ETS

GOLF DELLA MONTECCHIA
WHERE ORDINARY BECOMES EXTRAORDINARY

Università degli Studi di Padova

DAFNAE

6th ETS Field Days

TRANSITIONING TURFGRASS

Turfgrass management in the Transition Zone, taking into account climate change and the limitations to the use of pesticides

IL VERDE EDITORIALE

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The 6th European Turfgrass Society Field Days

Padova (IT) 27th-28th May 2019

The European Turfgrass Society is pleased to welcome ETS members and other turfgrass specialists to the 6th ETS Field Days 2019 in Padova, Italy.
The ETS organizes its Field Days every two years: Valencia – Spain (2009), Ghent – Belgium (2011), Monte Carlo – Monaco (2013), Helsingør – Denmark (2015), and Brno – Czech Republic (2017) were the previous hosts of this international Field Days.
Italy has been chosen to host the event in 2019, the 27th-28th May 2019, in the heart of the Veneto region, home to beautiful natural scenery and internationally renowned works of art. The meeting venue is the Hotel Sporting, at the Radisson Blu Resort, Terme di Galzignano (Padova).
The seminars will be held at the University of Padova on the morning of the 27th, and at the Golf della Montecchia on the morning of the 28th, while the afternoons of both days will be dedicated to the technical visits.
The Organising Conveners of the Field Days, Dr. Stefano Macolino, University of Padova and Dr. Alessandro De Luca, Italian Golf Federation, chose the theme "*Transitioning Turfgrasses*" for these international Field Days for the peculiar climate of this area and of Italy in general.
The Transition Zone is so named because of the alternance between cool season grasses and warm season grasses. There is no one grass type that best fits this area. Its winter temperatures can be too cold for some warm season grasses and too hot in the summer for some cool season grasses.
With the introduction of the EU Directive on the sustainable use of pesticide, it's forbidden to apply these products. Furthermore, the management of Turfgrasses is facing weather extremes due to climate change (e.g. pronounced drought and hot waves, heavy rain, etc), legislation restrictions and various environmental challenges. That means it's even more difficult to maintain the turf quality in the transition zone.
The Department of Agronomy Food Natural resources Animals and Environment (DAFNAE) is part of the University of Padova, one of Europe's oldest, that was first established in 1222.
DAFNAE works nowadays to combine innovative teaching and up-to-date research with its advanced laboratories and experimental farm at Agripolis, a modern university campus devoted to educational and research activites at excellent levels.
The mission of DAFNAE is to promote the quality of human life, the competitiveness of the agri-food sector, and the sustainable use of biotic and abiotic natural resources, through the production and dissemination of knowledge of the management and improvement of plants, animals, soil and microorganisms.
The Golf della Montecchia, a 27 holes golf course founded in 1988, is fully committed on environment since many years, as show by the numbers of awards received (GEO, INV, IAGTO).
Right now, 9 holes are under a sustainable golf course management program, according to the "Biogolf Protocol", a result from the cooperation between the Federazione Italiana Golf (FIG), the Golf Environment Organisation (GEO) and other major Italian environmental organizations, like Legambiente, Federparchi and Fondazione Univerde.
The management has insisted especially in the

adaptation of the entire structure and systems to the rules concerning ecology, safety and optimization of resources with particular regard to water and electricity, that brought to the recent conversion of the turfgrass to Bermudagrass.
The Golf Club offers to members and visitors numerous services easily accessible facilities, thanks to the quick access to the center of the city and all the tollgates.
The ETS Field Days is a two-day event that is organised every two years and it is intended to promote the exchange of information among turfgrass specialists from universities, official bodies, private companies but also among professional greenkeepers and groundsmen, to discuss technical issues related with the study of turfgrasses.
It is our ambition to provide a forum to spread innovative applications for the benefit of the turfgrass industry promoting the exchange of information among turfgrass specialists.

01

Site-Specific Management for the Reduction of Turfgrass Inputs

Gerald Henry, *PhD, Professor-Environmental Turfgrass Science, University of Georgia*

Turfgrass managers are often accused of exhibiting luxury consumption of several inputs such as fertility, irrigation, cultivation etc. Recent research has attempted to change this perception by enhancing sustainability through the development and implementation of efficient, site-specific turfgrass management. The spatial variability of soil and plant parameters common to turfgrass environments makes it very difficult to oversee entire areas under the same management plan (Fig. 1). Therefore, the primary goal of site specific management is to define boundaries of site specific management units (SSMUs) (i.e. management zones) through the use of precision agriculture concepts, technologies, and products (Photo 1, page 4). Integrating current site assessment equipment/sensors into daily management practices will help turfgrass managers to apply inputs to areas where needed, when needed, and in the amount needed, resulting in management on a smaller scale and reductions in overall inputs.

Extensive research has been conducted at the University of Georgia to determine optimal sampling technique, timing, and application. Research was conducted to compare handheld and mobile sensor data acquisition of soil moisture [Volumetric Water Content (VWC)], soil compaction [Penetration Resistance (PR)], and turfgrass quality [Normalized Difference Vegetative Index (NDVI)]. Spatial maps of VWC and NDVI displayed similar patterns of variability between handheld and mobile devices, while spatial maps of PR were inconsistent due to device design and user reliability. Consequently, mobile devices may provide the most reliable results for soil compaction measurement.

The magnitude and frequency of spatial variation with respect to several agronomic conditions present within turfgrass systems requires intense sampling techniques for data acquisition. Research was conducted to determine the minimal number of samples needed to accurately describe the spatial variability of soil and plant parameters. Six sampling grid sizes (2.4 m x 4.8 m, 4.8m x 4.8 m, 4.8 m x 9.6 m, 9.6 m x 9.6 m, 9.6 m x 19.2 m, and 19.2 m x 19.2 m) were employed for the spatial analysis of VWC, PR and NDVI when areas were near field capacity and under drier soil conditions.

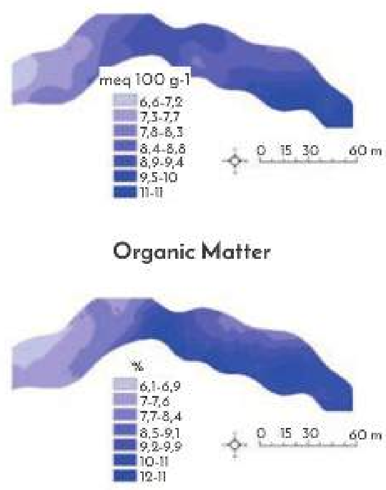

Figure 1 *Kriged maps of Cation Exchange Capacity (CEC) and Organic Matter (OM) content of a fairway at the Georgia Club Golf Course in Statham, GA in 2016.*

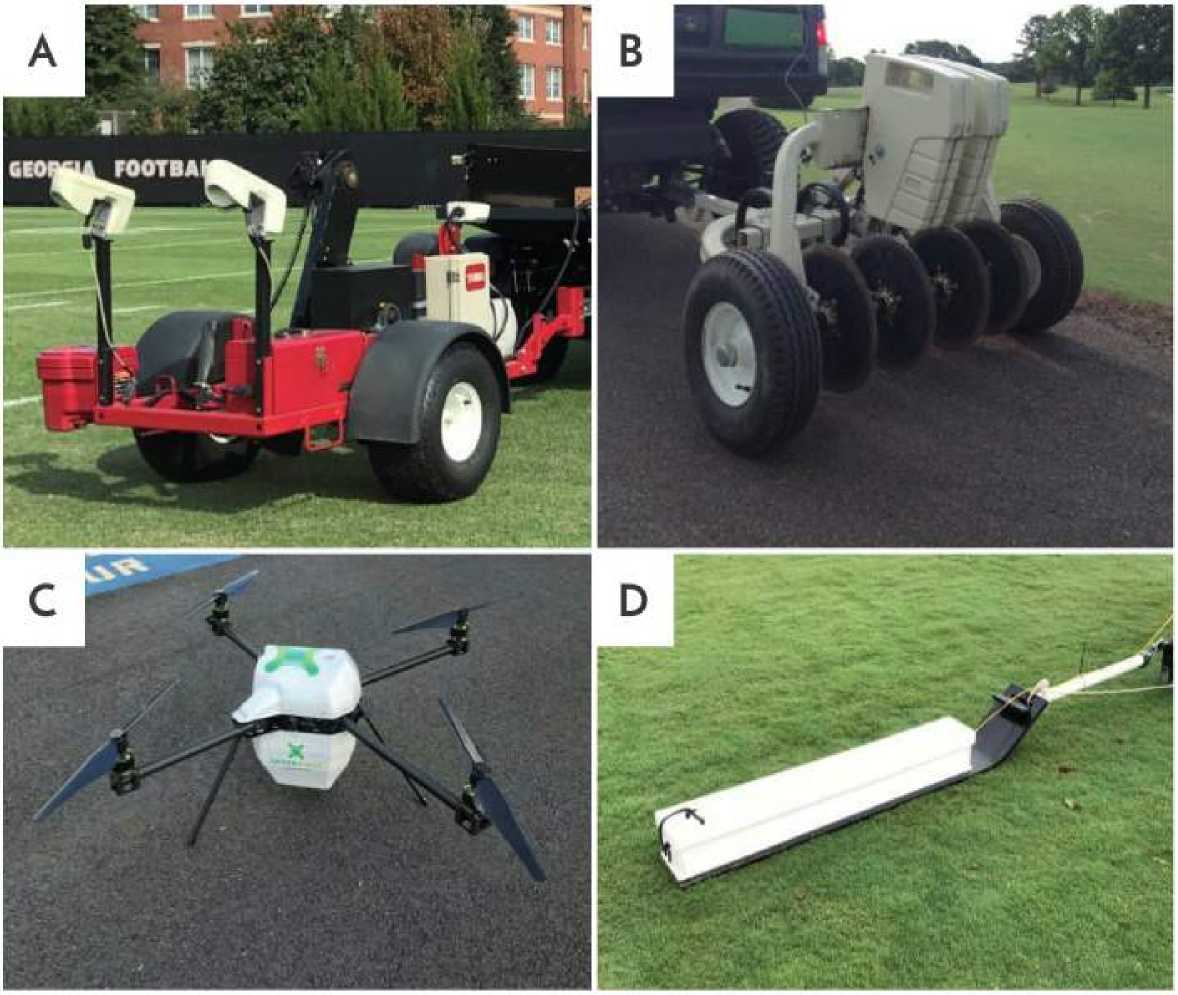

Photo 1 *Precision Sense 6000 mobile, multi-sensor data acquisition unit (A), a 4-disc Veris Q1000 soil EC mapping system (B), unmanned aerial vehicle (C), and mobile electromagnetic induction device (D).*

It was recommended from the results of this study that turfgrass managers begin with a 4.8 m x 9.6 m sampling grid to conduct a baseline standard of agronomic properties when soil is near field capacity. Subsequent sampling should be conducted under similar soil moisture conditions with the baseline used for comparison over time. The sampling grid can be adjusted depending on the variability of the agronomic property and desired accuracy.

Further research examined PR and surface hardness (SH) on the basis of VWC resulting from either rainfall or irrigation. The spatial variability of VWC and PR appeared to be most affected between periods of rainfall versus irrigation. Spatial variability of SH was not influenced substantially by soil moisture condition, but rather the combined effect of PR and turfgrass cover on each sampling date. Spatial maps of VWC collected after a rainfall event may provide insight into the infiltration and drainage capabilities of a turfgrass site, whereas data collected after irrigation are likely best for assessing malfunctioning irrigation heads. Spatial maps of SH may be useful for the delineation of site-specific cultivation zones, since the spatial distribution of SH was not influenced by soil moisture.

Autonomous Mowers Save Energy and Improve Quality of Lawns

Marco Volterrani, Michel Pirchio, Marco Fontanelli, Nicola Grossi, *Centre for Research on Turfgrass for the Environment and Sports (CeRTES), Department of Agriculture, Food and Environment, University of Pisa (Italy)*

Autonomous mowers are machines that don't need an operator to perform turfgrass mowing. The first autonomous mower was produced in 1995 by Husqvarna (Sweden) and was powered by solar energy, while current autonomous mowers are battery-powered machines. Autonomous mowers usually move randomly within a precise perimeter defined by a shallow-buried boundary wire which generates an electro-magnetic field. Once the autonomous mower reaches the boundary wire or an obstacle, it stops and changes direction. It is an effective solution to cover areas with many obstacles, but leads to frequent overlapping. Some larger autonomous mowers use GPS technologies with the aim of reducing overlapping. The working capacity of autonomous mowers ranges from 400 to 30,000 m^2. Autonomous mowers can be equipped with razor-like pivoting blades mounted on a cutting disc or with solid blades. Compared to conventional mowers, autonomous mowers have several advantages:

- they help to save a great amount of time; especially for people who doesn't like to mow the grass;
- they prevent humans from coming into contact with dust, allergens, polluting gasses;
- they are so silent that they can perform mowing even at night;
- given that autonomous mowers are usually programmed to operate every day, the clippings are very small and are left in place;
- they consume about one third of energy compared to gasoline powered rotary mower (Grossi *et al.*, 2016). Autonomous mowers have also proved to produce a superior turf quality compared to traditional walk-behind rotary mowers.

Based on scientific evidence, some trials have been carried out to develop and study different autonomous mowing solutions and innovations for improved turfgrass management and turf quality control:

- Very little is known about the effects of autonomous mowing on encroaching weeds, the aim of this research was to compare the effects of an autonomous mower and an ordinary gasoline-powered mower on weed development in an artificially infested tall fescue (*Festuca arundinacea* Schreb.) turf with different nitrogen (N) rates. A three-way factor experimental design was adopted. Factor A consisted of three N rates (0, 75, and 150 kg ha^{-1}), factor B consisted of two mowing systems (autonomous mower vs. walk-behind gasoline rotary mower equipped for mulching), and factor C which consisted of four different transplanted weed species: (a) *Bellis perennis* L., (b) *Trifolium repens* L.; (c) *Trifolium subterraneum* L. and (d) *Lotus corniculatus* L. Of these, *B. perennis* is a rosette-type plant, while the other three species are creeping-type plants. The interaction between mowing system and transplanted weed species showed that the four transplanted weed species were larger when mowed by the autonomous mower than by the rotary mower. The autonomous mower yielded larger weeds probably because the

Photo 1 *Festuca arundinacea cut at 2.6 cm by an autonomous mower.*

constant mowing height caused the creeping weed species to grow sideways, since the turfgrass offered no competition for light. N fertilization increased turf quality and mowing quality, and also reduced spontaneous weed infestation. Autonomous mowing increased turf quality, mowing quality, but also the percentage of spontaneous weed cover (Pirchio *et al.*, 2018a).

- Autonomous mowers have several advantages over manually - operated mowers but they are not designed to mow lower than 2.0 cm and are consequently not used on close mowed turfs. An ordinary autonomous mower was modified to obtain a prototype autonomous mower cutting at a low height. The prototype autonomous mower was tested on a manila grass (*Zoysia matrella* (L.) Merr.) turf, and compared its performance in terms of turf quality and energy consumption with an ordinary autonomous mower and with a gasoline reel mower. A three-way factor experimental design was adopted. Factor A consisted of four nitrogen rates (0, 50, 100 and 150 kg•ha^{-1}), factor B consisted of two mowing systems (autonomous mower vs. walk-behind gasoline reel mower with no clipping removal), and factor C consisted of two mowing heights (1.2 and 3.6 cm). The interaction between mowing system and mowing height showed that the turf quality was higher when the turf was mowed by the autonomous mower and at 1.2 cm rather than at 3.6 cm. Autonomous mowing reduced mowing quality but also reduced leaf width. Lower mowing height induced thinner leaves. N fertilization increased overall turf quality, reduced weed cover percentage, but also reduced mowing quality. These results show that autonomous mowers can perform low mowing even on tough-to-mow turfgrass species and on high quality sports turfs (Pirchio *et al.*, 2018b).
- Warm-season turfgrasses can be grown suc-

cessfully in the transition zone, but dormancy occurs to some extent during the winter. Overseeding with cool-season turfgrasses is necessary if winter desiccation of warm-season turfgrasses is not tolerated. The increasing availability of zoysiagrass cultivars has enabled this genius to be considered suitable for low-maintenance golf courses. Zoysiagrasses have the most rigid leaves of all turfgrass species so turfgrass mowers need more sharpening. Autonomous mowers have proved to produce a superior turf quality compared with traditional walk-behind rotary mowers, but no autonomous mower has ever been tested at a low mowing height on an overseeded warm season turfgrass. Because of this, the trial was carried out to simulate a golf tee overseeded with cool season turfgrasses as polystand, with low input fertilization rates and with one of the most difficult turf species to mow; i.e., manilagrass. The trial was carried out in Pisa (Italy), from October 2016 to October 2018. After a two-year period, the best turf quality was achieved with *Festuca rubra* spp. cultivars. In many cases turf quality increased after manila grass green-up since the combination of both cool season and warm season species gave a higher quality to the turfgrass, especially because of the finer leaf texture and higher shoot density. A year-round polystand of manila grass with some cultivars of *Festuca rubra* spp. could be suitable for golf tees with low-input management, looking forward to the reduction of chemical inputs allowed on turfs by the European regulations (Grossi *et al.*, 2019).

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Challenges and Opportunities for Growing Grass in the Transition Zone

Diego Gómez de Barreda Ferraz, *Universitat Politècnica de València (Valencia-Spain)*

In March 1998, James B. Beard published an article on Golf Course Management entitled "The origins of turfgrass species" (Beard, 1998). The author stated that each grass species tends to thrive best under climate and soil conditions similar to those in its region of origin. This obvious statement was complemented by an "entertaining" description of the origin of each turfgrass genus, the summary of which can be observed in Table 1. Cool season grasses evolved almost exclusively in the cool Eurasian geographical regions in forest-margin areas, characterized by a cool temperate climate plus reasonably good precipitation and soil fertility, while warm season species evolved close to the equator under warm and sunny climatic conditions (Beard, 1998).

That region of the world between the abovementioned climatic areas is also a great environment for growing crops, in fact, the origin of agriculture began in that area, but according to Beard almost no turfgrass species were domesticated there. That is the area we call the turfgrass Transition Zone (TZ).

In the USA, the TZ is an almost rectangular area between northern cool humid regions and southern warm humid regions (parallels 34 to 37). In Europe that same area between parallels 34 and 37 does not exist in the same way since it involves mostly the Mediterranean Sea, but also regarding land area it includes the far South of Greece, Portugal and Spain and Sicily in Italy together with northern areas of Morocco, Algeria and Tunisia in Africa. However, in Europe the Mediterranean Sea has a big influence on coastal areas, softening the climate and increasing the TZ latitude range until parallel 45 in coastal areas.

Growing turfgrass species in the TZ is a big challenge as they are not completely adapted to that region with 4 different climatic seasons, but on the other hand it is a big opportunity.

COOL SEASON GENUS		WARM SEASON GENUS	
Turfgrass genus	**Origin zone**	**Turfgrass genus**	**Origin zone**
Agrostis	Central Europe	*Cynodon* and *Pennisetum*	Eastern Africa, in the Kenyan and Uganda regions
Festuca: (Tall fescue)	Southern part of Europe	*Paspalum*	East-central South America
Festuca: (Fine fescues)	Cool forest regions of the Alps	*Zoysia* and *Eremochloa*	Southern China and the rest of southeast Asia
Lolium	Southern Europe and temperate regions of western Asia around the Mediterranean sea to northern Africa	*Stenotaphrum* and *Axonopus*	Eastern regions of the American continents including the West Indies
Poa	Northern regions of Europe	*Buchloe* and *Bouteloua*	North America semi-arid and arid great plains

Table 1: *Origins of Turfgrass species (Beard, 1998).*

Photo 1 *Turfgrass species/commercial varieties show different leaf texture and green colour.*

Challenges

The main challenge is merely to have a green, dense and perennial turfgrass surface throughout the year, as climatic conditions are very changeable. It can be easy to achieve when turfgrass quality requirements are low as in big city parks or residential gardens, just using the only species that is really adapted to the TZ, *Festuca arundinacea*. But it is really a big challenge when turfgrass quality standards are high, like in ornamental gardens and sport facilities. In this case, a number of secondary issues appear and need to be addressed like in an obstacle race:

- Turfgrass seed mix design: mixing 2-3 species or at least 2-3 commercial varieties within a species, is almost compulsory in the TZ in order to achieve a high quality turfgrass sward all year long. Some species/varieties of the mix will tolerate some biotic and abiotic stresses more than the others saving the sward when difficulties appear. But the mix design is not easy, as species/varieties will compete with each other threatening the initial balance. As a general rule, one should not include more than 50% of *Lolium perenne* in the mix as it is very competitive during implantation, or one should not include less than 65% of *Festuca arundinacea* in the mix due to its texture and growing habit. In the same way, it is unaesthetic to mix different leaf texture and/or green colour species or varieties (Photo 1). However, it is possible to grow in the TZ just one species/variety along the year (the case of a golf course green) but it is a risky situation, above all if there is no appropriate management knowledge and input use.
- Turfgrass seed availability: turfgrass produc-

tion areas are far from the TZ, above all in Europe, where it is almost impossible to find appropriate field structure, machinery and farmer expertise for growing grass in the TZ. Due to this, and also due to seed quality purposes, most seed companies in the European TZ purchase turfgrass seeds in the USA, C3 species mainly in Oregon and C4 species in Arizona. It implies an extra cost and sometimes more important, a delivery delay, which is a decisive factor for example to have access to the most recent July-August harvesting of *Lolium perenne* seed, programmed for overseeding on *Cynodon dactylon* in early October.

- Turfgrass implantation window: it can be a big problem for C4 species as these species in the TZ just have a few months with vigorous growth. A sufficient period of warm weather should follow seeding in order to promote rapid warm season turf establishment (Turgeon, 2005). Bermudagrass seeding window in some areas of the TZ is June-July while for zoysiagrass, this is even narrower due to its slower growth rate. On the other hand C3 species in the TZ are easier to get established than C4 species.
- Irrigation is almost compulsory: the big weather diversity of the TZ does not only involve temperature, but also rainfall events which are unequally distributed throughout the year. Therefore, irrigation systems are necessary (Photo 2), with the following associated problems occurring frequently: high cost, poor design, lack of uniformity, lack of water quality, low management expertise,...
- Elevated and diverse number of inputs are used: it is clear that turfgrass species in the TZ run into difficulties at some point during the year and groundkeepers act preventively or curatively by applying pesticides, fertilizers, growth regulators, wetting agents, pigments, etc. more intensely than in turfgrass adapted zones. Additionally, the type and quantity of agronomic practices increases as well, like: overseeding, irrigation, fertilization, pesticide application, etc. which implies a higher managing expertise level.

Photo 2 *Irrigation is almost compulsory in the Transition Zone.*

Opportunities

Only the fact that turfgrass could be cultivated in the TZ is a big opportunity. Human beings, above all those living in big cities, benefit from turfgrass for its sensorial qualities: freshness, smell, touch and sight. Turfgrass can be found in every public park where people can spend hours on it relaxing themselves or playing games.

Turfgrass is also a big business opportunity for the TZ, as the golf and football industry is completely dependent on turfgrass species that are not originals of that area. But unlike other places on earth (cool and warm areas) all turfgrass species can be grown in the TZ.

Finally, turfgrass has proven to be effective in sequestering atmospheric CO_2 and in improving soil quality (Quian *et al.*, 2015).

In conclusion, although most of the turfgrass species are not well adapted to the transition zone, and hence, a big effort has to be made in order to maintain a good quality turfgrass sward, benefits for the transition zone are unquestionable.

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04

High Distribution Uniformity of Irrigation Systems to Ensure Turf Quality and Efficient Use of Water

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A controversial issue about lawns is related to their high water consumption, although their capacity to provide many ecosystem services is widely recognized and it is well known that turf is an irreplaceable surface for recreational sports/activities (Monteiro, 2017). Without water their benefits may be reduced or annihilated but high-quality standards in turfgrass can be maintained also reducing water irrigation volumes (Carrow, 2006). Different studies show that in most cases, under moderate levels of deficit irrigation (50%-60% of actual evapotranspiration), turf quality can be maintained at an acceptable level but with lower water consumption compared to irrigating back to field capacity (Gómez-Armayones, 2018).

To ensure efficient irrigation, or to reduce water irrigation volumes, it is necessary to apply uniformly the appropriate water amount to plant and soil in correct timing, without wastage through runoff, deep percolation, wind drift and direct evaporation (Fig. 1). In summary good irrigation is the efficient application of the right amount of water at the right time in the right place (Connellan, 2002). For the most effective results, uniformity and efficiency must work together. Only with a high distribution uniformity it's possible to have a high irrigation efficiency without losses and able to ensure the right amount of water to all the plants, basic condition to have a high-quality turfgrass.

Distribution uniformity indicates the uniformity of application throughout the field and the Low Quarter Distribution uniformity DUlq (Merriam and Keller, 1978) is the more suitable index to evaluate it. DU_{lq} emphasizes the areas which receive the least irrigation by focusing on the low quarter area, typically by placing catch can devices across an irrigated area and is calculated using the following equation:

$$DU_{lq} = \frac{\textit{Average low - quarter depth of water received}}{\textit{Average dept of water received}}$$

DU_{lq} is often used as a basis to judge the quality of a turf irrigation system and it well describes the performance of an irrigation system. Even if site condition may alter the performance during operation, distribution uniformity is in large part established during system design. The American Irrigation Association indicates the catch can DU_{lq} values to describe the quality of irrigation system, ranging from excellent to poor, and sets the minimum values for fixed spray heads (55%) and rotary sprinklers (70%). Mecham (2004) reviewed

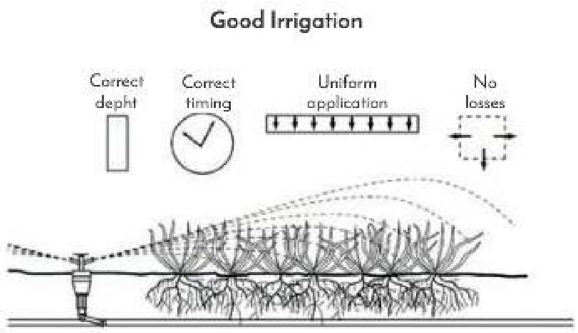

Figure 1 *The four key principles of good irrigation practice (Connellan, 2002).*

the results from over 6800 audits of landscape irrigation systems pointing out that the most sprinkler systems fell into the "fair" or "poor" category (DU_{lq} < 59%). Very often the lower the distribution uniformity, the lower the irrigation efficiency due to overirrigation to ameliorate turfgrass appearance of the driest zones suffering the least water application. In fact, any degradation in turfgrass will likely result in the increasing irrigation volume to the area. During audits in residential irrigation systems, Thomas *et al.* (2002) found that, to overcome the poor water distribution uniformity related to inappropriate selection of sprinkler nozzles, the irrigation time was usually set too high, resulting in overapplication of water. And overwatering, besides wasting water and energy and leading to environmental degradation, produces poor agronomic conditions for healthy turfgrass.

Other factors may influence distribution uniformity. Baum *et al.* (2005), analysing the distribution uniformity of residential irrigation systems, noted that sprinkler brand and pressure also affected the uniformity values. In a field investigation conducted at five golf courses, Miller *et al.* (2014) found that the DU_{lq} was 55% on average, and the highest values were measured in the golf course that presented very little pressure variation among sprinklers and sufficient sprinkler overlap.

Pitts *et al.* (1996) listed, in order of frequency, the reasons that can be a cause of low DU_{lq} values: maintenance and faulty sprinkler heads, mixed equipment type in zones (spray and rotor), excessive pressure variations, and poor head-to-head coverage. Although distribution and redistribution into the soil of irrigation water are affected by many other factors, such as soil texture, slope, thatch accumulation, turfgrass canopy, Straw *et al.* (2018) found that volumetric water content DU_{lq} is similar to catch can DU_{lq} on the sand capped turfgrass sports fields. It would therefore be necessary to simulate options of sprinkler placement for the desired uniformities before installation on the field. However, several analytical tools able to give irrigation designers the ability to evaluate and compare different sprinklers, nozzles, spacing, combinations have been developed, most of them in the last few decades (Dwomoh *et al.*, 2014).

In conclusion, though many factors may affect turf quality and efficient use of water, a starting point is the high distribution uniformity obtained with good design and careful maintenance of the system during the time.

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05

A New Hyperspectral Based System for the Estimation of Weeds and Botanical Composition of Turfgrasses

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The botanical evolution of mixtures and weeds invasion and their diffusion are important aspects in turfgrass research. Monitoring plant population dynamics in turf mixtures have shown increasing interest by turf specialists in consequence of herbicide-use reduction and the increase of low-maintenance management. Mixing two, three or more species is the simplest and probably best known method to reduce maintenance inputs for maintaining turfgrasses, especially in transition zones (Dunn and Diesburg, 2004). Mixtures of different turfgrass species have better visual quality and reduced environmental and pest stresses compared with monostands (Salehi and Khosh-Khui, 2004). However, vegetation dynamics of different species determine uniformity and composition of the turf, and are influenced by several factors such as seeding rates (Brede and Duich 1984a), mowing height and frequency (Brede and Duich 1984b), and fertilisation (Gough *et al.*, 2000). Indeed, studies on botanical composition of weed invaded turfgrasses are very important especially with the recent rules in banning herbicides imposed by the European Union. The most used methods for determining turfgrass species composition are visual estimation (Cropper *et al.*, 2017; Knot *et al.*, 2017), point quadrat method (Macolino *et al.*, 2014), or the combination of the two (Leasure, 1949). A less used alternative is plant count of single species, but this method is usually used in pot trials (Bailey *et al.*, 2013; Earlywine *et al.*, 2010) or in field trials using profile sampler (Brede and Duich 1984a).
A number of studies have looked at identification of species from hyperspectral reflectance datasets (Cho *et al.*, 2010; Ghasemloo *et al.*, 2011). The use of hyperspectral image analysis for vegetation mapping is mainly used for ecosystem monitoring and remote sensing of vegetation (Malenovsky *et al.*, 2009; Drusch *et al.*, 2017). Several studies were conducted to classify tree species from hyperspectral imaging data with different results (e.g., Xiao *et al.*, 2004) according to their spectral or spatial resolution (e.g., Dalponte *et al.*, 2009), and the adopted platform (airborne or satellite; Vyas *et al.*, 2011; Xu *et al.*, 2011). Specific studies were conducted on species classification in grasslands (Cushnahan *et al.*, 2016; Monteiro *et al.*, 2008). However, the spectral variability showed to be very high and linked to the phenological stage and stress level of the canopy (Cushnahan *et al.*, 2016).
Hyperspectral sensors collect the light reflected from objects in a series of contiguous bands. The

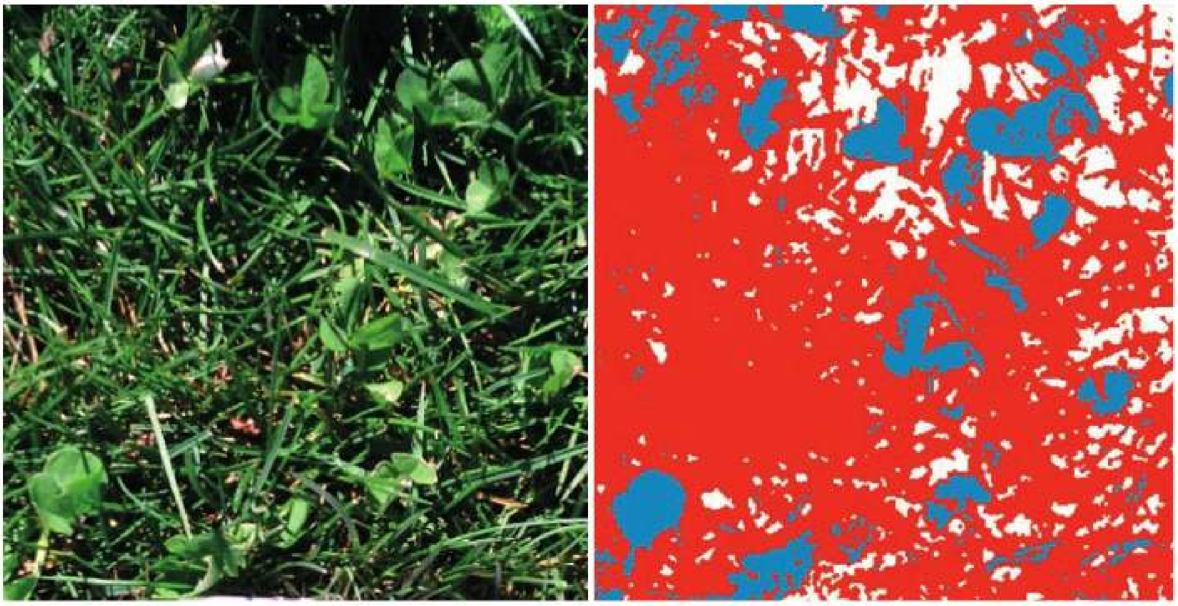

Figure 1 *RGB image derived from Specim IQ hyperspectral data (a - left) and classification raster obtained with the hyperspectral analysis (b - right) of dataset collected in plot with* Trifolium repens *and* Festuca rubra.

high spectral resolution allows vegetation classification, and the selected bands are used for calculating vegetation indices to analyse biophysical and biochemical properties (Galvão *et al.*, 2011). Vegetation indices are commonly used to remotely evaluate vegetation covers both quantitatively and qualitatively (Rascher *et al.*, 2007; Fang *et al.*, 2016), and in some case continuum-removed reflectance is used instead of reflectance data to normalize spectral features reducing noise (Aneece *et al.*, 2017).

The above mentioned studies were conducted on complex grasslands with a high number of species. Our hypothesis is that hyperspectral sensors can be successfully used for species classification in a simplified canopy as that of turfgrass, with a limited number of species maintaining the same growth stage over time. This method helps in determining the species composition of the turfgrass in terms of percentage coverage. In this study we used hyperspectral data collected from different turfgrasses in order to obtain the percentage at coverage of species in the mixtures.

Data were collected in plots of an existing trial established in September 2018 with *Trifolium repens* L., *Achillea millefolium* L., and *Festuca rubra* L. Plots were arranged in a complete randomized block design with three replications. Plots in each block consisted of three monostands (*T. repens, A. millefolium, F. rubra*), three two-species mixture (*T. repens + A. millefolium; T. repens + F. rubra; A. millefolium + F. rubra*), and one three-species mixture (*T. repens + A. millefolium + F. rubra*). Plots were mowed with a rotary mower machine at 4.7 mm every other week. A high-resolution hyperspectral camera system (Specim IQ from Specim, Oulu, Finland) was used to take reflectance images of plots using a white panel (50% reflectance) as a reference target. The hyperspectral camera acquires data from 400 to 1000 nm. On 2nd April 2019, reflectance images were taken just before the mowing in each plot. For classification of the species, a supervised classifier (Dalponte *et al.*, 2012) was used and analysis was performed with R software (version 3.1.3, R Development Core Team 2015).

Region of interest for the classification were drawn using the QGIS 3.4.1 software (QGIS Development Team 2018). Instead of the original reflectance values, the continuum removal reflectance was considered, adopting a spectral transformation technique to enhance individual spectral

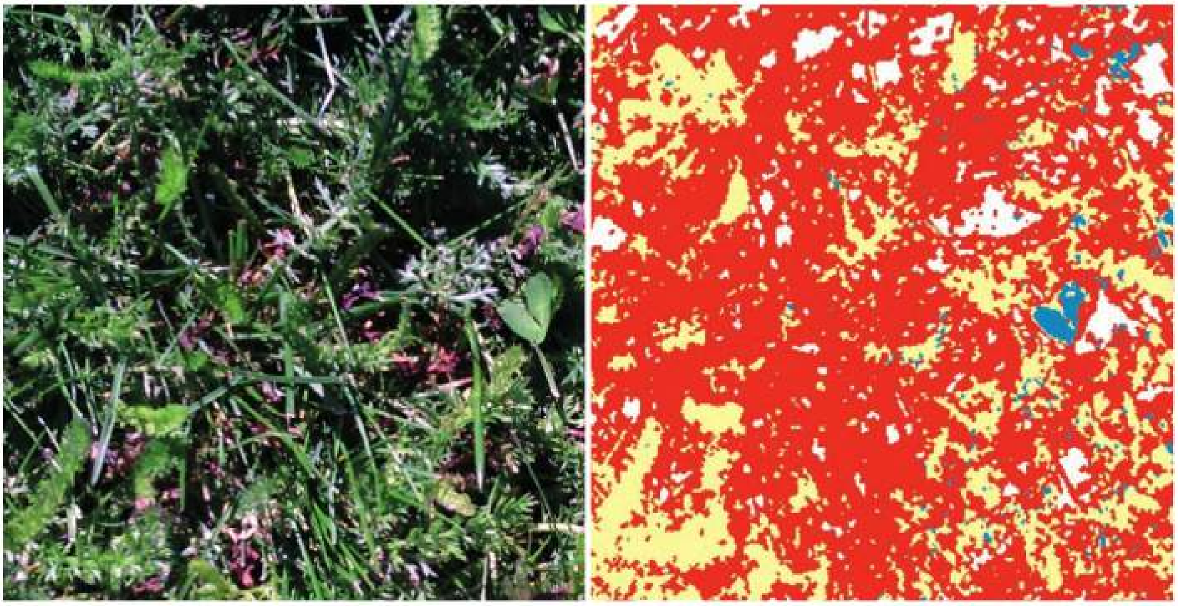

Figure 2 *RGB image derived from Specim IQ hyperspectral data (a) and classification raster obtained with the hyperspectral analysis (b) of dataset collected in the plot with* Achillea millefolium, Trifolium repens, *and* Festuca rubra.

features (Sakowska *et al.*, 2019). The dark pixels that typically are due to the canopy shadows and can negatively affect the classification accuracy were excluded from the datasets. We considered as dark pixels the pixels with a mean reflectance value lower than 0,01.

We report here the results of hyperspectral analysis performed on two images (Fig. 1 and Fig. 2) as an example. Figure 1 (page 14) reports the RGB image and the raster resulting from the analysis of the dataset collected in plot with *T. repens* and *F. rubra*. We found that 12,1% were dark pixel, while *F. rubra* reached 76,4% and *T. repens* 11,5%. From the analysis of the dataset collected in the plot with *A. millefolium*, *T. repens*, and *F. rubra* (Fig. 2) we found that 7,6% were dark pixels (canopy shadows), while *F. rubra* reached 56,2%, *T. repens* 4,3%, and *A. millefolium* 31,9%. Comparing RGB images (Fig. 1a and 2a) and rasters (Fig. 1b and 2b), it is possible to observe that the hyperspectral system can be used to classify plant species in a close mowing sward. However, with this preliminary analysis, we found that dark pixels represent a great percentage of the whole image and this could strongly affect the accuracy in the estimation of species cover. The technique turned out to be promising in the classification of plant species in turfgrasses. However, further analyses are needed to define the appropriate data collection method and to improve the classifier performance.

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06

The Effect of Fairway Rolling on Dollar Spot Suppression on Golf Courses

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Introduction

Dollar spot, caused by the ascomycete fungus *Sclerotinia homoeocarpa* (now *Clarireedia* spp.), is the most economically important turfgrass disease causing significant damage to turfgrass swards throughout the growing season on golf courses worldwide. Fungicide applications to control dollar spot during the growing season account for a significant portion of golf course maintenance budgets, especially on fairways. Furthermore, reducing fungicide applications on fairways could considerably reduce overall pesticide usage on golf courses, thus saving substantial amounts of money and allowing for resource allocation towards other maintenance practices. Moreover, with ever growing pressure to reduce pesticide usage due to environmental concerns, golf course fairways serve as an excellent place to develop management alternatives where pesticide use is restricted.

Rolling is an alternative cultural practice originally incorporated into management programs to improve speed on putting greens. In the last 25 years, much of the work done to explore the practice of rolling has been done at Michigan State University under the direction of Dr. Thomas Nikolai, where researchers examined the impact of lightweight rolling on performance of putting greens, specifically. In addition to improvements in performance and speed, Nikolai's research group also observed other agronomic benefits of the practice as well, including a reduction in dollar spot incidence. Similarly, improvements in performance and reduction in dollar spot have also been anecdotally reported on golf course fairways where rolling programs on fairways have been initiated. Therefore, University of Massachusetts Amherst has begun a first fairway rolling project funded by New York State

Photo 1 *Tru-Turf FR-108 rolling head mounted on Jacobsen fairway mower at Star Hue CC, Korea.*

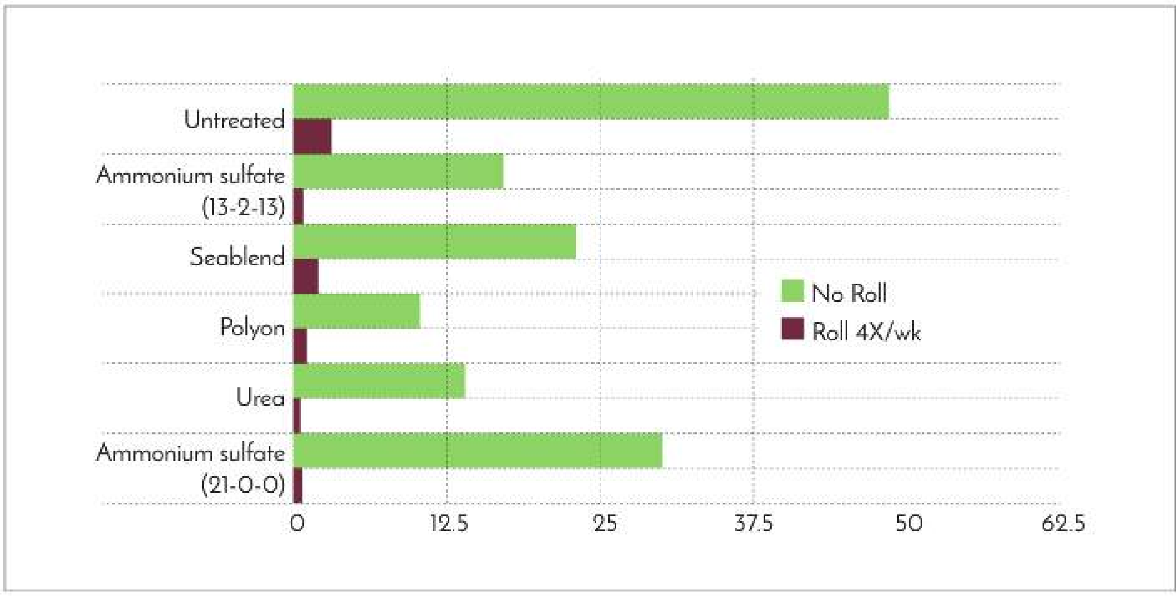

Figure 1 *Effect of fairway rolling and various fertilizers on dollar spot uppression (rating on July, 2016) at Star Hue CC, Korea.*

Turfgrass Association (NYSTA) and New England Regional Turfgrass Foundation (NERTF) in 2015 to examine the practice of rolling using a Smithco Fairway Ultra 10 Roller and confirm its potential to reduce fairway fungicide applications for dollar spot while also determining proper rolling frequencies and exploring interactions with bio-control products and nitrogen fertilizers. In brief, in comparison to non-rolled plots, increased fairway rolling frequencies at 3X, 4X and 6X per week increased dollar spot reduction by 40-60%, with a positive correlation between reduced clipping yields and increased rolling frequency. Additionally, a substantial reduction in dollar spot was observed while rolling (4 times per week, Tuesday and Thursday, double roll) and applying 0.20 lb nitrogen/1,000 ft2 every 14 days. Yet, there are still more questions on whether dollar spot reduction by fairway rolling is affected by different turfgrass species or different rolling machines.
Therefore, the main objectives of the 2017 study were:

- ☐ determine the effect of fairway rolling using Tru Turf FR-108 rolling heads to control dollar spot on Kentucky bluegrass and perennial ryegrass fairways on golf courses.
- ☐ determine the interactive effect of common fertilizers and fairway rolling using Tru Turf FR-108 rolling heads on dollar spot control.

Materials and Methods

Field efficacy testing was conducted at Sapporo Golf Club Yuni Course, Hokkaido, Japan and The Star Hue Country Club, Yangpyeong, Korea. The trial was conducted on perennial ryegrass at Sapporo GC Yuni and on Kentucky bluegrass at Star Hue CC. Rolling began at each course in mid-May, 2016 and was applied Tuesdays and Thursdays as a double roll for a total of 4 rolling passes over the experimental plots each week using a Tru Turf FR-108 rolling head mounted on Jacobson fairway mowers (Photo 1, page 17). Fertilizer treatments were applied on May 19, July 7 and August 10 at Sapporo GC and May 24, June 14 and July 5 at Star Hue CC. Urea (46-0-0), ammonium sulfate (13-2-13 and 21-0-0), organic fertilizer (Seablend, 12-0-12) was applied at 1.22 g/m^2 on all application dates (Fig. 1). Polyon (polymer coated urea, 41-0-0) was applied at 7.32 g/m^2 once on the first application date at both locations.
Field trial plots were arranged in a randomized complete block design, with four replications. Plot

size measured 1 x 2 meters. One half of the plot was devoted to rolling 4X weekly and the other half was not rolled. Ratings were taken on select dates by counting the number of dollar spot infection centers. Means were subject to an analysis of variance and were separated using Fisher's LSD test ($P < 0.05$).

Results

- Sapporo Golf Club Yuni Course: rolling reduced dollar spot compared to the non-rolled in all treatments. Minimal differences were observed among the fertilizer treatments, however, all fertilizers did reduce dollar spot more than untreated. This experiment indicated that rolling and fertilizer application could reduce dollar spot up 65% more than no rolling or fertilizer application.
- Star Hue Country Club: Rolling reduced dollar spot in all treatments compared to non-rolled (Fig. 1, page 18, and 2). Fertilizers that consisted of urea as the main source (Urea and Polyon) were the top-rated fertilizer treatments (Fig. 1, page 18). Overall, all rolled treatments reduced dollar spot by more than 90% when compared to the non-rolled untreated.

Figure 2 *Experimental plot demonstrating no-rolled plot significantly infested with dollar spot at Star Hue CC, Korea (picture taken on July 15, 2016).*

Discussion

These fairway rolling experiments using Tru Turf FR-108 rolling head mounted on Jacobson fairway mowers showed the potential to reduce dollar spot infection substantially if rolling programs are used regardless of turfgass species composition at golf courses fairways in Asia. Overall, both locations showed the potential for a 65-90% reduction in dollar spot compared to non-rolled untreated plots. These disease reductions could substantially reduce fungicide inputs on fairway turfgrass. In addition to reduced dollar spot incidence, other benefits were also observed including increased quality, firmer surfaces and broadleaf reduction, as well as thatch compression and/or reduction. Furthermore, we concluded that no turfgrass species-specificity was observed in this study, nor was there any specificity observed between rolling machines in our previous studies. Consequently, the potential of reducing fungicide applications with fairway rolling under nitrogen applications could offer an economically and environmentally friendly solution for dollar spot management. A deeper investigation of the factors influencing mechanisms of fairway rolling on dollar spot reduction is undergoing.

Acknowledgement

Our sincere appreciation goes to superintendents at respective golf courses. We extend our gratitude to Tru-Turf's funding for the study and delivery of a fairway roller to each country.

The US Experiences on Sustainable Turfgrass Management

Michael Kenna, *Program Director, USGA Green Section Research*

The USGA's vision for turfgrass and environmental research is to "use science as the foundation to benefit golf." Since 1983, the USGA has emphasized sustainable turfgrass management and environmental protection in several ways. Here are six ways the USGA has supported research to achieve this goal.

Water Conservation

Early research on turfgrass water use established the amount of evapotranspiration for the grasses used on golf courses (Fig. 1). The results lead to the development of water budgets and improved irrigation scheduling to reduce water use. In areas where recycled water was available, the USGA strongly encouraged it to be used. Research also focused on new technology such as the time domain reflectometry (TDR), soil moisture sensors and unmanned aerial systems (UAS) with spectral cameras (Fig. 2, page 21). Now, additional projects are conducted on the adoption of precision irrigation technology. Since 2005, a 21 percent reduction in water usages was achieved by U.S. golf courses.

Environmental Benefits

The social and economic value of green space that a golf course provides to the community was emphasized. Golf courses provide valuable wildlife habit in out of play areas allowed to grow native plant materials. Wildlife Links, a cooperative research program with the National Fish

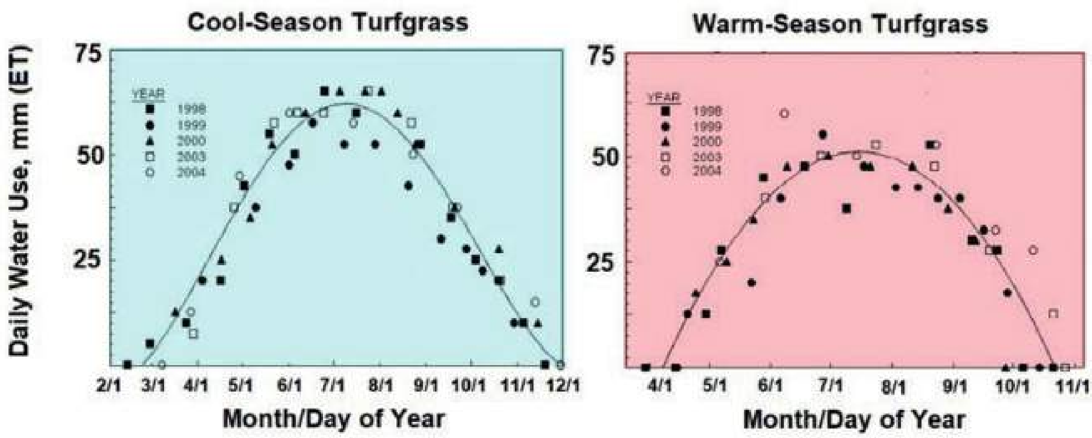

Figure 1 *Average daily evapotranspiration (ET) of cool-season and warm-season turfgrasses over five years (University of California, Riverside, California, U.S.A).*

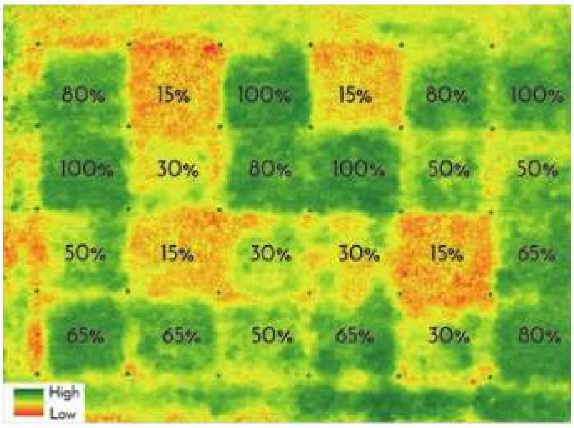

Figure 2 *Color-enhanced image of plots in the nearinfrared (NIR) band on 31 August 2015. Percentages denote evapotranspiration (ET) replacement irrigation treatments. Dark green(high) indicates more turf biomass (Kansas State University, Manhattan, Kansas, U.S.A).*

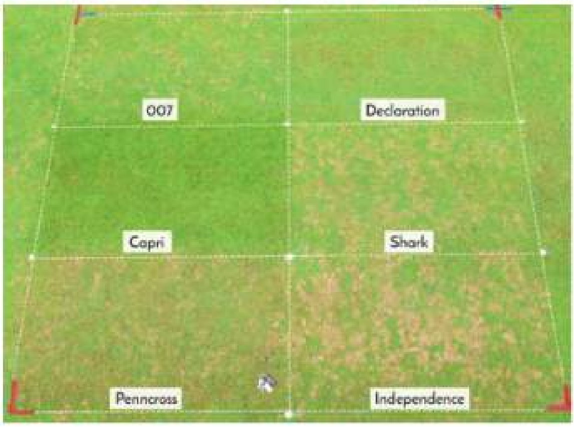

Figure 3 *Researchers at Rutgers University are evaluating methods to reduce fungicide usage on golf course fairways. Bentgrass cultivars with dollar resistance can help the golf course become more sustainable (Rutgers University, New Brunswick, New Jersey, U.S.A).*

and Wildlife Foundation, provide valuable information on how mammals, birds, fish, reptiles, and amphibians use the golf course. In 1990, the USGA established the Audubon Cooperative Sanctuary Program in cooperation with Audubon International. Currently, the USGA is supporting new research on the ecosystem services, such as carbon storage, stormwater management, and heat island reduction that golf courses provide to a community.

Pesticide and Nutrient Fate

The USGA research showed that proper application of pesticides and nutrients would not negatively impact the environment. However, this research also demonstrated that quality turfgrass could be produced with fewer pesticide and fertilizer applications. Since 2005, golf courses in the U.S. have reduced nitrogen use by 35 percent (31,000 tons annually) and phosphorous by 53 percent (17,000 tons annually). USGA research showed tall vegetation along ponds and streams protect water quality. However, pesticide use has remained at the same level since 2005, and more needs to be done in the area. The USGA is actively supporting disease forecasting models and the introduction of new turfgrass cultivars with disease resistance.

Putting Green Construction

The USGA continues to improve the recommendations for putting green construction. This method is the most method of green construction that provides consistent playing conditions worldwide. To some degree, the USGA putting green recommendations have helped expand the game of golf throughout the world. This method provides the best chance to have quality greens because it

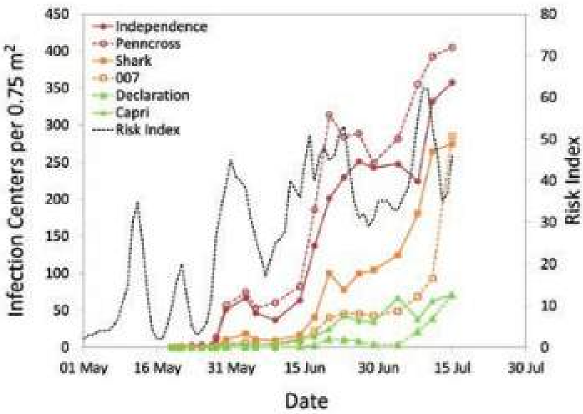

Figure 4 *The number of dollar spot infection centers in highly susceptible (red lines), moderately susceptible (orange lines), and more tolerant (green lines) bentgrass cultivars and dollar spot risk index (black line) calculated using a weather-based, logistic regression model during 2015 (Rutgers University, New Brunswick, New Jersey, U.S.A).*

is resistant to compaction, provides fast surface drainage, yet retains subsurface moisture.

Golf Course Management

The USGA provides many best practices to reduced inputs. Cultural practices, biological control, plant growth regulators, disease and insect tolerant turfgrasses, and pest forecast models are pieces of a much larger golf course management puzzle (Fig. 3 and 4, page 21). The USGA is supporting the Golf Course Superintendents of America (GCSAA) to develop Best Management Practices (BMP) for all fifty states by the end of 2020. The USGA also has worked with Green Section agronomists and the Research, Science, and Innovation team to develop USGA Resource Management. Integrating new technology and data management that provides a daily dashboard view of golf course inputs is the future.

Breeding Better Grasses

Many new grass cultivars used today on golf courses resulted from USGA turfgrass breeding programs. More than 30 game-changing cultivars were developed that use less water and provide better playing quality with fewer resource inputs (Photo 2). Attention to developing cultivars for the needs of different climates will allow these new grasses to be used worldwide (Photo 1). The new cultivars not only benefit golf but are used on other sports facilities around the world. Since 1990, the USGA has received more than $6 million in royalties, and all of this and more has been reinvested in university plant breeding programs.

Photo 1 *Bermudagrass experimental cultivars remained green without water for eight weeks during July and August at the University of California, Riverside, California, U.S.A. The goal is to develop drought-tolerant bermudagrasses with improved winter color to eliminate overseeding with perennial ryegrass.*

Photo 2 *'Latitude 36', a cold-hardy bermudagrass variety developed at Oklahoma State University and funded in part by the USGA, is gaining popularity across the transition zone of the U.S.A.*

08

The "Biogolf Protocol" at Golf della Montecchia

Alessandro De Luca, *Italian Golf Federation, Green Section (Sutri, Italy)*

Golf course management has witnessed important developments over recent years. New requests and expectations by the players as well as important ecological considerations have changed the approach to golf.

Growing awareness that is particularly strong in Europe and that has been focusing on the environmental impact of golf courses has led to new legislation regulating the use of pesticides; similar restrictions regarding the use of water are already in the making.

The Biogolf Case Study was launched in January 2015 as a part of the Biogolf protocol, at the behest of the public bank Istituto per il Credito Sportivo and supported by the Italian Golf Federation (FIG), the Golf Environmental Organisation and other important Italian environmental groups such as Legambiente, Federparchi and Fondazione Univerde.

The Biogolf Case study is supervised by the Agronomists of the FIG and by researchers from the Universities of Bologna, Padova, Pisa and Torino and is charged with managing 9 of the 27 holes of the Golf della Montecchia in accordance with organic farming principles.

Its main objective is to guarantee environmental and economic sustainability as well as to protect the players'enjoyment and the aesthetic. It is a study that aims to directly verify on the field the real implications of an ecological approach to maintenance.

The Golf della Montecchia has long been committed to managing the golf course in an environmentally sustainable way by seeking efficient solutions to optimize all aspects of golf course management. Contributions on the part of various universities and institutes have led to interventions involving the local flora and fauna, the woodlands, CO_2 emissions and turfgrass. It is in view of these efforts that the club has received numerous national and international awards.

In the effort to share the experience of the study, to encourage comparisons and to set future goals, in September of 2017 the data of the first two years of study were gathered with more than 100 expert consultants, greenkeepers, gardeners, technicians and researchers (Photo 1).

Here are some of studies carried out at Golf della Montecchia.

A comparison between maintaining bermudagrass *(Cynodon dactylon x transvaalensis)* tees and fairways and cool season grasses maintenance

Analyses carried out by the Green Section of the FIG and the Universities of Pisa and Bologna re-

Photo 1 *2017 Biogolf Seminar.*

Photo 2 *Alternative weed control tests on the car cath.*

vealed that at the specific weather conditions of the golf course, bermudagrass is more sustainable compared to a traditional cool season grasses. A significantly lower use of water and fertilizers, a significant reduction in CO_2 emissions were found and no chemical products were necessary.

The adaptability of ultra-dwarf bermudagrass *(Cynodon dactylon x transvaalensis)* Miniverde at Northern Italy climatic conditions

Given the sensitiviity of Agrostis stolonifera to diseases and the marked improvement in the varieties of bermudagrass for putting greens, 9 greens were converted to Miniverde. Experts from the University of Pisa and Bologna evaluated the establishment, the resistance to adverse conditions, the water requirements, the quality and the resistance to low temperatures. Alternatives to the greens cover to defend the turf from the cold were evaluated.

Evaluation of sustainable weeding methods for the control of spontaneous flora in urban areas

Glyphosate-based herbicides were banned in Italy three years ago. Researchers from the University of Padova examined alternative methods to the use of traditional chemical weeding products on the paths of the golf course over an entire season. The efficacy and cost of pelargonic acid, acetic acid, flame weeding, and mechanical scraper were examined and compared. (Photo 2)

Golf course management strategies to improve biodiversity in naturalised rough zones

Wild areas in a golf course enhance its aesthetic and environmental value. According to the study's findings, interventions should be carried out to encourage their growth. Researchers from the University of Padova have been carring out studies in naturalized rough areas to compare different approaches to increasing biodiveristy.

Perspective use of *Rhinantus alectolorophus* for suppressing tall fescue in golf roughs

Researchers of the University of Padova and of the Brno Mendel University (Czech Republic) have been studying the use of the Rhinantus alectolorophus, a hemiparasitic photosynthetic plants which can 'steal' water and nutrient from their hosts as Festuca arundinacea, a species frequently found in the rough areas of Italian golf courses and in other areas. Promoting its growth could promote the establishment of new species benefitting insects, wildlife and the landscape.

Photo 3 *Insect monitoring in the field.*

Photo 4 *Acidification plant in the pumping station.*

Photo 5 *Instrumental control of trees.*

Nature Conservation at the Golf Course

Operation Pollinator was recently launched by the experts of the "Esapolis", the Insect Museum of Padova. After conducting a census of the insects and plants found at the golf course (Photo 3, page 24), the researchers evaluated how to create new habitats for insects to attract birdlife. One of the ways is by introducing scents that can attract insects that will, in turn, attract birds.
The operation also intends to focus the attention of members of the golf course towards the beauty of the natural environment in which the course is included by, among other things, positioning beehives to produce honey along its paths.

The role of Golf della Montecchia in protecting nature

The staff of Golf della Montecchia has long been working to maintain and enhance all aspects of the natural environment including wild grass areas, acquatic and riparian vegetation in the ponds and woodlands. These interventions have increased the space for wildlife particularly in anthropized environments. In 2017 using the census carried out by the National Italian Institute for Wildlife, researchers were able to verify that the area of the golf course have a larger quantity and density of wild species with respect to the surrounding area. Nine of these species are considered as conservation priority.

A new bunker construction technique: comparison of maintenance costs

Bunkers maintenance is certainly an important and expensive part of golf course management. In fact, bunkers need to be regularly checked and maintained because vegetation can develop around and within its borders, the sand is contaminated by dirt or gravel or is washed out. Three materials to avoid contaminating the sand and to limit the growth of weeds were tested. Zoysia matrella, a species characterized by a slow growth was planted on the edges of the bunkers. Technical and economic analyses were made.

Studies presently underway

Studies presently underway are:

- Examining the advantages at using irrigation water acidification system to control the soil pH (Photo 4);
- Comparing mechanical system to control broad leaf weeds;
- Evaluating protocols to control Spring Dead Spot (*Ophiosphaerella* spp.) on bermudagrass and dollar spot (*Sclerotinia homeocarpa*) on creeping bentgrass (*Agrostis stolonifera*);
- Monitoring and manage tree heritage (Photo 5).

Study on the Naturalization Process of Roughs

Stefano Macolino, Cristina Pornaro, *Department of Agronomy, Food, Natural Resources, Animals, and Environment, University of Padova (Italy)*

Golf courses are mainly characterized by plant communities with simplified botanical composition (Pornaro *et al.*, 2018). Improving naturalized rough helps to enhance golf courses biodiversity and allows to reduce management inputs (Brame, 2012; Gross and Eckenrode, 2012; Dobbs, 2013). Little information is available on the importance of naturalized rough for the increase of plant and wildlife biodiversity and habitat complexity of golf courses. However, if these areas consist of wild plants, they can restore grass communities in a highly urbanized area which also represents ecological corridors that host many plant and animal species for the benefit of the environment and of the landscape (Pornaro *et al.*, 2018).

We found only few studies comparing plots mowed at a standard turf height to unmowed plots, since unmanaged plant communities are rarely found in recreational and aesthetic turfgrasses. In an 18-year experiment on roadsides, Parr and Way (1988) observed a gradual increase in species richness with increasing numbers of cuts per year. Dickinson and Polwart (1982) found an increase of litter accumulation, together with a reduction in belowground biomass, and forbs invasion following cessation of mowing. These studies highlight that maintenance practices play a key role in the succession of most plant communities since they influence botanical composition and competition among species. The time at which the mowing occurs may also affect species composition as a delayed cutting allows for seeds to be released into the soil which can improve the species seed bank (Williams, 1984). However, Parr and Way (1988) delayed the date of a single cut from June to July but found no differences in long-term species richness.

The objective of this study was to characterize the vegetation of recently naturalized roughs of Golf della Montecchia (Venetian Valley, Italy) through the analysis of spatial distribution of naturalized roughs by means of GPS. Naturalized roughs were divided into sections homogeneous for their vegetation structure and in particular for

GROUP ID	Woody and shrubby cover (%)	*Lolium perenne* L. (%)	*Agrostis stolonifera* L. (%)	*Elytrigia repens* (L.) Beauv. (%)	*Festuca rubra* L. (%)	*Lolium arundinaceum* (Schreb.) Darbysh. (%)	*Cynodon dactylon* (L.) Pers. (%)
1	82	1	0	3	3	2	3
2	22	0	5	11	15	23	80
3	34	13	8	14	28	13	11
4	20	20	17	8	62	26	39

Table 1 *Mean percentage of woody and shrubby ground cover and mean percentage of dominant grasses of groups identified with the cluster analysis on 101 naturalized rough sections at Golf della Montecchia (northeaster Italy).*

Photo 1 *Fairways and naturalized roughs at Golf della Montecchia.*

the abundance of trees and shrubs, and botanical surveys were conducted in each section recording all plant species and their percentage of abundance (Pornaro *et al.*, 2018). The matrix of species was subjected to cluster analysis. Moreover, with the aim of increasing biodiversity, a 3-year study (2013-2015) was conducted in two selected sites characterized by low plant diversity, and dominated by *Elytrigia repens* (L.) Nevski (Site 1) and *Festuca rubra* L. (Site 2). Three cultural practices were applied once in spring 2013: A) cut with biomass removal; B) cut with biomass removal and supply of hay to provide seeds of local species; C) uncut (control). All species and their abundance were recorded yearly in spring. The number of species and percentage of dominant species were subjected to ANOVA.

We found that naturalized roughs are composed by habitats rarely found in the surrounding area, and that suspension of management practices allows the natural development of these habitats. Nineteen percent of the golf course surface is naturalized rough with a total of 131 species. Even if the structure of the vegetation is more complex and richer in terms of flora than in a typical rough, in some naturalized roughs the development process goes through a critical stage where just a few species are more competitive and prevail over the others. The cluster analysis allowed to identify four groups. Group 1 included most sections with wood and shrubby layer dominant on the herbaceous one (Table 1, page 26). Other groups mainly included sections with few trees or shrubs and were distinguished for including sections dominated by a few *Poacea* species such as *F. rubra*, *Lolium arundinaceum* (Schreb.) Darbysh. (=*Schedonorus arundinaceus*, *Festuca arundinacea*), *Cynodon dacty-*

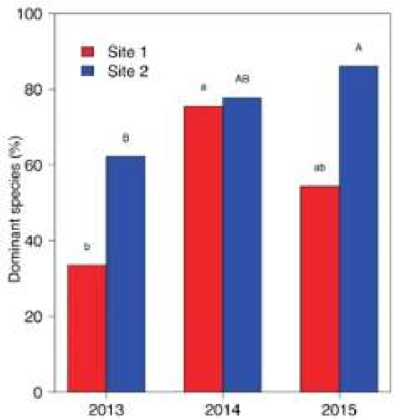

Figure 1 *Effect of the interaction between year and management practices on a number of species in a naturalized rough section dominated by* Festuca rubra. *A = mowed and seed supplied; B = mowed; C = control. Error bar represents the least significant difference at P = 0.05 for comparing means (modified by* Pornaro et al. *2018).*

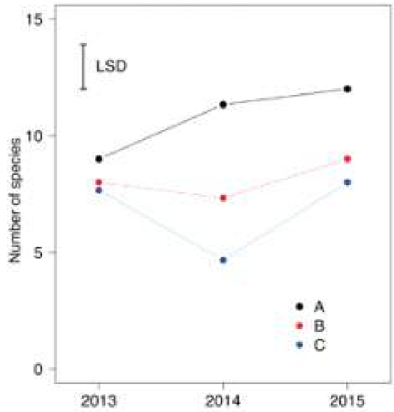

Figure 2 *Year effect on the percentage of dominant species in two naturalized rough sections of Golf della Montecchia (northeastern Italy) dominated by* Elytrigia repens *(Site 1) and* Festuca rubra *(Site 2). Bars with the same lowercase letter are not significantly different according to the least significant difference test at 0.05 level of probability. Bars with the same capital letter are not significantly different according to the least significant difference test at 0.05 level of probability (modified by* Pornaro et al. *2018).*

Photo 2 Tragopogon porrifolius *in a naturalized rough.*

lon (L.) Pers. (Table 1, page 26) that were included in the original seed mixtures used for sowing the roughs. The high shoot density typical of turf-type cultivars together with good soil fertility may lead to their dominance in the sward. As reported by other authors, the presence of simplified habitats with one or few species dominating suggests that mowing is necessary to increase the species richness, promotes the complexity of botanical composition, and limits the aggressiveness of grasses.

Results of the ANOVA for the plot trial indicate that a number of species was significantly affected by year and management practice at Site 1. While for Site 2, we found a significant interaction between management practice and year on species richness. In Site 1, plots receiving management practices A and B displayed a higher number of species than those receiving management practice C (9.6, 10.0, and 6.1, respectively); moreover, the highest species numbers occurred in the last year of investigation (7.7 species in 2013, 7.9 in 2014, and 10.1 in 2015) (data not shown). In Site 2, plots receiving management practice A had the highest number of species in 2014 and 2015 (Fig. 1, page 27). No significant differences were observed between plots receiving management practice B and control plots, with the exception of 2014. For both sites, the ANOVA revealed that the percentage of dominant species was affected by year. In Site 1, the lowest percentage of *E. repens* was observed in 2013, while the highest occurred in 2014 (Fig. 2, page 27). In Site 2, the percentage of *F. rubra* steadily increased over time.

In Site 1, the impacts of the management practices in botanical composition were only observed in the second year of the study, and they appeared to be related more to the effect of mowing than to the supplying of seed, while in Site 2 the increase of species richness within the year was due to management practice A. Furthermore, a single cut was not able to limit the dominance of *E. repens* or *F. rubra*, regardless of the addition of external seed. These findings agree with other studies that documented the role of mowing in increasing plant species population of natural roughs and roadsides (Parr and Way, 1988; Voigt, 1996).

The results of our study suggest that cultural practices are essential to increase plant biodiversity on rough areas in golf courses. The effectiveness of these practices depends on the dominant plant species initially present. Moreover, the supply of external seed may have an additional positive effect, but its efficacy seems to be related to the competitive ability of existing species.

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10

Conversion Methods from Cool Season to Warm Season Turfgrasses

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Maintaining a high quality cool season turfgrass in the transition zone of Europe is becoming an increasingly difficult task due to conflicts between high irrigation requirements and restrictions to water use, disease susceptibility and pesticide reduction policies. Thus, conversion to warm season turfgrasses is becoming the preferred option by turf managers.

The simplest approach to the conversion of a pre-existent cool season turf into a new warm season stand is to follow the ordinary technique for turfgrass establishment. Chemical suppression and removal of the old turf, soil tillage, post-planting or post-seeding chemical control of weeds and use suspension are standard steps to accomplish the conversion.

However, due to economic and environmental concerns, a "soft" or "smooth" transition approach is gaining popularity among turf managers. Reduced or nil soil tillage, minimal surface disruption, short period of use suspension with little or no herbicide application are key practices of this approach that turn into cost savings and a more sustainable turfgrass management.

Under a European perspective, the recent ban of most of the chemicals from sports turfs has two contrasting effects on the conversion to warm season grasses. On one side it makes conversion a more stringent choice for the need to abandon the use of fungicides, while on the other side it reduces the number of tools available to turf managers to complete the conversion by strongly reducing or eliminating the use of herbicides.

Investigations have been carried out in the last two decades with the aim of improving the effectiveness of a soft transition through the adjustment of ordinary treatments or through the development of new techniques.

One of the main issues is to complete the conversion while keeping the surface playable or with the shortest period possible out of use. This implies that the surface is not disrupted or only partially damaged during the sequence of treatments.

Attempts to simply seed or sprig straight into an existing cool season turf while keeping the turf growing have led to the establishment failure or have no practical relevance.

Scalping and verticutting before spreading the propagation material over the entire surface to convert is a basic method to prepare the surface for broadcast seeding or broadcast sprigging (or stolonizing). Cool season grass growth is temporarily suppressed, seed or bud to soil contact is enhanced enough to allow germination or sprouting while canopy thinning allows a better light penetration.

Once the propagation material has generated new plants the competition between the two grasses is the key factor in determining the final composition of the stand, hence, treatments that are most inhibitory to the cool season turf are the most beneficial in promoting the conversion to the warm season stand. The suppressive effect on the cool season species is then maintained with a low cutting height, while the growth of the warm season grass is encouraged with repeated nitrogen fertilizations during summer.

In order to maximize the competitive effect of the warm season over the cool season grass, the correct scheduling of seeding or sprigging is of para-

Figure 1 *The strip seeder and its components that were used to convert a perennial ryegrass turf to seeded 'Riviera' bermudagrass (Fry* et al., 2007. Strip seeding: A new approach for converting cool-season turf to warm-season grasses. *USGA Turfgrass and Environmental Research Online 6(4):1-6).*

mount importance since early plantings may encounter an aggressive growth of the cool season grass and low temperatures for seed germination or bud sprouting. On the contrary late plantings may lead to reduced establishment and higher susceptibility to winter kill.

Post emergent herbicides or plant growth regulators have been tested with success to assist the transition; however, the use of such products is not in accordance with the environmental sustainability recalled as one of the main factors leading to a soft transition strategy. For this reason, this issue is not reported here. According to available data, a broadcast seeding of riviera bermudagrass on a verticut cool season stand gave a ground cover of 12% the year of seeding and a 60% cover the following year.

Data on broadcast seeding of Zoysiagrass over a cool season stand indicate that a 40-75% seeded zoysia ground cover may be obtained in three growing seasons. Ground cover reaches 90% in four growing seasons without closing the area, however, cool season suppression with selective herbicide is necessary.

Other methods have been developed with the aim of making a more efficient use of the propagation material. Strip sodding, row planting, strip seeding and single plant transplanting are all methods that concentrate the propagation material in strips from which the warm season grass will progressively spread and completely cover the ground. The advantage over the broadcast seeding or sprigging as described above is that ideal conditions for establishment are created on

a relatively small portion of the area to convert and the propagation material is positioned only where such conditions exist.
Strip sodding is a partial replacement of the existing turf. The main advantage is the reliability of the establishment method and the cost reduction compared to complete re-sodding of the area. Nonetheless, it remains a labor and time consuming method.
Row planting is a method of vegetative establishment. Planting machines with coulter disks open 5 cm deep slits at 15 cm centres and then press sprigs into the slits, allowing to use vegetative propagation material both on prepared soil or a desiccated turf. Row planting has been tested to establish the vegetatively propagated Patriot bermudagrass on a mixed stand of Kentucky bluegrass and Perennial ryegrass. Results showed that 14 weeks after planting the Bermudagrass cover was 81% where the cool season stand had received no pre-planting treatment, while 93% and 100% where recorded where the pre-existing turf was strip killed or totally killed before planting.
Lower values have been reported with row planting yielding a 30-40% bermudagrass ground cover at the end of the growing season when scalping was applied as pre-plant treatment.
Strip seeding is the adaptation conventional seeding to narrow strips within an existing turf. A specific piece of equipment has been developed in order to create 5 cm wide strips of tilled soil where seeds are positioned. Competition from untilled borders is further decreased by spraying a non selective post-emergence herbicide that widens the treated area to approx 7,5 cm. A press wheel ensures good seed to soil contact, thus providing a further improvement of conditions for seed germination. Reduced use of seed and herbicide (80% less), limited surface disruption (11% of the treated area) and ideal conditions for seed germination are the main advantages of this technique. Published data report a Riviera bermudagrass cover of 41% the year of planting and 71% cover the following year with verticut applied as pre-seeding treatment. Strip seeding with zoysiagrass gave 52% seeded zoysia ground cover in two growing season that rised to 73% and 90% the following two growing seasons with selective herbicides being applied for cool season suppression.
Single plant transplanting is a technique for warm season turfgrass establishment that has been developed from the technology of greenhouse horticulture. Single plants of turfgrass species are produced in seed trays and mechanically transplanted in the field at the preferred density. Also, for this technique specific machinery is required to create furrows, deliver plants to a given place and press the soil to make good contact with the roots. In this case, competitive advantages with respect to the existing turf lie in the propagation material itself that is represented by whole plans with shoots, leaves and a fully developed root system that start their active growth immediately after transplant. Resistance to traffic is similar to that of mature plants and occasional irrigation deficits are not as harmful as for germination seeds or sprouting buds.
Whatever the method adopted some general considerations can be drawn. A period of at least two weeks of use suspension is required to allow frequent watering. As to turf quality, after propagation material is seeded or planted the quality of the surface may be acceptable for play but objectionable for some: local rules for play should be applied when a ball comes to rest on a seeded or transplanted spot. As to turf appearance unpleasant visual quality occurs due to disturbed soil strips and during first winter due to non uniform browning. Non chemical weed control might be the most challenging task for turf managers that adopt a soft transition strategy.

Photo 1 *Fully automated transplanting machine: details of the double disk coulters used for transplanting single plants into an existing turf.*

Bermudagrass Maintenance above the 45th Parallel

Brian Óg O'Flaherty, *Bachelor of Agricultural Science (Land Hort), Master of Science*

Maintaining turfgrass to a suitable standard for the game of golf in a transition climate zone is highly challenging. In Italy, this challenge is increased by high player expectations of course conditions, relatively modest resources for golf course maintenance and increasing restrictions on pesticide use.

Golf della Montecchia is a 27 hole facility, covering 82 hectares situated at 45°23'N, 11°45'E (Fig. 1). The climate is typical of the transition zone; hot summers with maximum temperatures above 30°C and cool winters with minimum temperatures below 0°C. The course was constructed in 1992 and seeded with bentgrass greens and tees and a mix of perennial ryegrass, smooth stalked meadowgrass and red fescue in the fairways and rough. The greenkeeping team consists of a superintendent, 5 full time greenkeepers and a mechanic. During the busier months the team is assisted by 4 part time staff. Local contractors are used to help with certain annual maintenance operations.

During the hotter months of the year the course suffered summer decline in all areas and at the end of August the condition of the fairways was no longer acceptable for play (Photo 1). The club began evaluating warm season turf species in the course nursery in 2003. These trials were done with the Italian Golf Federation and the University of Pisa and concluded in 2007. *Bermuda* spp., *Zoysia* spp., *Paspalum* spp., Kikuyu and Centipede grass were among the species evaluated. Evaluations over the duration of the trial showed Bermuda grass to be the species most adapted to the climate at Montecchia. In 2010, the club began to convert the fairways (Photo 2, page 33) on the first nine holes to bermuda grass (var. Patriot). In 2011, this project was expanded to include the tees. The third nine holes were completed in 2012. The use of pesticides became more restricted af-

Figure 1 *Golf della Montecchia geographical position.*

Photo 1 *Unacceptable fairway conditions.*

Photo 2 *Fairway conversion to Bermuda grass.*

Photo 3 *Spring dead spot.*

ter a European Union directive on pesticide use was introduced into Italian law with the National Action Plan (PAN). The club decided to convert the greens and surrounds on the Verde course into bermuda grass in 2016 using Miniverde on the greens and Patriot in the surrounds. The Verde course is maintained in accordance with Biogolf protocols. Management practices are divided into normal maintenance on the Bianco and Rosso courses and Biogolf protocols on the Verde course. The major limiting factor in maintenance is manpower and the maintenance programs are adjusted to this limit. Fairways and tees on all courses are mowed at 14mm on average twice a week with verticutting every two weeks. Clippings are dispersed by blowing cut areas. Bermuda greens are mowed daily during the growing season at 2,5mm with light verticutting every two weeks. In the normal maintenance programs fertilizer applications are applied using visual observation and soil analysis. In the Biogolf maintenance program fertilizer is applied on a year round basis due to the slow availability of organic nitrogen. It has been necessary to apply mineral fertilizer when growth has been unacceptable at peak growth periods of the year. A maximum of four non organic product applications are permitted under the Biogolf protocols. Irrigation is applied as necessary based on visual appearance with weekly averages being approximately 10mm in rain free periods. The Bermuda grass greens are hollow cored once a year using 16mm tines at 5cm centers. Topdressing is applied to greens every 2 to 4 weeks during the growing season. Topdressing is applied to fairways only after autumn overseeding. No herbicides, fungicides, insecticides or plant growth regulators have been applied to the greens, fairways or tees. A wetting agent is applied to the greens on a monthly basis throughout the year. Spring dead spot damage (Photo 3) was observed on all turf areas two years after conversion. The overall area affected by the disease is small although disease patches have been heavy in certain areas. The disease though unsightly has so far not affected playing conditions adversely. There are no fungicides currently registered in Italy against this disease. Localised aerification on affected areas has increased recovery. All bermudagrass areas are overseeded in September. The fairways, tees and surrounds are overseeded with perennial ryegrass and the greens are overseeded with rough bluegrass. Cutting heights are raised on all areas and light applications of fertiliser are applied to aid establishment. In the spring, the overseeded species are transitioned out by lowering cutting heights and minimum use of irrigation. No herbicides are currently registered in Italy to aid with spring or

Photo 4 *Winter kill.*

autumn transition of bermudagrass. Painting the fairways and greens was trialled as an alternative to overseeding but heavy weed invasion and the lack of any control method for this weed invasion meant that playing conditions were unacceptable. Winterkill has not been a problem on tees and fairways. However, significant damage occurred on the greens (Photo 4) during the first winter after establishment when the greens had not been overseeded. Dessication is thought to have been the main contributing factor and wind break plantings around the affected greens have been established to try and limit this damage. The use of geotextile materials has also been trialled to protect the greens during periods of low temperatures (below -5°C). However, no significant difference was observed between covered and non covered areas. Using green covers would create significant challenges due to the manpower required to carry out the operation.

Overall, the conversion to bermudagrass has been positive. Playing conditions have become more consistent during the twelve months of the year and player satisfaction has increased. The reduction in water use and the better drainage of the bermudagrass surfaces has led to drier and firmer surfaces with improved ball roll. The heat and drought stress tolerance of the bermudagrass has created a greater margin of error in our maintenance practices. Our management practices are evolving and there is still room for significant improvement.

The reduction of pesticide use and water use on the golf course is a major step forward in creating sustainable playing conditions for the golfer while having minimum impact on the environment.

12

Management of the Main Issues Observed without the Use of Chemicals

Massimo Mocioni, *AntNet Srl*, Alessandro De Luca, *Italian Golf Federation, Green Section (Sutri, Italy)*

In Italy the introduction of the National Action Plan on the sustainable use of pesticides has actually reduced dramatically the authorised chemicals on turfgrass in public areas (including sport fields and golf courses). Only some products containing *Bacillus thuringiensis*, one with chlorpyrifos as insecticides and two formulations of *Trichoderma* spp. as fungicides are authorised. No herbicide is permitted as well as any other products authorised and registered by Health Ministry as pesticides in organic farming. In this context the golf Superintendents and the turfgrass maintenance workers have to adopt other control strategies (in particular cultural practices) that can help to reduce pests. One of the most dangerous pests is *Clarireedia* spp. (formerly *Sclerotinia homoeocarpa*), causal agent of dollar spot, that causes damages on turf particularly in spring and autumn. The control strategies relied on IBS fungicides (mainly propiconazole) that cannot be used in public areas, replaced by biofungicides containing *Trichoderma* spp. Last year, severe attacks of dollar spot caused damages on bentgrass and *Poa annua* greens and *Trichoderma* spp. formulations showed a partial control, particularly if the product was applied on a preventive basis in spring, with a reduced efficacy in autumn when the weather conditions were very conductive for the disease; in many cases the signs of the disease were visible until the following spring, causing an inadequate playability of the green surfaces. Also increased nitrogen fertilisation seems to contrib-

Photo 1 *Severe attacks of dollar spot on a golf green.*

Photo 2 Ophioshaerella *spp. on Miniverde bermudagrass.*

Photo 3 Ophioshaerella *spp. on Tifway bermudagrass.*

Photo 4 Digitaria *spp. infestation at the end of the season.*

Photo 5 Digitaria *spp. infestation.*

ute to reduce attacks, as mentioned in many publications, and some Superintendents according to organic farming techniques increased the organic fertilisation in order to help stimulate microbial population in the soil. A lot of Superintendents also applied biostimulants and amendments, and they noted some good results mainly on recovering after the pathogen attacks, but their effects and application timing should be investigated in order to increase the turf resistance to diseases.

Many golf courses converted turf from cold season to warm season grasses in order to reduce inputs and contrast the weed invasion. The warm season grasses (in particular bermuda grass) give good results in Italy and now they are also used in the North, over the 45th parallel, that was considered the limit of the warm season grasses adaptability. Bermudagrass is really tolerant in Italian weather conditions to the main diseases, but in the last years some attacks of spring dead spot (*Ophiosphaerella* spp.) have been observed, favored by a lack of cultural practices and soil conditions, conductive for the disease. Spring dead spot should become a real problem, due to the unavailability of fungicides effective against the disease.

Annual weeds (particularly *Digitaria* spp. and *Eleusine indica*) as well as broadleaf weeds cannot be controlled using chemicals, but only partially reduced by cultural practices as verticutting or spring harrowing on cool season grasses. Repeated harrowing has shown a good control on clover, with some damage on turf. Non-chemical methods were also adopted to control weeds on bunkers or paths, like heat or warm water, increasing costs and requiring repeated applications compared with pesticides.

The adoption of the National Action Plan, it seems to be too strict and we expect some changes in the next review (about the possibility to use some low toxicity chemicals or organic farming authorised products), however it should be considered an opportunity for a more sustainable maintenance. In any case, the expectations in particular for golfers should be reduced accepting a imperfect turf in some period of the year.

Experimental Tests in Golf della Montecchia

A

A New Bunker Construction Technique: Comparison of Maintenance Costs

Alessandro De Luca, *Italian Golf Federation, Green Section (Sutri, Italy)*, Massimo Mocioni, *AntNet Srl*, Elisa Portigliatti, *Mapei Spa*, Andrea Battistella, *Battistella Golf*

INTRODUCTION

Bunkers represent a small portion of the total golf course, but they are an essential part of the golf course and the proper construction and maintenance are really important. The maintenance requires a lot of manpower and materials and it includes periodical raking, water removing, edge restructuring, ace rebuilding, sand addiction,drainage and weed control.

In the last years a lot of different construction methods were studied and tested in order to save operational time, provide a good drainage and maintain the sand clean.

MATERIALS AND METHODS

At Golf della Montecchia a new construction method was tested, developed by Mapei in collaboration with Battistella Golf. The system, called Mapei Technology, consists of the installation of a specific draining porous bonded layer, in order to separate the soil from sand.

The purpose was to increase the drainage capacity, allowing to increase water removal, reduce face erosion, avoid drainage work, maintain the sand clean and limit the growth of weeds.

In order to reduce the edge maintenance, the bunker perimeters were plugged with 40 cm wide *Zoysia matrella* sods.

All data of maintenance operations have been collected throughout two years, in order to compare them with the previous data collected on the same bunker before changes.

CONCLUSIONS

The Mapei Technology allows to save more than 40% in operation time, with an average time

of 13 hours/year/bunker instead of 22 hours/year/bunker. The largest saving are in raking (20% less), edge and face cleaning (90%) and water removal. The cleaning of the drainage system, annual in the golf course bunkers, should be less frequent in Mapei bunker as well as full sand replacement.

Considering only the labor, the saving should be more than 200 €/year/bunker and the construction costs will be amortized in 6 to 7 years.

Operation	Traditional bunker			Mapesoil technology		
	Number of operations/year	Time for each operation (min)	Total time (hours)	Number of operations/year	Time for each operation (min)	Total time (hours)
Raking	100	8	13.3	80	8	10.7
Face cleaning	20	15	5.0	2	15	0.5
Edge restructuring	2	10	0.3	2	10	0.3
Sand thickness check	6	5	0.5	6	5	0.5
Sand addition	2	30	1.0	2	30	1.0
Water removal	10	15	2.5	0	15	0.0
TOTAL TIME			22,7			13,0
Drainage cleaning	1	120	2.0	1 every 2 years*	60	1.0
Full sand replacement	1 every 5 years*	60	1.0	1 every 8 years*	45	0.8
TOTAL ADDITIONAL TIME PER YEAR			3			1.8

* - considering the total time (6 hours) broken down by the number of years

B

The Role of Golf della Montecchia in Nature Conservation

Marta Visentin, Alessandro De Luca, *Italian Golf Federation, Green Section (Sutri, Italy)*

Introduction

Golf dellaMontecchia has always been committed to sustainability and has received several awards : Committed to Green award (2007, 2012), GEO Certification (2013, 2016), IAGTO Sustainability Award (2017).

The course is located in a semi-urban/agricultural area. The natural ecosystem is represented by a strip of residual woodland around the castle and villa together with the trees, hedgegrows and wetland areas. Montecchia is close to the Euganean Hills Regional Park and is in the Federparchi list of sites selected for the European Charter for sustainable tourism. Since 2015, a "Biogolf case study" is being conducted on nine holes of the course.

Panel on biodiversity study in rough areas

Methodology

Since 2000, qualitative species census has been carried out to identify all classes of fauna species observed by researchers and course staff on the course (Visentin et al. 2003; Sorace e Visentin 2011). Census were taken at different times and seasons to constantly monitor the usage of the territory by the fauna community. Since 2017, wetland areas of the course are part of the wintering waterfowl census within IWC by ISPRA (Ministry of the Environment Agency). Reptiles and amphibians have been recorded for the Padua Province Atlas. Research on insect species is undertaken by the local entomology museum Esapolis. The University of Bologna has been delegated to curate the tree heritage. Since 2013, the University of Padova is researching renaturalization of the grasslands around the course to enhance and preserve biodiversity (Pornaro et al. 2018). Artificial nests were created to allow nesting of the Barn Swallow (*Hirundo rustica*).

Artificial nest for *Hirundo rustica*

Recorded conservation priority species
Ardea cinerea
Egretta garzetta
Falco tinnunculus
Caprimulgus europaeus
Picus viridis
Hirundo rustica
Delichon urbicum
Sturnus vulgaris
Passer montanus

Results and Recorded Species

In the past no specific scientific research on birdlife on the course was done. Some information can be taken from the IGM Table. Bird investigations on the course recorded 36 species. Mature trees allows Great Spotted Woodpecker (*Dendrocopos major*) nesting. Wetlands on the course allow several aquatic bird species to stay on the course with high numbers recorded in the 2017 Wintering Wildfowl Census by ISPRA (148 Mallards, 35 Moorhens and 1 Teal). The Eurasian coot (*Fulica atra*), Eurasian Jay (*Garrulus glandarius*), European bee-eater (*Merops apiaster*), European penduline tit (*Remiz pendulinus*) and the spotted flycatcher (*Muscica pastriata*) were recorded on other census. Mammal species such as the redfox (*Vulpes vulpes*),the European badger (*Meles meles*), the Brown hare (*Lepus europaeus*) and Amphibian species such as the Agile frog (*Rana dalmatina*), the Italian tree frog (*Hyla intermedia*), the edible frog (*Rana esculenta*), the smooth newt (*Triturus vulgaris*) and the European green toad (*Bufo viridis*) have also been identified and recorded and research is on going on invertebrate species.

Nesting species detected	
Ardea cinerea	*Luscinia megarhynchos*
Egretta garzetta	*Turdus merula*
Anas platyrhynchos	*Sylvia atricapilla*
Caprimulgus europaeus	*Aegithalos caudatus*
Falco tinnunculus	*Parus major*
Gallinula chloropus	*Cyanistes caeruleus*
Larus michahellis	*Pica pica*
Columba palumbus	*Corvus cornix*
Streptopelia decaocto	*Sturnus vulgaris*
Phasaianus colchius	*Passer italiae*
Apus apus	*Passer montanus*
Dendrocopos major	*Fringilla coelebs*
Picus viridis	*Serinus serinus*
Hirundo rustica	*Carduelis chloris*
Delichon urbicum	*Carduelis carduelis*
Motacilla alba	

Triturus vulgaris

Anas crecca and *Ana platyrhynchos*

Conclusion

By preserving more natural spaces with no maintenance, a golf course can become a refuge for species in areas of high anthropization enhancing the local biodiversity and becoming an ecological corridor useful for the diffusion and dispersion of animal and plant species.

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C

Nature Conservation at Golf della Montecchia

Enzo Moretto, Guglielmo Pezzolo, *Esapolis Museum of Padova and the Butterfly Arc of Montegrotto Terme (Padua, Italy)*

Conserving biodiversity has become one of the most important global priorities of our time; given that, it is important to remember that insects are the largest existing group of invertebrate animals. Growing awareness of the danger of extinction of some insect species such as silkworms, bees, and butterflies has begun to affect public opinion and government policies. Insects are primarily in danger because of the widespread use of pesticides and herbicides that are toxic even to beneficial insects and can destroy wildlife habitats. A project launched by Golf della Montecchia developed in collaboration with the Butterfly Arc (a miniature tropical forest where hundreds of butterflies fly free) is proposing ecological interventions that are friendly and healthy to both humans and nature. The project aims to demonstrate that even a work/play environment, such as a golf course, can promote wildlife conservation and biodiversity. The project involves monitoring pol-

linators, such as bees (*Apoidea*) and butterflies, and introducing plants that encourage and attract natural wildlife. It also proposes to evaluate the status of biodiversity at Montecchia using the "Syrph the Net" method and to create an educational platform by positioning natural artifacts at specific points in the golf course to draw golfers' attention to nature.

Nature Conservation at Golf della Montecchia

Basing their assertions on findings published in the literature, some researchers and scientists have hypothesized that over the next few decades 40% of insect species will become extinct and that there will be a 75% reduction in their biomass. This apocalyptic prediction has attracted the attention of international media. Although the theory may be erroneous, it has evidently touched the soul of the ordinary man and in particular of individuals who have little contact with nature. It has recently been demonstrated, in fact, that more than 50% of the world's population lives in cities, and the percentage is even higher in rich industrialized countries. At the same time, there appears to be only a limited awareness of these issues even on the part of those who are in contact with nature, largely because of the culture of intensive agriculture or because of low levels of education.

Many have asked why we should worry about insects that most people fear, find disgusting, or even hate. Insects are the largest and most diverse group of organisms on Earth and their presence is essential to our ecosystem. About 950,000-1,000,000 species of insects have been described, but it has been hypothesized that there are actually between 8 and 15 times that many. Not all insects are seen in a negative light; butterflies, for example, are often strikingly beautiful and have a positive image in most people's minds. Bees too are seen as beneficial, useful "bugs" both because they were already producing honey in prehistoric times and because they are considered the world's most important species of pollinators. Other insects have also played important roles in humanity's history. Although grasshoppers are thought of as frightening swarms destroying everything in sight, the food of holy men in biblical times, or a dish commonly eaten even today in Saudia Arabia, there are also the cochineal, a parasitic scale insect used to make carmine, and the domesticated silkworm or *Bombyx mori*.
First recorded in France in 1854, Pèbrine disease, a protozoan disease of the silkworm, caused the collapse of the French and Italian silkworm industry in 1865. According to some studies, while neonicotinoid pesticides do not obliterate bee colonies outright, they kill them over extended periods of time. Although the correlation between these events and the diminuition of certain species can-

not be clearly traced, the connection between the destruction of natural habitats and the drastic diminuition and even the extinction of many species is straightforward. Butterflies are a case in point; they are considered optimal indicators of the state of health of a natural environment; the presence of large quantities and many different species in an area clearly testifies to the good health of that ecosystem. Even apparently positive changes such as forest restoration or wider use of intensive farming have led to a drastic decrease in many butterfly species habitating mixed or calcareous meadows and grasslands, described in the Habitats Directive, as important areas of biodiversity that must be protected.

Actions that seek on the one hand to protect biodiversity and on the other to avoid creating wastes that are damaging to protected areas must replace anthropic activities and using soil in such a way that it is inaccessible to other organisms (e.g. urbanization and intensive farming). Measures that can help to educate the general public on this subject and interventions that can be positioned in places and at times during which most people are receptive also need to be planned. Last, but not least, programs monitoring the habitat's health will be able to contribute to favoring and increasing its biodiversity.

The project being developed by Golf della Montecchia and the Butterfly Arc is a case in point. Aiming to propose ecological, sustainable models for playing golf, the project will create an environment on a human scale that is respectful of wildlife; it proposes popular indicators that are easily understandable by everyone, such as the presence of butterflies and bees together with pollinators and entomofauna repesenting a large part of the planet's living organisms. This explains the need to monitor some species that are more representative of insects and pollinators. The methodology to be used, which has already been tested, will be able to underscore the value of biodiveristy. The two families of insects that were examined for this use were the coleopterous (*Carabidae*) insects and the dipterous ones. The latter were chosen because although they are able to represent different types of ecosystems including aquatic ones, they are more representative of pollinators. The Syrph the Net database will be utilized. The project also intends to introduce native plants that will not only attract pollinators and enhance biodiversity but also beautify the area. Finally, the project is planning to create an educational platform by positioning natural artifacts at specific points in the golf course, including bee hives for local honey production, to draw golfers' attention to the environment's natural beauty.

D

Perspective Use of *Rhinanthus Alectorolophus* for Suppressing Tall Fescue in Golf Roughs

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The importance of naturalized roughs at golf courses is increasing in order to reduce maintenance costs and enhance biodiversity. However, they are often dominated by one or a few grass species. One way to enrich of biodiversity is the introduction of hemiparasitic plants to the roughs. Hemiparasites are photosynthetic plants which can 'steal' water and nutrients from their hosts. A promising hemiparasite plant is European yellow rattle *(Rhinanthus alectorolophus)*, already studied in order to enhance diversity and reduce biomass production in roughs dominated by tall fescue *(Festuca arundinacea Schreb.)*. Tall fescue is a vigorous grass known to have allelopathic effects and is linked to low diverse stands. The experiment was conducted from November 2016 to June 2017 in two locations: Kaskáda Kuřim Golf Course in Czech Republic and the Agricultural Experimental Farm of Padova University in northeastern Italy (Heyduk *et al.*, 2018). The field trials were established in both sites on existing mature grassy sward dominated by tall fescue. The effect of seeded *R. alectorolophus*, nitrogen fertilization and the interaction of the two was investigated. The results highlight that *R. alectorolophus* reduced tall fescue dry mass and height, giving evidence on the potential use of *R. alectorolophus* for reducing tall fescue biomass. The present study aims to corroborate the results found by preliminary experiments. A field

trial has been established in a naturalized rough dominated by tall fescue at Golf della Montecchia. Four treatments were compared: 1. plot seeded with *R. alectorolophus* without spring fertilization; 2. plot seeded with *R. alectorolophus* and fertilized in spring; 3. plot without *R. alectorolophus* and fertilized in spring; 4. plot without *R. alectorolophus* without spring fertilization (control). *Rhinanthus alectorolophus* was seeded in November 2018, and spring fertilization consisted in 60 kg/ha of N using urea. Plots are arranged in a randomized complete block design with three replications. *Rhinanthus alectorolophus* plants will be counted, the height of tall fescue and *R. alectorolophus* plants will be measured during the spring, and dry mass of tall fescue and *R. alectorolophus* will also be determined. The assumption is that hemiparasites can reduce biomass production and vertical growth of grasses, helping the spontaneous establishment of new species.

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E

Evaluation of Sustainable Weeding Methods for the Control of Spontaneous Floral in Urban Areas

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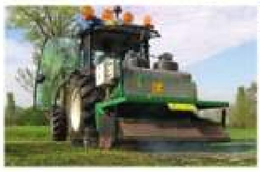
European directive
2009/128/CEE
⬇
D.Lgs 150, August 14th, 2012
⬇
National action plan for the sustainable use of pesticides (*PAN*)

Introduction: Spontaneous flora can be a problem in urban environments and green spaces. Following the current European laws regarding the use of herbicides, a study on alternative methods to the traditional application of glyphosate is proposed. Specifically, the goal was to evaluate the effectiveness on weeds control of each method used in order to find the better solution.

Materials and methods: the experimental tests took place in two paths of the *Montecchia golf course* (Selvazzano, PD), in which a protocol called BioGolf is implemented, aimed at enhancing and safeguarding natural resources. Two bioerbicides and two physical treatments were tested (9 m² plots with 3 replicates for each treatment) and compared with no treated plots (control):

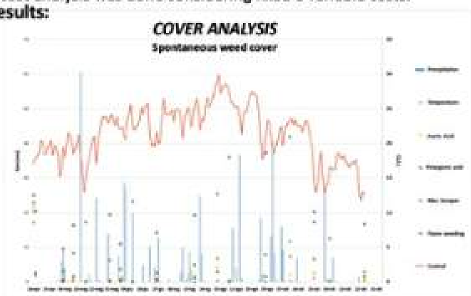
- Acetic acid (Urban Weed™)
- Pelargonic acid (Finalsan® Plus)
- Flame weeding (Emilverde, Italy)
- Mechanical scraper (Barbieri S.r.l., Italy)



After each treatment photos were taken to evaluate the trend of weed repopulation in each plot. The images were processed using *CANOPEO, a Matlab plugin*, to obtain a percentage coverage value for each parcel.
A cost analysis was done considering fixed e variable costs.

Example of photos before and after treatment

Results:



COST ANALYSIS

Methods	Treated area (m²)	Work Times (sec)	Unit Time (sec/m²)
Acetic Ac.	9	60	6.7
Pelargonic Ac.	9	60	6.7
Mec. Scraper	9	300	33.3
Flame weeding	9	20	2.2

Methods	Cost (€/m²)	Total cost (€)
Acetic Ac.	0.11	404.46
Pelargonic Ac.	0.20	824.58
Mec. Scraper	0.28	1137.39
Flame weeding	0.14	573.55
Glyphosate	0.05	208.41

Acetic acid showed the lower percentage of weed coverage over the experimental time and a cost of 0.11 euros/m².
Pelargonic acid showed good results but less effective than acetic acid; also the cost per m² was about the double of it.
Flame weeding showed a good initial result acting more quickly on weeds than the other methods, but its effect does not last over the time because weed repopulations were noted a week after each treatment; the cost was 0.14 euros/m².
Mechanical scraper showed the same trend of flame weeding with very low percentages of weed infestation only the first days after each treatment; the cost per m² was the highest among the treatments.

F

Project of a Green Area Close to Bermudagrass "Green": the Case of Golf della Montecchia

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INTRODUCTION

In winter 2017 the 9 greens of the Green Course of the Golf della Montecchia, managed under the Biogolf protocol, composing of Bermudagrass (*Cynodon dactylon* x *transvaalensis* variety P18 - Miniverde ™), suffered cold damage.
The young age of the turf, established a few months earlier have certainly accentuated the problem.
In particular, more damages were found in the areas most exposed to north-east, where there was no tree and shrub vegetation, able to act as a windbreak barrier against colder winds.
Unlike cool-season species, *Cynodon* spp. and in particular the ultradwarf varieties selected for greens, if not adequately protected, are particularly affected by low temperatures during the winter season.

PURPOSE

The article describes the criteria and parameters that must be taken into consideration to design the areas close to the greens of Bermudagrass.
The study therefore seeks to identify the suitable species, ensuring the practicability of the field in terms of play, a correct landscape fitting and low management and maintenance costs of the vegetation.

Fig. 1: Cold damages in Golf Montecchia – green n. 5

Fig. 2: Identification of area affected by damage: green hole n. 5.

Fig. 3: GPS survey of the study area.

METHOD AND MATERIALS

- Identification of the areas most affected by damage.
- Vegetational analysis performed within the yellow path.
- GPS survey of the study area.
- Green design.

RESULTS AND DISCUSSION

WHAT ARE THE DESIGN CRITERIA TO BE CONSIDERED TO ENSURE SUCCESS OF BERMUDAGRASS GREENS AND A BIOGOLF?

- Avoid excessive interference between turfgrass and the surrounding vegetation (nutrients, water, etc.)
- Avoid shading of the turf (*Cynodon* spp. Heliophilous species)
- Where necessary, provide a windbreak barrier with plants
- Ensure the playability of the field
- Ensure a proper landscape insertion
- Provide low maintenance species

Fig. 4: Identification of areas affected by damage, by the red circles.

5

6

Fig. 6: Example of planting and green of hole n. 5 after planting.

Fig. 5: Example of Green design and species for green of hole n. 5.

CONCLUSIONS:

First results confirm that it is necessary:
Add shrubbery strips at a distance from the turf able not to damage it, in terms of intake of nutrients and water to the green (strip close to the bunker); Select species that do not interfere with the green: the maximum height of the plants is around 3-4 m; The shrub hedge near the bunker acts as a windbreak, able to protect the "green" from cold winter winds; Use most of the species that are already present within the yellow route, therefore they fit perfectly with the landscape. In association, species that fit with existing plants (color homogeneity, leaf characteristics, adaptability to the landscape, etc.) have been selected; Use selected species that are rustic, resistant to water stress, disease and with low maintenance, but with a good aesthetic-ornamental aspect.

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The ETS Field Days is a two-day event that is organised every two years and it is intended to promote the exchange of information among turfgrass specialists from universities, official bodies, private companies but also among professional greenkeepers and groundsmen, to discuss technical issues related with the study of turfgrasses.

The Organising Conveners of the Field Days, Dr. Stefano Macolino, University of Padova and Dr. Alessandro De Luca, Italian Golf Federation, chose the theme *"Transitioning Turfgrasses"* for these international Field Days for the peculiar climate of this area and of Italy in general.

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