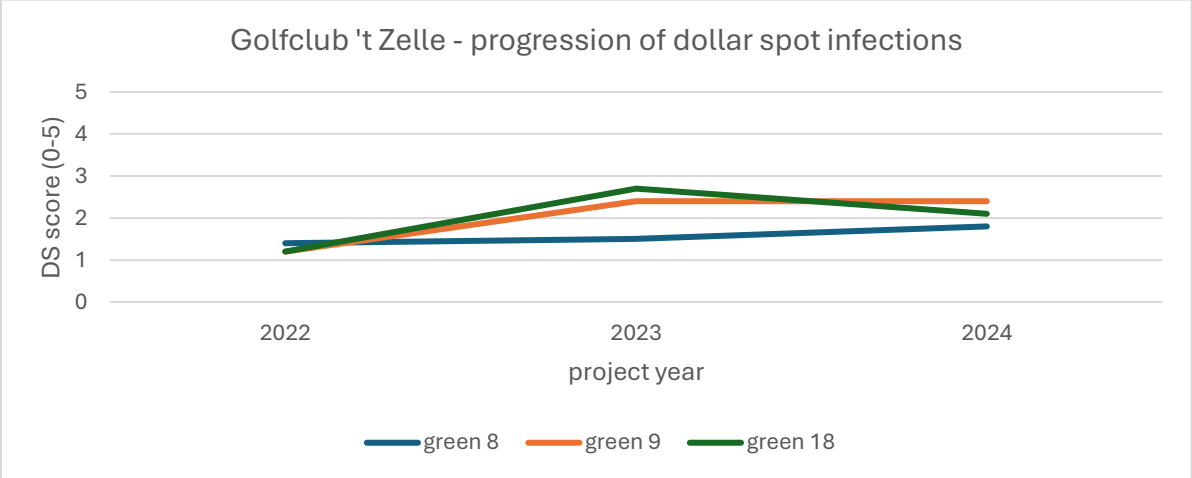


Figure 199: development of dollar spot symptoms/damage.

Management approach

Nature and environment are core values and plant protection products are effectively a no-go. While “natural” management is the goal, the programme is intensive. Distinctive is the extensive monitoring setup (meteo and soil sensors) enabling data-driven decisions.

Programme

The strategy aims for the right ingredients under a natural philosophy. However, many products are used, making effects difficult to interpret. Mechanical operations are also relatively intensive. This has less negative impact on green 8 than on greens 9 and 18.

Meteo and soil sensors steer irrigation (and suction tension) with target moisture ranges of 15–20%, combined with evapotranspiration, rainfall and humidity data. Organic matter (2–4–6) is around or above 3%—appropriate for the programme—yet pressure remains too high, especially on green 18.

Adjustments

In 2024 higher disease pressure also increased workload; optimisation options include:

- **Water management:** raise target moisture to reduce plant exhaustion. The current 15–20% may need to shift to **20–25%** for greens 9 and 18 during the most disease-sensitive period.

- **More targeted cultural work:** topdress differently and less; reduce (deep) aeration—given infiltration is excellent.
- **More selective use of plant-health products** to obtain clearer insight into effects on soil and plant vitality.
- **Perfect timing** using weather station data and local Smith–Kerns forecasts interpreted into practical greenkeeping actions.
- **Turf composition:** overseed with red fescue to increase resilience after stress periods.



Golfclub ‘t Zelle green 9 after topdressing, November 2023

4.3 From Specific to Generic Profiles

The table below summarises, for all 12 golf courses, the qualification with regard to organic matter management, management approach, and dominant turfgrass species. In addition, overall dollar spot susceptibility across 2022–2024, the use of iron sulphate, dew removal irrigation, and the effect of rolling have been included.

Table 62: Profiles of the 12 golf courses.

	Organic matter content	management strategy	dominant species	Susceptibility to dollar spot average over 2022-2024 * low **** high	Use of iron sulphate in management * little, ***** much	effect of rolling - little + much	use of dew irrigation	specific attention to green(s)
Amelisweerd	moderate	intensive	*A. capillaris*, decreasing *Poa annua*	***	**	-	yes	not relevant
Amsterdamse	low	intensive	*A. capillaris*, decreasing *Poa annua*	****	*****	-	yes	18
Bentwoud	high	extensive	*Festuca rubra spps.*	*	***	+-	no	not relevant
Domburg	moderate	extensive	*Festuca rubra spps.*	**	****	+	no	8
Ede	moderate	moderately intensive	*A. capillaris* and *canina*, decreasing Poa	***	****	nvt	no	14
Geijsteren	moderate	from intensive to extensive	*A. capillaris* and (decreasing) *stolonifera*	***	**	+-	yes	6 and 8
Lauswolt	moderate	extensive	*Festuca rubra spps. , A. capillaris*	*	****	0	yes	not relevant (evt 17)
Links Valley	high	data driven moderately extensive	*Festuca rubra spps., A. capillaris*	*	**	+	yes	not relevant
de Pan	high	moderately intensive	*A. capillaris*	***	**	+	no	17
Salland	moderate to high	data driven intensive	*A. capillaris and stolonifera*	****	****	0	yes	17
Veluwe	low	from extensive to (more) intensive	*A. capillaris*	***	*	0	yes	7 (en 3)
t Zelle	moderate	data driven intensive	*Festuca rubra spps., A. capillaris*	****	***	-	yes	9 en 18

The 12 monitored golf courses are all unique in terms of their location, construction, management strategy and intensity of use. Nevertheless, based on the collected data and observations, a broad classification into three main groups can be made.

Please note: this grouping is based on all available data and information up to this point (which is limited to January 2025). If the monitoring period is extended, this classification may change and will become more robust.

1. Courses with moderately intensive management

These courses are characterised by predominantly **(common) bentgrass (Agrostis capillaris)** and a **low to moderate organic matter content**. Fertilisation, topdressing, aeration and overseeding are carried out frequently, and total inputs (kg N/Fe and m³ sand per hectare) are relatively high. Annual meadow grass (**Poa annua**) is also often present in substantial proportions.

Overall, dollar spot susceptibility is **moderate to high**, and chemical plant protection has been required at least once on several courses within this group.

This group includes:

- Utrecht Golf Club Amelisweerd
- Amsterdamse Golfclub
- Edese Golfclub
- Sallandse Golfclub
- Utrecht Golfclub De Pan
- Golfclub ’t Zelle

2. Courses with extensive management (“less is more”)

These courses follow a low-input approach, dominated by **fine fescue (Festuca rubra)**, sometimes combined with browntop bentgrass. The number of mechanical operations such as topdressing, fertilisation and aeration is low (maximum 3–4 times per year).

However, **iron (sulphate) is applied frequently**, usually in small doses. Dollar spot susceptibility is generally **low**, and chemical plant protection has not been necessary.

This group includes:

- Golfbaan Bentwoud
- Domburgse Golf Links
- Golf- and Countryclub Lauswolt
- The Links Valley Golf

3. Courses in a transitional phase

These courses are currently shifting towards a more resilient system. Turf composition still contains common and/or creeping bentgrass (**Agrostis capillaris and/or stolonifera**), while fine fescue is gradually becoming more established.

Dollar spot susceptibility is, on average, **moderate**, but the aim is to move towards a more robust BMP-based system where fungicide use becomes unnecessary.

Courses following this pathway include:

- Veluwse Golfclub
- Golf- and Countryclub Geijsteren

In fact, Golfclub ’t Zelle also shows characteristics of this transitional group.

Role of iron and data-driven management

Iron (sulphate) is used across all three groups, although courses in Group 2 tend to apply it more frequently and at lower individual doses compared to Group 1.

The factor “data-driven management” did not show a clear effect within this study in terms of directly reducing dollar spot incidence. This does not imply that data-driven greenkeeping has no value. Instead, it underlines that the **interpretation of predictive models (Smith-Kerns)** and a **proactive management attitude** are key in reducing damage caused by dollar spot.

PART 5: DISCUSSION, INDICATIONS, RESULTS, CONCLUSIONS & RECOMMENDATIONS

5.1 Discussion of Results from Parts 3 and 4

The previous sections demonstrate that the “classic” generic measures for controlling dollar spot are still highly effective.

Iron sulphate

Frequent applications of iron — whether supplied through nitrogen fertilisation, as ferrous sulphate, or in the form of lawn sand — have a beneficial effect by keeping the turf surface drier and thereby suppressing infection by the fungal pathogen *Clarireedia bennetti*. The combination with sulphate is effective, whereas chelated iron is not.

With this objective, a US study (McCall & Ervin, 2016) showed that ferrous sulphate can completely inhibit mycelial growth, provided that sufficient amounts are applied. At lower rates, iron acts mainly as a foliar nutrient and may even stimulate mycelial development. The Fe component was found to be suppressive against dollar spot, while the SO_4 (sulphate) fraction played only a minor role through a slight reduction in pH.

A later study (Hockemeyer et al., 2019) demonstrated that ferrous sulphate produced significant suppression already in the first year of use. Two application intervals were tested: a 7-day interval with lower rates, and a 14-day interval with higher rates. The 7-day interval proved more effective in nearly all cases, suggesting that smaller doses applied more frequently represent a superior strategy compared with larger doses at longer intervals.

Effects of iron sulfate on dollar spot severity in Minnesota

Treatment	Rate/1,000 square feet	Water volume/1,000 square feet	Dollar spot severity[1]
			Aug. 14
1	Non-treated control		111.8 a
Iron sulfate, 7-day application interval			
2	3 ounces	0.75 gallon	19.5 d-g
3	3 ounces	1.5 gallons	15.5 efg
4	3 ounces	3.0 gallons	20.0 d-g
5	6 ounces	0.75 gallon	3.5 fg
6	6 ounces	1.5 gallons	4.8 fg
7	6 ounces	3.0 gallons	8.8 fg
8	12 ounces	0.75 gallon	1.0 g
9	12 ounces	1.5 gallons	0.3 g
10	12 ounces	3.0 gallons	0.3 g
Iron sulfate, 14-day application interval			
11	3 ounces	0.75 gallon	58.8 bc
12	3 ounces	1.5 gallons	58.0 bc
13	3 ounces	3.0 gallons	68.8 b
14	6 ounces	0.75 gallon	37.5 cde
15	6 ounces	1.5 gallons	44.5 bcd
16	6 ounces	3.0 gallons	27.8 def
17	12 ounces	0.75 gallon	25.0 d-g
18	12 ounces	1.5 gallons	13.3 efg
19	12 ounces	3.0 gallons	25.0 d-g

[1]Means in the same column followed by the same letter are not significantly different.

Table 2. At the Minnesota site, iron sulfate was applied to putting greens at three different application rates and two application intervals. The volume of water for tank-mixing was 0.75 gallon, 1.5 gallons or 3.0 gallons/1,000 square feet (305.6, 611.2 or 1,222.4 liters/hectare). 3 ounces/1,000 square feet = 9.2 kilograms/hectare, 6 ounces/1,000 square feet = 18.3 kilograms/hectare, and 12 ounces/1,000 square feet = 36.6 kilograms/hectare.

Figure 200: Results of ferrous sulphate research (Hockemeyer et al., 2019)

Within this three-year project, opinions and practical experiences regarding iron (sulphate) use were divided. Excessive iron applications may potentially lead to soil structural decline due to compaction and the formation of an iron pan (“oerlaag”), or to further soil acidification, reducing nutrient uptake capacity.

In this study, no deterioration of soil structure was observed. Nutrient uptake was not always sufficient, but no direct relationship with iron use could be demonstrated within the scope of this project.

Golf courses applying the strategy of small Fe doses at short intervals include The Links Valley, Amsterdam and Amelisweerd, with varying results. Lauswolt, Geijsteren and Bentwoud also apply ferrous sulphate, generally at slightly longer intervals and somewhat higher total rates, with predominantly positive effects. At Lauswolt and Bentwoud, turfgrass species composition (fine fescue!) may also play an important role.

A general explanation for differences in effectiveness may lie in the following factors (after Turgeon 2008 & Horgan 2009):

- Timing of operations: applications are often too late, once the pathogen is already active
- Excessive iron applied in one event may disrupt nitrogen dynamics, weakening the plant
- Ferrous sulphate has a strong drying effect on leaf tissue, increasing water demand and potentially stressing the turf
- Mechanical injury to leaves creates wounds that may serve as infection courts

Rolling

Rolling can have a major impact on reducing dollar spot activity. Over the past three years, this has been particularly evident at The Links Valley, Geijsteren and Bentwoud.

On other courses, such as Amsterdam and ’t Zelle, the positive effect of rolling was less apparent, and other parameters proved more decisive.

Rolling trials by Nikolai (2011) on creeping bentgrass greens concluded:

“The reason for the reduction in dollar spot with increased rolling is not entirely clear, but it is believed to be related to the increase in beneficial bacteria in the soil, which may help combat fungi-caused diseases like dollar spot.”

Research at Vallda GC in Sweden (Espevig et al., 2017) on a 100% fine fescue green showed that rolling 2–4 times per week reduced dollar spot severity by 49% and 96%, respectively. On a bentgrass/fescue green at Roskilde GC in Denmark, reductions were 27% and 62%.

This suggests that frequent rolling is most effective on greens with a high proportion of fine fescue.

Each course in this project maintained its own rolling frequency and seasonal schedule. In an exploratory multivariable field study, it is unrealistic to make definitive statements about rolling effectiveness. However, an analysis of total disease incidence in relation to rolling frequency did indicate a strong negative relationship at Geijsteren, Bentwoud and Links Valley. At Utrecht GC De Pan, this relationship was weaker but still present.

Nutritional Status (nutrients)

For many years, it has almost become a “sport” to maintain playable greens under the lowest possible nutrient regime. Annual nitrogen inputs below 50 kg N/ha were often the norm — even on bentgrass-dominated greens.

It is precisely these low regimes that created favourable conditions for active dollar spot during the past three seasons. The combination of (extreme) drought, occasional heat, and insufficient nutrient buffering has resulted in turf stress and reduced resistance.

Clear examples from this study are Golfclub ’t Zelle and Veluwse Golfclub.

Water Management

In greenkeeping practice, water management is driven by rainfall and irrigation scheduling. Excessive moisture can lead to undesirable outcomes, such as increased *Poa annua* encroachment or reduced infiltration and surface firmness.

However, insufficient water — particularly during prolonged dry and hot summers — can equally lead to turf stress, increasing susceptibility to fungal diseases such as dollar spot.

The particle size distribution of the rootzone (M50 sand fraction) also plays a role. Coarser sands have greater pore volume and retain more air, potentially stimulating dollar spot activity. Rolling is often less effective under such conditions, as observed at ’t Zelle and Amsterdam.

Infiltration capacity is a key parameter for maintaining dry, playable greens. Many greens are constructed according to USGA specifications, designed for rapid drainage. In many cases, infiltration rates far exceed the norm, causing low organic matter rootzones to become highly drought-prone.

Furthermore, repeated topdressing with pure sand (300–330 µm) and frequent (deep) aeration — especially at the wrong time — further increases porosity, accelerates gas exchange, and may result in softer greens and increased dollar spot.

Under certain conditions, this appears to stimulate fungal activity. More in-depth research is needed, for example involving oxygen measurements.

Amsterdam and Amelisweerd are examples of overly sandy rootzones combined with moderate dollar spot levels.

Organic Matter Management in the Rootzone

Organic matter plays a crucial role in nutrient supply and soil structural improvement, supporting root development. During the inventory visits, root length was also measured (see Appendix 2). Healthy roots are better able to cope with stress factors such as drought, excess water, and diseases like dollar spot.

At appropriate levels, organic matter provides balanced water retention and drainage, preventing both waterlogging and excessive drying. Water retention is an essential buffer during drought stress periods, when turf becomes more vulnerable to dollar spot.

Between 2022 and 2024, this was frequently observed across most courses. Notably, organic matter appeared less critical on greens with a substantial proportion of fine fescue, such as Lauswolt, Domburg, Links Valley and Bentwoud.

Organic matter also supports microbial activity, contributing to nutrient availability and a healthy rootzone. More on this is discussed under “role of soil microbiology.”

Low organic matter levels strongly influenced nutrient buffering and turf utilisation capacity, as illustrated by data from Amsterdam, Amelisweerd, ’t Zelle, Veluwse, Geijsteren and Sallandse.

Leaf Wetness Period

Leaf wetness duration was not directly monitored in this study, as it requires specific on-site meteorological measurements. Only Golfclub ’t Zelle has such a station, where the following relationship was demonstrated:

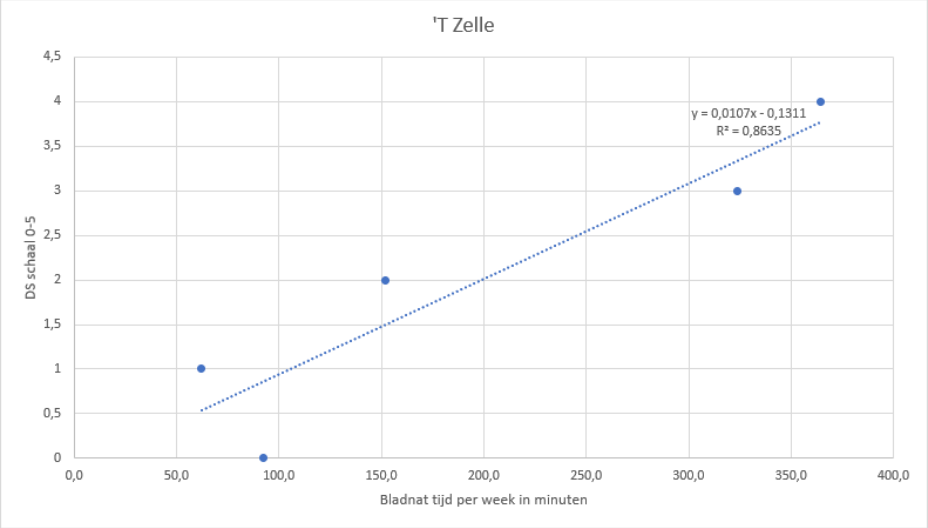


Figure 201: Relationship between leaf wetness duration and dollar spot severity (based on local measurements at 't Zelle)

Morning dew removal may help prevent fungal activation by shortening the leaf wetness period. However, sugars produced in the leaf are not removed and remain as a food source for the pathogen.

The initiation of dew removal irrigation during the third season appears to play a key role. By running irrigation briefly during late evening, night or early morning, guttation fluids containing sugars can be washed off before fungal activity begins.

Guttation fluid consists of nutrient-rich plant sap released under high root pressure when transpiration is low, typically during cooler, shorter days. Sugars in guttation fluid provide an ideal substrate for fungal development.

Whether dew removal irrigation represents a sustainable long-term BMP requires further field research. Timing, duration and frequency remain key questions. Early results are promising, with Golfclub Geijsteren reporting very positive experiences.

Turfgrass Species and Cultivar Composition

Browntop bentgrass combined with fine fescue seems to be more tolerant to dollar spot than mixtures containing creeping bentgrass (*Agrostis stolonifera*).

This is partly due to the wide genetic variation among creeping bentgrass cultivars. Many cultivars — as shown in national trials such as the US NTEP — are not tolerant to dollar spot and often suffer severe damage following infection.

Another argument for limiting creeping bentgrass on Dutch greens is its extremely dense canopy structure, which prolongs leaf wetness duration and increases risk of infection.

Courses such as Geijsteren and Sallandse still contain *Agrostis stolonifera* and show moderate dollar spot severity.

A further bentgrass subspecies, *Agrostis canina* (velvet bentgrass), was identified at Edese Golfclub. Its benefits in reducing dollar spot are not yet statistically significant. However, observations suggested reduced dollar spot on Green 9 during drought stress due to the presence of *A. canina*.

Velvet bentgrass is extremely fine-leaved and shares low-input characteristics with *Festuca rubra*. It also builds a thick thatch layer, retaining more moisture and nutrients, potentially reducing drought stress and dollar spot susceptibility.

Fine fescue greens in this study consistently exhibited far lower dollar spot pressure than bentgrass-dominant greens, as seen at Bentwoud and Domburg (especially Greens 7 and 9), Lauswolt Green 4, and the mixed bent/fescue greens at Links Valley.

Plant Sap Analyses

In season three, plant sap analyses were initiated. A stable nutrient profile — rather than sharp peaks or deficiencies — may provide greater disease stability. Elements such as Mn, Ca and Mg are also influential.

No correlation with dollar spot has yet been found, as at least two additional seasons of monitoring are required. Figure 202 provides an illustrative overview of average leaf pH, which may serve as an indicator of infection susceptibility.

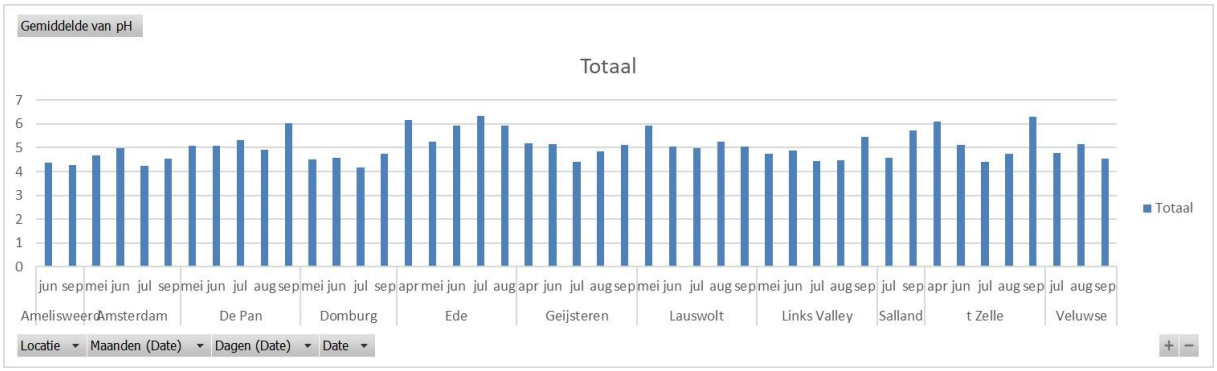


Figure 202: Average pH measured in plant sap

Oxalic acid is a key virulence factor in fungal pathogens. Research has shown that oxalic acid production is strongly dependent on leaf surface pH, with twice as much produced at pH 7 compared with pH 4.

The role of *Clarireedia jacksonii* in oxalic acid production remains unclear, although early findings suggest the pathogen requires an acidic leaf environment to develop and cause dollar spot. Promoting a more neutral or slightly alkaline leaf surface may therefore represent a strategy for limiting dollar spot caused by *C. jacksonii* (Townsend et al., 2020).

Plant sap analyses may provide supportive data for such strategies. Research in this area remains in its early stages, although initial work is underway in the USA (Koch et al., 2024).

The location of the green

Shade and shelter are not decisive drivers of increased disease pressure caused by *Clarireedia bennetti*. While they can be stress factors, if other conditions are optimised — such as dew removal, rolling and nutritional status — the risk of severe dollar spot outbreaks is reduced, even on sheltered greens.

Examples include Golfclub Lauswolt, where open greens proved more susceptible than shaded greens.

Role of Soil Microbiology

DNA Multiscan

At two moments in 2023 (May and July), DNA analyses were conducted on at least one monitored green per course. The objective was to detect fungal DNA and enable further study into *Clarireedia* activity and triggers.

However, results were too unreliable, requiring a re-evaluation of the analytical strategy. Discussions with experts revealed that the method was overly sensitive and insufficiently specific for *Clarireedia*, although detection of other fungi such as *Fusarium* spp. and *Pythium* spp. was successful.

Further investigation confirmed that the observed symptoms were indeed caused by *Clarireedia*. Triggers included high temperatures, humidity, and likely reduced plant resistance.

DNA Multiscan remains a potentially useful rapid screening tool, but further refinement is required before reliable conclusions can be drawn.

Fungal/Bacterial Ratio

Since *Clarireedia* primarily manifests on leaf tissue and at the crown of the turf plant, this field study focused on the upper 2 cm of the rootzone. Microbial biomass and the fungal/bacterial ratio were determined for all courses.

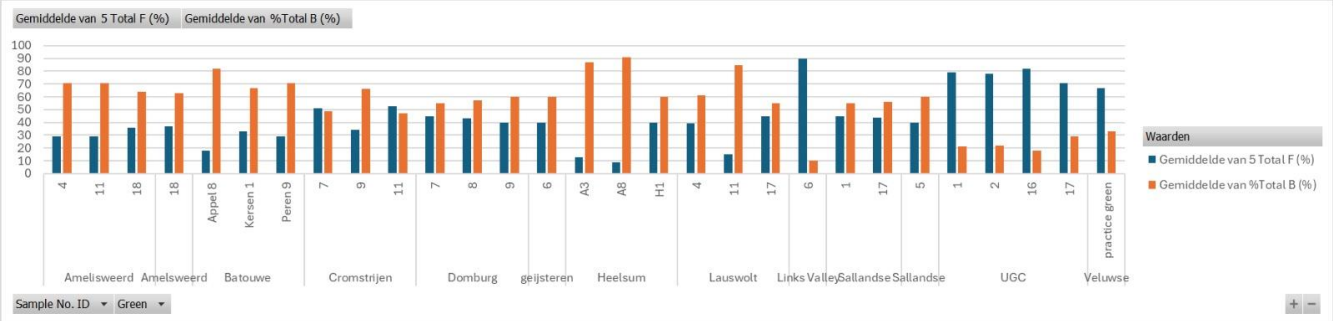


Figure 203: Fungal (F) to bacterial (B) ratio (illustrative)

Microbial biomass represents total living biomass in the soil. Higher microbial activity reduces the opportunity for pathogens to dominate and impair plant health. Microbial processes drive the conversion of organic matter into essential nutrients such as nitrogen, sulphur and phosphate.

The fungal/bacterial ratio indicates whether the soil microbiome is dominated by fungi or bacteria. Fungal dominance supports organic matter accumulation and slower nutrient turnover, reducing risks of N losses through leaching and denitrification.

Bacterial dominance accelerates organic matter breakdown and increases N and S mineralisation, but may also increase nutrient loss risk and reduce buffering capacity during stress periods.

Dr. Thomas Nikolai (“the rolling professor”) suggests that rolling may positively influence beneficial bacterial communities. This requires further investigation.

Since microbial measurements only began in the final season (2024), no meaningful conclusions can yet be drawn regarding resistance to dollar spot. Multi-year monitoring is required, potentially including direct measurements of carbon and nitrogen sequestration.

Recent research confirms that turfgrass microbial communities are significantly correlated with soil P, Fe and C content, pH, organic matter, sand and clay fractions, and overall turf health assessment (Chou et al., 2024).

Importance of Trueness as a Playability Metric

Dollar spot directly affects ball roll consistency. Therefore, trueness is arguably more critical than green speed (stimp). The more numerous and deeper the “spots,” the less reliable holing-out becomes.

During this study, hole locations were almost always placed on unaffected areas of moderately to severely infected greens, meaning the collected data were not representative of playability under true disease impact.

Future work should repeat these tests at shorter intervals and under more representative conditions.

Role of Thatch

During the inventory visits, thatch thickness was measured at four locations per monitored green. According to Evers (2025), thatch consists of both thatch and mat.

“Thatch” refers to visible, poorly decomposed plant residues with minimal mineral soil mixing. “Mat” is the underlying layer where decomposed organic matter is strongly mixed with mineral particles.

Measurements primarily captured the thatch layer, although in cases where the boundary with mat was unclear, the two were recorded together.

The relationship with dollar spot infection remains unclear. However, there are indications that thicker thatch layers (>10 mm) may correlate with lower dollar spot severity on certain courses. More research is needed before valid conclusions can be drawn.

Conclusions & Indications

The conclusions and indications below are based partly on findings from this field-based practical study, and partly on information from the reviewed literature. None of the conclusions are statistically substantiated, as this study concerns only 12 courses and 36 greens, and the dataset is incomplete because not all information was collected with equal consistency across all 12 courses. The indications relate to specific, one-off observations in practice at the respective golf course and can only be confirmed (or rejected) through further observation or research.

5.2 Conclusions

Technical (turf management)

1. Although maintenance and management operations are broadly similar across greens, greens often respond very differently in terms of tolerance to dollar spot.
2. The historical development of greens as well as their construction profile are frequently the underlying drivers of a green's susceptibility to fungal diseases.
3. The use of ferrous sulphate has a positive effect on suppressing dollar spot activity, provided it is applied preventatively. Many courses in this study showed that **application frequency** has a greater effect on reducing damage than the **total amount of iron** applied. US research confirms this.
4. After moderate to severe infection, applying **more** ferrous sulphate may have the opposite effect on damage reduction. In that case, ferrous sulphate is used curatively: it may sufficiently dry the turf surface and suppress the pathogen, but it can also increase stress and damage to the turf plant.
5. Rolling can reduce dollar spot activity, provided that the particle size distribution and porosity of the topdressing sand are not too coarse. Compressibility of the upper rootzone is a prerequisite to achieve measurable effect.
6. The Smith-Kerns prediction model is a useful tool to forecast dollar spot and implement timely preventive measures. At present, this is hardly used across the 12 courses. In addition, the commonly used threshold of 20% should be lowered to **12%**.
7. Bentgrass-dominant greens should receive at least **70–100 kg N/ha/year**, supplemented with other elements such as magnesium and potassium, and divided over at least **five applications** if organic matter content over the top 6 cm is below **2.5%**.
8. Organic matter across 2–4–6 cm should average above **3%** to ensure sufficient buffering capacity for the turf plant. A measure to increase organic matter is topdressing with sand that contains a compost fraction.
9. Hand-watering the most sensitive greens prevents drought stress and reduces susceptibility to dollar spot. This requires a green-specific approach rather than a course-wide approach. An application of wetting agents (surfactants) may support this strategy.
10. Green location in shade or sheltered conditions is not a decisive trigger for dollar spot.
11. Leaf wetness duration is directly correlated with dollar spot severity. *Agrostis stolonifera* (creeping bentgrass) has a fine leaf texture and forms a very dense sward due to its above-ground stolons—more leaf area per surface area, therefore a longer leaf wetness period. Regardless of genetic resistance to dollar spot, creeping bentgrass is undesirable.

Communication & playability

12. Use the Holing Out Tester frequently to determine a reliable damage/acceptance threshold. For example, follow the protocol developed by The R&A, which uses a minimum trueness of **70%** for a well-playable green. Repeat the test at a minimum of four different positions at a distance of **6 feet** (approx. **1.83 m**) from the hole.
13. Timely communication with the club and its members is essential to improve understanding of dollar spot issues: build awareness of damage acceptance, manage expectations, and share knowledge about greenkeeping.

Indications

1. Dew removal irrigation appears to have a positive effect on reducing dollar spot infection. Key questions include duration, timing (evening, night, or early morning), and the influence of green construction type.
2. A thatch layer reduces gas exchange, which may also reduce dollar spot activity. Initial data analysis suggests that a slightly thicker organic layer (max. 3.5 cm) can lead to lower dollar spot on greens with fine fescue and velvet bentgrass. Key questions include the optimal combined thickness of thatch + mat, and whether the thatch type is related to the dominant turfgrass species.
   Agrostis canina (velvet bentgrass) forms a thicker thatch layer and can therefore buffer more moisture and nutrients. It appears that this species can maintain itself under dollar spot pressure.
3. Oxalic acid in the plant appears to be an important virulence factor in fungal pathogens. Early research indicates that *Clarireedia jacksonii* may require an acidic leaf environment to develop. Plant sap analyses may help steer management in time.

Recommendations for further research

1. What is the optimal ratio between bacteria and fungi in the 0–2 cm zone?
2. Why do fine fescue greens appear more tolerant to dollar spot than bentgrass-dominant greens? To what extent are C/N ratios in fine fescue comparable to those in (common) bentgrass? And what role might C/N play in suppressing dollar spot?
3. What is the best timing of maintenance operations throughout the day? When is the risk of (mechanical) injury—and therefore infection—lowest?
   To what extent can we monitor the spatial spread pattern of dollar spot across the course to improve understanding of the pathogen?
4. What are the antagonists of the pathogen?
5. What is the role of oxalic acid production by and within the plant, and what is the interaction with *Clarireedia* spp.? How can this be influenced in practice to reduce susceptibility to dollar spot?

6. Can plant sap analyses become a valuable tool for greenkeepers to steer plant vitality and thus reduce dollar spot infection risk?
7. The role of breeding: how do we develop the ideal anti–dollar spot seed mixture for greens? In practice this remains overseeding, so positive effects will only become visible during transition.
8. International collaboration: identify overlapping questions, share knowledge, and exchange national experience.

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