Edition 4

NEWSLETTER

September - **December** 2019

Welcome *to Edition 4 of the Amenity Newsletter.*
Autumn will soon be upon us (and it probably is as you read this!). For us we see a difference balance of products leaving our doors – a switch to grades more suited to this season.
One key consideration now is maintaining plant health and minimising disease potential on sports turf and we believe there is a lot you can do without resorting to overuse of plant protection products. Not to be overlooked, we believe, is the use of an effective dew dispersant programme to keep the sward drier and less prone to fungal infections.

In this edition we discuss the needs of the grass plant with regard to macro and micro nutrients and the relationship to disease as well as an article on the movement of water and nutrients in the soil matrix – both these excellent pieces are written by Peter McMorran, our Northern Area Representative and ex-Course Manager of 23 years at Farnham Golf Club. Dew dispersants are also discussed briefly and there's a Q&A which discusses some of the key products we sell at this time of year.

We hope you find it useful!

Paul Morris
Managing Director

Contents:

Movement of Water and Nutrients in the Soil Matrix

Plus Water as a Limiting Factor for Microbial Activity

Soil water or the soil solution is found in the pore space of a soil. The texture of the soil i.e. the percentages of sand, silt and clay plus organic matter will dictate the porosity, size of pores and how much water is held by a soil at saturation, field capacity and wilting point.

The 3 main groups of pore sizes are:

Transmission or Macropores >50μm and linked with drainage, aeration and plant root extension.
Storage or Mesopores 0.5-50μm and linked with plant available water once soil has drained to field capacity.
Residual or Micropores <0.5μm and linked with tightly held water that the plant cannot access and soil structural properties.

The water molecule is polar due to the asymmetrical arrangement of the hydrogen atoms with the oxygen atom giving rise to both an electronegative and an electropositive side to the water molecule. This polarity is the reason why water molecules are attracted to colloidal surfaces and electrostatically charged ions. Where water is attracted to a solid surface this is known as adhesion and where one water molecule is attracted to another this is known as cohesion.

Adhesion and cohesion represent the forces behind capillary action and the water molecules held closest to the solid surface are held by the strongest force of adhesion and this force lessens as the distance from the solid surface is increased, thereby giving the water molecule more freedom. These combined forces of adhesion and cohesion allow water to be held or pulled up against the force of gravity and the phenomenon of capillary rise is inversely proportional to the diameter of a tube or pore matrix in the soil. When considering soil texture the percentages of sand, silt and clay influence the porosity of the soil and the ratio of transmission, storage and residual pores present and how the porosity of an individual soil will influence capillary rise, water holding capacity and drainage – see example data in the table below.

Example of water contents - (volume %)

	Unavailable (residual) Water	*Available Water*	*Transmission Water*
SAND	4	6	29
LOAM	9	29	12
CLAY	29	20	6

These figures are a general guide and will vary depending on the texture of the soil being tested for sand, silt and clay. What the figures highlight is that sand and clay are completely opposite in how they react with water and loam represents a compromise between the two as well as providing the highest % of available water.

The main forces that act upon water in the soil are the Matric, Osmotic and Gravitational forces. When a soil is at field capacity it will have a water potential around -10kPa and wilting point is reached at a water potential of around -1500kPa. The volumes of water held by individual soils will be dictated by the texture and the bulk density as both of these factors strongly influence the type and percentage of pores present within the soil. Organic matter also influences water holding capacity and increasing from 1% OM to 5% OM can almost double soil water content in a silt loam.

Another interesting point to note is surface area per gram of material i.e. sand, silt or clay as water adheres to the surface of the solids present within the profile and as expected sand has a significantly lower surface area in comparison to silt and clay e.g.

Medium sand circa 80cm^2/g
Fine sand circa 100cm^2/g
Silt circa 420cm^2/g
Clay circa 8 x 10^{6}cm^2/g

An important characteristic of soil is its CEC as this influences the hydrogen bonding with water as well as the soil's capacity to hold nutrients. The CEC of sand and silt is generally low and in the region of 1-4 mEq/100g this rises to >50mEq/100g for some clays and 100 – 300mEq/100g for soil humus. Reflecting on the origins of golf and its relationship with coastal links environments the profile will be predominantly sand with a build-up of humus over time through the profile from the plants growing on the site. There will also be a topdressing of lighter sand particles spread from the shore line during dry and windy conditions and so the depth of the developing soil increases over time and this new sand layer will also develop a humus content over time through the natural cycle of things.

Movement of water/soil solution and nutrients to the plant.

One common feature for access to water and nutrients by the plant is root development into the soil profile and therefore root interception of water and nutrients. Assuming there is no mycorrhizal relationship then the volume of soil solution and nutrients available in the soil volume occupied by the roots needs to be known (this on average is 1% of the top soil volume) along with the share of the soil volume that is occupied with pores (average about 50% but varies with bulk density). These guide figures highlight that only a small percentage of the available soil solution and nutrients is tapped into by direct contact through root interception. The amount of water and nutrients required by the plant's demands relies upon the soil being able to correct the lowered water potential at the rhizosphere by allowing water to move by capillary action from zones of higher water potential to lower water potential. This water/soil solution will also carry nutrients by mass flow to the root surface for uptake. Where a specific nutrient is depleted at the rhizoplane these are then replaced by fertilisation to ensure adequate supply or by diffusion from the mineral matter of the soil. Diffusion and movement of diffused ions in an aerated soil will only take place in pore spaces that are filled with water and therefore the path to the surface of the root maybe considerable and this is classed as the impedance or tortuosity factor when calculations are being made. This process of diffusion is the main form of movement of at least potassium and phosphorous to the rhizoplane.

Knowing the volume of water held at field capacity for a known soil texture and how quickly this will be depleted to wilting point will provide a good indication of what water management is required to maintain continuity of water film within the soil matrix. This is essential if optimum movement of water/soil solution from zones of high to low water potential is to be maintained to meet the plant's demands arising from transpiration and nutrient uptake. As the soil dries, the water film around soil particles becomes thinner, water is held more tightly and capillary movement reduced. If water loss from the soil matrix is not replaced the soil dries further and the continuity of water film is broken and the degree of impedance increases thus restricting movement of water/soil solution and diffusion of nutrient. Also, as the conditions dry down and the plant is still transpiring the roots may shrink in diameter by as much as 30% thus reducing direct root/soil contact. Another point to consider is that as the soil dries the mechanical strength of the soil increases restricting further root penetration down into the profile, at this point, the plant will increase development of root hairs to tap into what moisture is available from the volume of soil the root mass occupies.

Microbes and Moisture

Although soil is made up from sand, silt, clay and organic matter the microbes exist in the aquatic environment provided by the soil solution that provides the film of moisture around the soil particles. Maintaining soil water content at an acceptable level ensures microbial activity can be maximised when temperature and soil air (oxygen) content are also favourable for growth of microbial populations. Soil water, as a medium, transports nutrients to the microbes and removes waste products, also, water is involved in hydrolysis reactions and the movement of extracellular enzymes towards non-water soluble nutrients amongst other things essential for the microbial community. Water content will influence gas exchange between the soil and the atmosphere and as the water content increases the volume of soil air is reduced and this will impact aerobic activity. Water will also have a direct effect upon how quickly a soil heats up and cools and a soil with a higher water content will be affected to a lesser degree compared to a soil with a lower water volume content. This is important when managing irrigation to provide suitable soil water content throughout the rooting zone for the plant's need for water and nutrients along with maximising microbial activity.

Water content linked with microbial activity is usually around field capacity but texture, bulk density and organic matter content have to be taken into consideration. A general guide on water filled pores at field capacity would

be circa 60% leaving 40% of pores to be air filled and this would appear to be the ideal balance to maximise activity and mineralisation. However, knowing the individual soil's characteristics is essential if the soil's potential and limitations are to be understood.

Moisture content will influence the microbial communities present within the edaphic zone and moist soils will favour bacteria whilst drier soils are more suited to actinomycetes and fungi as these species can form resting structures to cope with low soil water content. However, some research puts forward the view that selected bacteria may use extracellular polysaccharide that can hold many times its own weight in water to improve survival potential during low moisture conditions.

Where moisture conditions are routinely low, microbial communities will adapt to these conditions and survive, however, the level of activity will be less compared to the same soil being maintained at optimum water volume content and this low level of moisture will limit decomposition of organic matter. However, increasing moisture content above the optimum will reduce soil air content (oxygen) and microbial activity and mineralisation of organic matter will decline.

Managing a sand based green will thus provide the Course Manager with a number of challenges regarding water management that will not only influence microbe activity but water and nutrient supply to the plant. This challenge is made more demanding as target firmness readings are strived for and it may be necessary to research further the moisture content at a known firmness reading for the soil profile/texture in question to ascertain the percentage of water filled pores that are present and if this can deliver the continuity of water film throughout the soil matrix for optimal microbial activity for organic matter control and movement of water and nutrients to the plant.

Conclusion

With greens being constructed of pure sand or sandy loam plus the move to pure sand topdressing the texture of the soil environment for the main root zone on greens is likely to be free draining, low CEC, low levels of colloidal humus essential for improving CEC and water holding and low available water content between field capacity and wilting point. The free drainage will allow the greens to be in play longer but it may exacerbate leaching of nutrient and this will be compounded by the low CEC and an understanding of this is necessary if a plant is to receive balanced nutrient supply. Add this to the lower volume of available water within the profile, the depletion time to wilting point as ET increases and the management of this sandy profile requires regular monitoring both for growth rate and plant health plus moisture content to ensure the continuity of water film within the soil matrix is maintained so the needs of the plant are met for both water and nutrients. With the low CEC and the potential for leaching then drip feeding of nutrients to deliver a balanced feed throughout the year is worth consideration. The input of fulvic acid and seaweed will assist root development and the moisture management programme should ensure the continuity of water film is maintained so water up take, mass flow of nutrients plus diffusion of nutrients is not hindered to the detriment of the plant's health.

Where a thatch layer exists on top of a sandy layer it maybe the level of irrigation being applied does not provide the volume of water necessary to deliver a wetting front that penetrates through the thatch layer and charges the sandy profile below resulting in the plant surviving on moisture and nutrients available in the top 50mm or so.

Also, the likelihood of low soil moisture content will occur during the summer months when there is higher ET rates and the weaknesses of the irrigation design come to the fore. In this situation it maybe the plant comes under a greater degree of moisture stress as well as restriction of nutrient uptake due to the water film within the soil matrix being hindered and this weakens the plant at a time when the natural cycle of things is moving towards increased pressure from fungal activity that picks up from late summer onwards.

Reflecting on these issues above that highlight the advantages and disadvantages arising from soil water content in a sandy or pure sand profile it is essential to look at the effect of water within this situation on the microbial community, their level of activity and mineralisation of organic matter and what the ideal moisture management regime should be for both the plant and the soil food web. Once this is known then a comparison can be made on soil water content at the targeted surface firmness reading and whether this is within acceptable parameters for the sound management of the plant and the microbial community.

Bearing the above points in mind there is good reason to know and understand the soil texture of each individual green, available water content for that texture and how to manage a soil moisture deficit that does not hinder the continuity of water film within the main zone of rooting, thereby ensuring microbial activity, movement of both water and nutrients to the plant as well as diffusion of nutrients from the mineral content of the profile to deliver plant health throughout the year.

Effective Dew Dispersancy

The New Programme for Fungal Disease Control?

The use of switching has long been promoted as best practise to aid the reduction of fungal disease, as well of course for early morning playability. Switching though will not prevent dew and rain building up on the sward – it is only used at regular intervals to knock the moisture off. With a highly effective dew dispersant you can keep surfaces much drier night and day – aiding playability but also crucially reducing the likelihood of fungal disease outbreak.

We have seen some dramatic results now from an effective dew dispersant programme. Key is to use a product that it both highly effective and long lasting as well as not depositing an appreciable film on the leaf surface (which can affect the effectiveness of fungicidal sprays). Enter two products from GBR Technology – one brand new and one redirected from its initial use as a wetting agent.

Endew Plus – an anionic-type dew dispersant for use at 5 litres per hectare.

Programme: Apply every 2 weeks during autumn and winter at 5 litres per hectare (i.e. 10L/Ha consumption per month)

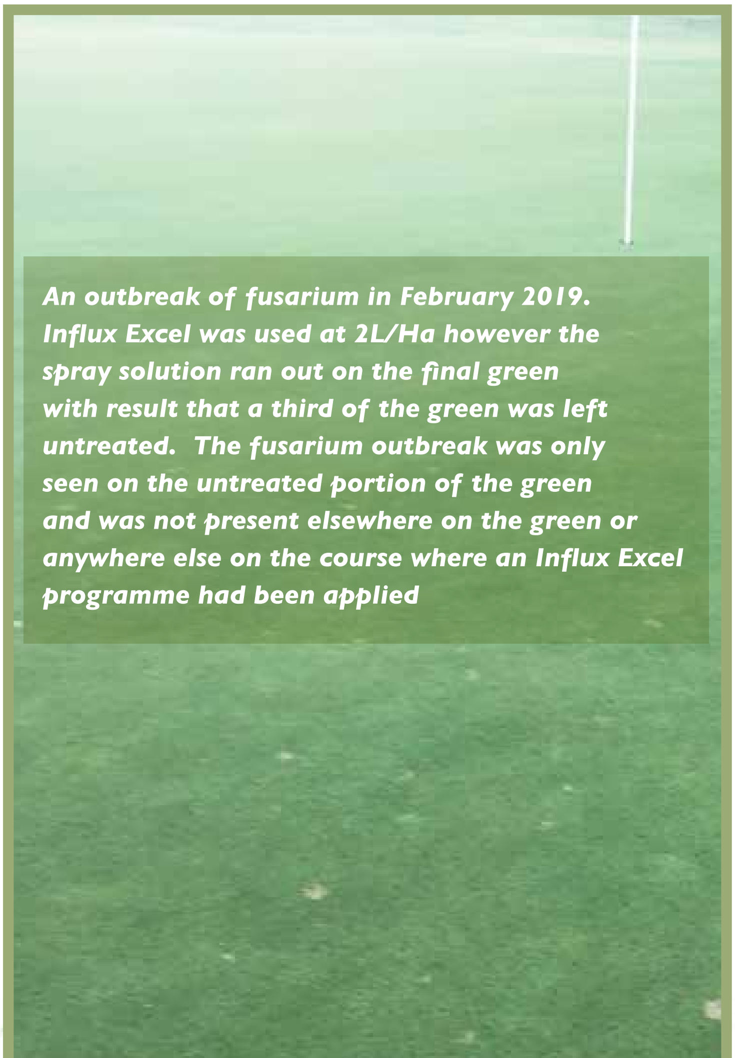
Influx Excel – a siliconised surfactant type dew dispersant for use at 2 litres per hectare.

Programme: Apply every 2 weeks during autumn and winter at 2 litres per hectare (i.e. 4L/Ha consumption per month)

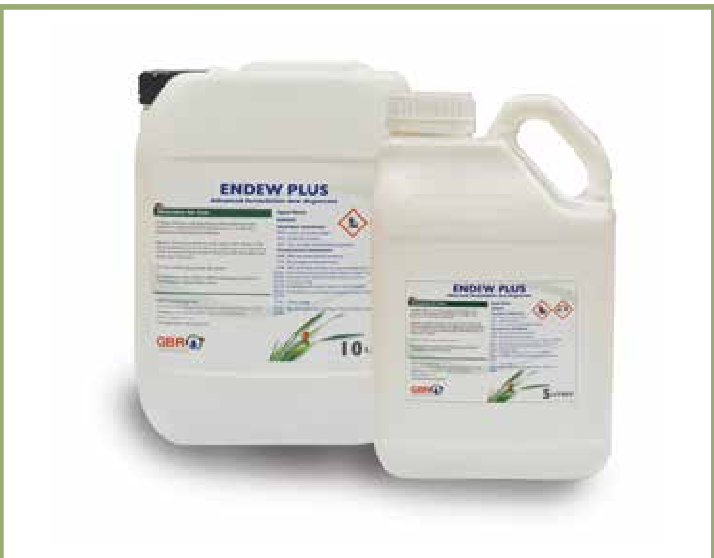
Notes: Influx Excel has wider tank mix compatibility but should not be acidified below pH 5. It is best to apply an Influx Excel solution onto dry sward.

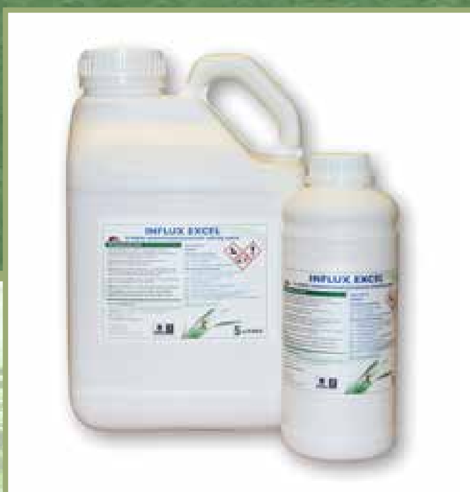
Both the above applications give very reliable dew dispersancy under suitable conditions and for extended periods. High growth rates and cutting will of course reduce the effect quicker.

Two highly effective dew dispersants with disease suppressing qualities. GBR's NEW Endew Plus and Influx Excel tailored for use at 2L/Ha for dew dispersal.



An outbreak of fusarium in February 2019. Influx Excel was used at 2L/Ha however the spray solution ran out on the final green with result that a third of the green was left untreated. The fusarium outbreak was only seen on the untreated portion of the green and was not present elsewhere on the green or anywhere else on the course where an Influx Excel programme had been applied





Plant Nutrition with Respect to Resistance to Pests and Pathogens

Data taken from research highlights that a balanced input of nutrition delivers healthy growth allowing the plant to resist and/or tolerate pathogens to a greater degree. Resistance is improved by formation of barriers through the process of lignification and synthesis of toxins e.g. phytoalexins. Tolerance increases due to the general improvement in plant health and growth providing greater energy to tolerate the infection.

Typical elemental constituents of a higher plant in dry matter terms

Element	ppm	%	Element	ppm	%
Hydrogen	60,000	6.000	Sulphur	1,000	0.100
Carbon	450,000	45.000	Chlorine	100	0.010
Oxygen	450,000	45.000	Boron	20	0.002
Nitrogen	15,000	1.500	Iron	100	0.010
Potassium	10,000	1.000	Manganese	50	0.005
Calcium	5,000	0.500	Zinc	20	0.002
Magnesium	2,000	0.200	Copper	6	~0.001
Phosphorus	2,000	0.200	Molybdenum	0.1	<0.001

The structure and function of the plant dictates that the root/soil relationship plays an important part in the supply of nutrients and water/soil solution. The majority of nutrients and water are taken up through root hairs and these are found in greater abundance just behind the root tip and the volume of soil that can be tapped into by the plant is greatly increased if a symbiotic relationship exists with Mycorrhizal fungi. Consideration to soil texture and CEC also has to be given so that an understanding can be developed of the nutritional reserve within the soil profile and its capacity to hold and deliver water/soil solution to the plant.

Summary of plant defence against pests and pathogens

Investigation into the plant's defensive system highlights the following nutrients as having an essential role to play: potassium, calcium, boron, copper, zinc, iron and manganese.

The germination of a pathogenic spore on the surface of a leaf or root is stimulated by plant exudates i.e amino acids and sugars in the apoplasm. As the concentration of sugars and/or amino acids increases, the risk of disease infection also rises. This increase in concentration of sugars and amino acids comes about because the permeability of the cell membrane increases due to a deficiency of calcium and/or boron and a potassium deficiency has a negative effect on the synthesis of polymers. Once the spore has germinated, hyphae develop and penetrate into the apoplasm releasing pectolytic enzymes to dissolve the middle lamella – these pectolytic enzymes are strongly inhibited by calcium.

To limit/control the effect of the attack the plant relies on the epidermal cells of leaves, roots and stems to function at their optimum and produce the necessary level of phenolic compounds and flavonoids that have fungistatic properties. Boron and copper are important for phenol accumulation and biosynthesis in the epidermal cells. Also, the peroxidases that are cell wall bound catalyse the polymerisation of phenols to lignin and this gives strength to the epidermal layer. These phenolic compounds are essential in the early stages of infection either as phytoalexins or building blocks for lignin and an increase in their production within the epidermal layer is triggered by signalling molecules when infection occurs. It should be noted that the concentration of phenolic compounds within the epidermal cell is high when the plant is low in nitrogen and that their content and fungistatic effect can decrease when nitrogen levels increase.

A plant requires copper, iron, manganese and zinc for the generation and detoxification of oxygen radicals (O_2) and hydrogen peroxide (H_2O_2) and the increase in production of oxygen radicals is part of the plant's defence response. These molecules may also be involved with hyper sensitive reactions (oxidation of membrane lipids leading to cell death), initiation of cell wall lignification and injury of the pathogen and this highlights how a plant's defence mechanism is influenced by the right balance of micro nutrients being available when it comes to mineral nutrition for plant health.

Silicon is considered a beneficial element not an essential element in that the vast majority of plants can survive without it. However, as silicon is the second most common element in the planet's crust it is found in the prevailing form of monosilicic acid and interacts with polyphenols and pectin in the cell wall. As the plant matures, lignification and/or the accumulation and deposition of silicon in the epidermal cell layer may form an effective barrier against penetration by fungal hyphae. These processes are effected by mineral nutrition and are the plant's main structural defence against diseases and pests, especially in the leaves of grasses and the endodermis of roots. Although silicon is linked with the formation of haustoria at sites of penetration it is not the silicon that has the controlling effect on the pathogen but the phenolics that gather at the site of infection. The causal connection between silicon supply and phenolics is not clear but silicon appears to assist the plant's resistance to attack.

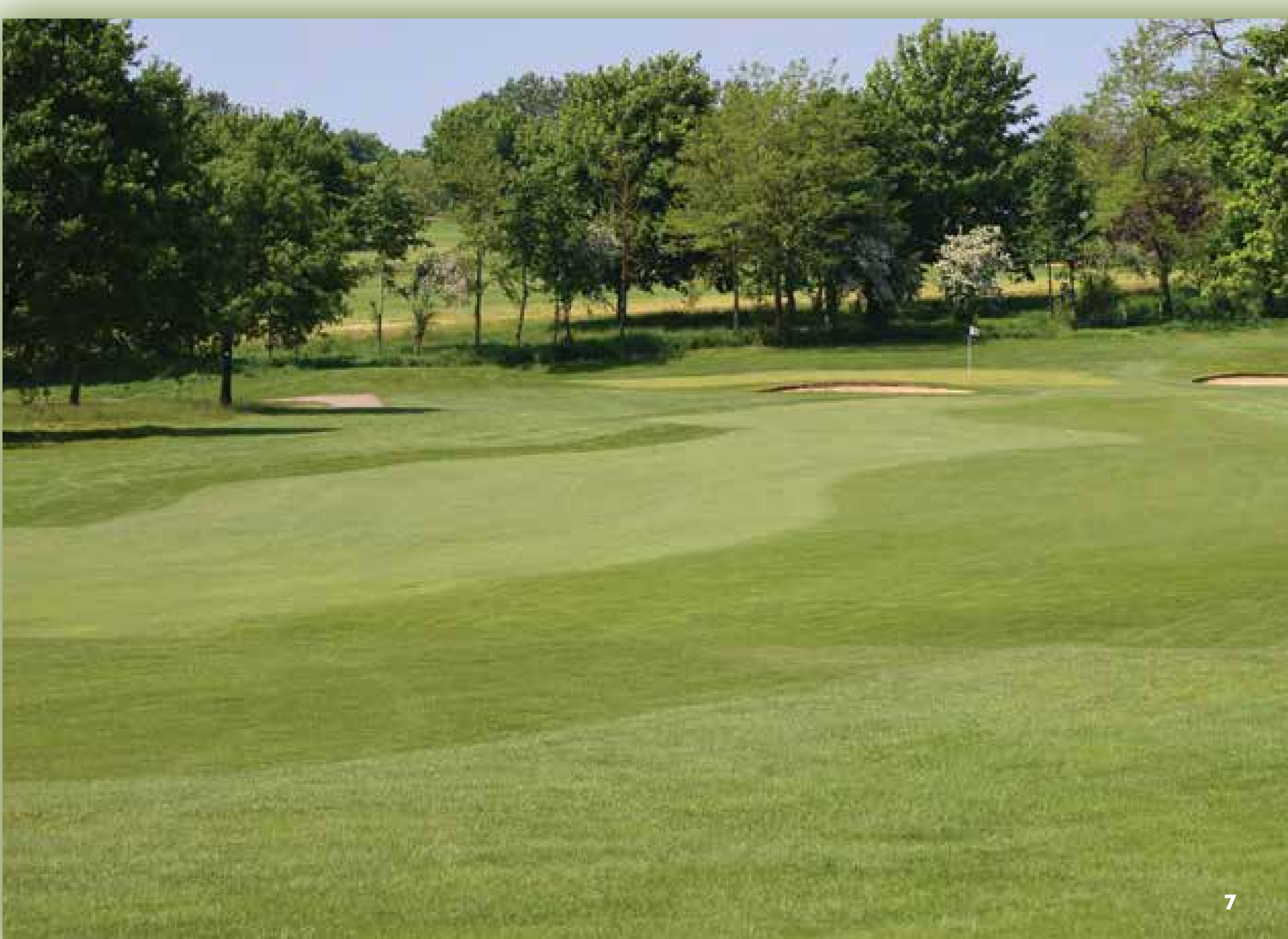
Two of the macro nutrients i.e. nitrogen and potassium are essential for plant health in quantities greater than other nutrients, however, they can bring about a phenomenon described as dilution by growth that in turn creates an imbalance within the plant affecting its mineral balance resulting in a weakened physiology making it more susceptible to pathogenic attack. Looking to apply these nutrients to deliver the optimum plant health will require judgement of the plant's current health, environmental conditions, abiotic and biotic stresses present and its growth and development stage within the annual cycle of growth. Low nitrogen input is linked with greater resistance to obligate parasites and when increased favours protection against facultative parasites whereas increased input of potassium delivers greater resistance to both obligate and facultative pathogens. Monitoring input of a balanced feed programme along with the plant's response and degree of infection is necessary to develop the right input for an individual site. Nitrogen input increases the level of amino acids in the apoplasm and at the leaf surface and some studies have shown this higher concentration of amino acids to have a greater effect than sugar concentration on the germination and growth of conidia. Also, as mentioned above, increased nitrogen input can affect the phenol metabolism, the content of some phenolics, the development rate of lignin and the dilution of growth caused by increased nitrogen can also reduce silicon content. In the case of potassium, a deficiency disrupts the synthesis of proteins, starch and cellulose and the result is an accumulation of amino acids and sugars. Once potassium input is increased, the above situation is reversed but there is nothing to be gained from applying more than the optimal amount. Dilution of growth by potassium can lower the content of other minerals and this may be more noticeable with calcium and magnesium and if calcium falls low there is an increased risk of physiological disorder and disease susceptibility.

To synthesise the various molecules and polymers the plant requires energy to be available and this transfer of energy within the plant is linked to the ADP/ATP molecules. These molecules contain phosphorous and although required only in small amounts it is essential for a plant to function at its optimum hence the development of the symbiotic relationship between plants and mycorrhizae fungi. These fungi have the ability to mineralise organic phosphate through synthesis of phosphatase and to solubilise mineral phosphorous through acidification of the soil habitat by CO_2 production. Mycorrhizal activity also improves the soil structure benefiting both the plant and the soil microbe community but where this symbiotic relationship is hindered or lost then consideration to the plant's need for phosphorous must be taken into consideration if the plant's demand for phosphorous is to be met.

Conclusion

In conclusion, an understanding of the plant's mineral needs and their ratio to each other is clearly highlighted when the dry matter content is reviewed. In practise, uptake of minerals from the soil into the plant will vary according to a number of factors including e.g. pH, moisture content, CEC and fertilisation. Creating a balanced fertiliser analysis for application makes sense and to apply on a "little and often" basis will ensure that "dilution by growth" is avoided.

Also, a reduction or loss of mycorrhizae from the soil profile will have a significant effect upon the plant's ability to source water and nutrients for good health and so, once again, drip feeding with a balanced nutrient input is worth consideration when reflecting upon the soil's CEC and nutritional status to meet the needs of the plant. This also has to be considered alongside the management of water content within the profile to ensure a continuity of water film within the soil matrix that will allow mass flow and diffusion of nutrients to take place at a rate to meet the needs of the plant with the overall aim of developing and maintaining plant vitality until the natural balance is restored and the minimal input level has been determined. It is this combination of knowledge and experience of each individual site that provides the building blocks towards a foundation of sustainable practice and an understanding that nature is not about more but accepting the optimum that it can deliver within the natural cycle of things.



Q&A

MD Paul Morris answers questions on products for the autumn/winter period

Hi Paul - so what products from GBR Technology are particularly coming into season now?

It's quite a wide question as we still sell quite a wide range but we should try and narrow it down.

Maybe start with spray aids?

Ok!

Our GBR Spray Pattern Blue is an exceptional product in terms of colour strength and cost effectiveness – you won't buy a stronger liquid – use rate we say 75-125ml per 100L of spray solution. We also make in-house a foam bout marker for those using blobbers. So those two products are good for showing coverage when spraying.

What about wetting agents?

Residual programmes may still carry on into September and even October – some people even spray year round. Penetrant use is useful for the winter to aid the firmness of greens. Also, anaerobic conditions can form at this time especially where saturated upper layers can prevent good airflow below – and here a penetrant is useful to disperse this water which also encourages air into the porosity. We have excellent penetrant products in the form of Intensive Wetter and Eco-Wet soil surfactants

Turf Hardeners and Biostimulants?

Yes – very important now – things to 'harden-off' and protect the turf against attack by pathogens. Our liquid turf hardener which contains calcium and magnesium is a useful product – so too a range of irons: Forti-Fe is a fully formulated product – 6% iron plus a little N and micros, ACTi-Fe a super soluble powdered ferric ammonium citrate and even Emerald Iron as 6% iron in the form of a very strong DTPA chelate. A good mix is Emerald Iron 5L per Ha/Liquid Turf Hardener 20L per Ha/Phosphite 5L/Ha. For green-up more iron is required (20L/Ha of Forti-Fe or Emerald Iron or 4.5-9KG/Ha of ACTi-Fe) and moss control is another topic too. We tend to add far more iron than is required for nutrition – ACTiFe and Emerald Iron are essentially sulphur free so great choices at this time of year.

People are using more phosphite now too – we sell Fielder Fighter. Fulvic acid is another good plant elixir – so too chitosan – all good to help plants cope with and better resist pathogens.

What about fertilisation?

Autumn fertilisers tend to emphasise potassium more. We'd say be a bit careful though and don't overdo this – potassium can still cause dilution by growth (as does nitrogen) and too much of it can increase the prevalence of disease. Potassium needs to be in balance with calcium and magnesium too – these latter two nutrients are in GBR's Liquid Turf Hardener. Nitrogen needs of course start to drop back in the autumn – drip feeding with sprays is a good way to go. So taking our Victus Pro Liquid fertilisers or soluble straights (coupled with micronutrients). For some they prefer a slow release granular. If you are drip feeding greens then ammonium sulphate, mono ammonium phosphate, potassium chloride and then add fulvic acid, seaweed and trace elements to give a really good tank mix for spraying. Please always remember to do a jar test on any new mix you plan to make up in your sprayer – just to check for compatibility!

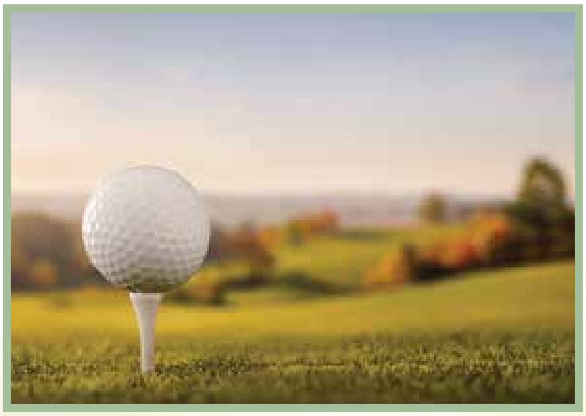
You mentioned the Victus Pro Liquids?

Yes – we currently do a VP 4-2-12 for autumn/winter – this contains a proper dose of fulvic acid as well as trace elements.

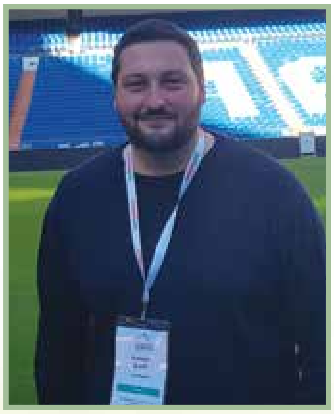
And Dew Dispersants?

I definitely wanted to cover that one! We do very much feel that these are a really useful tool to use now. Keeping the sward drier can really have an impact on prevalence of fungal disease. The loss of iprodione has meant that preventative measures are now vital. For dew dispersants to really help you need a product that works well and ideally be of a type that doesn't put down an appreciable film on the sward (that can then adversely affect fungicidal sprays). Now there are options that fit the bill – and two are from us – Influx Excel at 2L per hectare and our new Endew Plus at 5L per hectare.

Meet Nathan! - GBR Technology are delighted to welcome Nathan Scarff to our team.



Nathan started on the 2nd of September and is our Technical Sales Representative and Account Manager for our amenity customers in the Mid UK region (spanning Wales through the Midlands to East Anglia). Nathan is an experienced Head Groundsman having worked at various football stadia in the UK and most recently in Belgium. He has an in depth understanding of the products used in our industry and experience of managing teams and producing and maintaining exceptional turf playing surfaces. We are very excited about this appointment and feel confident our customers will benefit from their interaction with Nathan.



GBR Technology Ltd
Unit 42, Easter Park, Benyon Road, Silchester,
Reading, Berkshire, RG7 2PQ
Telephone: +44 (0)118 982 0567
Fax: +44 (0)118 982 0590
Email: info@gbrtech.co.uk
www.gbrtech.co.uk/amenity

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