Under the Microscope...

Turfgrass Production on Sandy Soils -
Irrigation and Fertiliser Management

Conventional

PLATE 1: Turfgrass colour for conventional fertiliser and pelletised poultry treatments (200kg N/ha at high (A) and low (B) irrigation treatments after 10 weeks

The University of Western Australia has evaluated the effects of irrigation and fertiliser regimes on turfgrass growth and quality, as well as nitrogen leaching, during turfgrass production on sandy soils.

The contributions of turfgrass systems to nitrogen leaching is increasingly being scrutinised by communities and environmental regulators. Turfgrass generally requires regular irrigation and fertiliser applications and is often perceived to be a source of nitrogen leaching. Nitrogen leaching is problematic as it can degrade surface and ground waters resulting in eutrophication and non-potable water supplies.

Applying nitrogen fertiliser is an integral part of turf management and is needed for maintaining turf growth and ensuring turf is aesthetically acceptable. Ideally, nitrogen fertilisers should be applied at a rate that the turf is able to assimilate or utilise the applied nitrogen.

Fertiliser applications may be better matched to turf growth demand by splitting 'soluble' fertiliser applications, or using fertilisers that slowly release nitrogen, such as resin-coated inorganic fertilisers or organic fertilisers.

The ability of turfgrasses to utilise applied nitrogen will also be affected by the rate that dissolved nitrogen moves through the soil profile. Turfgrass nutrient uptake often occurs at greater rates in the topsoil, where the majority of the turfgrass roots are located, than in the subsoil. Therefore irrigation management practices that maintain nitrogen fertilisers in the topsoil should increase the opportunity for plant uptake and decrease nitrogen leaching.

Developing irrigation and fertiliser management regimes that maximise turfgrass growth while minimising nitrogen leaching is required for the sustainable development of the turfgrass production industry in Australia.

Optimising fertiliser management strategies so that nitrogen leaching is minimised is particularly challenging for managers of turfgrass grown on sandy soils, as these soils are often conducive to nitrogen leaching due to their low biological fertility and free-draining nature.

Most field-based studies investigating nitrogen leaching from turfgrass grown on sandy soils have been conducted in North America using turfgrass species not widely grown in Australia. Furthermore, these previous studies have mainly evaluated nitrogen leaching from established turfgrass, rather than turfgrass grown for turfgrass roll (sod) production.

The University of Western Australia (UWA), in partnership with Horticulture Australia Ltd and industry groups, has evaluated the effects of irrigation and fertiliser regimes on turfgrass growth and quality (Wintergreen couch), as well as nitrogen leaching, during the production of turfgrass on sandy soils.

In this article we focus on the effects of irrigation and fertiliser regimes on turfgrass growth and quality. In a future article, we will present the findings from our nitrogen leaching study.

Fertilisers Trialed

The study includes four fertiliser types (conventional (water soluble), control-release, pelletised poultry manure and pelletised biosolids), three application rates (100, 200 and 300 kg N/ha per 'crop'), two irrigation rates (70 per cent and 140 per cent daily replacement of net evaporation), and three replicates in a randomised split-plot design.

Irrigation and fertiliser treatments were applied over 16–28 weeks, after which the turfgrass was harvested and then allowed to re-grow from the remaining rhizomes. Four crops were grown and harvested between October 2001 and August 2003.

Treatment plots ($10m^2$) were established at the UWA Turf Research Facility after pre-planting fertilisers (except control-release which was applied after planting) to 10mm, and incorporating turfgrass stolons into the soil surface using discs. Previous studies have shown the soil to be free-draining, have low chemical and biological fertility and a low phosphorus retention index (PRI).

Irrigation occurred daily from October–April each year; and then every second day from April-September when daily net evaporation was less than 5mm; and then occasionally from May-August when weekly net evaporation exceeded 5mm.

Fertilisers were applied at different frequencies depending on the type. For example, conventional fertiliser was applied every three weeks, the control-release was generally applied every six weeks, while the two organic fertilisers were applied every four weeks.

Turfgrass Growth and Quality

Turfgrass growth and quality were generally unaffected by increasing the irrigation rate from 70-140 per cent daily replacement of net evaporation. Instead, turfgrass growth and turfgrass colour mainly depended upon fertiliser type and rate.

Applying inorganic fertilisers (i.e., conventional and control-release) promoted greater growth than organic fertilisers (i.e., pelletised poultry and pelletised biosolids). For Crop 1, growth decreased in the order: conventional > control-release > pelletised poultry > pelletised biosolids.

For Crop 1 there was a significant interaction between irrigation rate and fertiliser type, and consequently for the high irrigation treatment

(140 per cent replacement) pelletised poultry produced similar growth to the pelletised biosolids, whereas for the low irrigation treatment (70 per cent replacement) pelletised poultry produced less growth than the pelletised biosolids.

For the remaining crops, the fertiliser types were ranked: conventional = control-release > pelletised poultry = pelletised biosolids. For all crops, increasing the fertiliser application rate generally increased growth.

Turfgrass colour appeared greener in the low irrigation plots than the high irrigation plots for the first 5-10 weeks after planting (Plate 1). However, by the time the first crop was harvested the chromameter results showed irrigation did not have a significant effect on turfgrass colour. Instead turfgrass colour at harvest was mainly dependent on fertiliser type and rate (Figure 1).

Greater colour was recorded for inorganic fertilisers than organic fertilisers, especially when applied at the higher rates. For crops harvested during summer (Crops 1 and 3) turfgrass colour was similar for conventional and control-release treatments. However, for crops harvested in winter (Crops 2 and 4), turfgrass colour was greater for control-release than conventional treatments.

For Crop 1, turfgrass colour was similar for pelletised poultry and pelletised biosolids. For Crops 2–4, pelletised biosolids treatments were greener than pelletised poultry. Only inorganic fertilisers applied at 200 or 300 kg N ha^{-1} produced turfgrass with colour that met WA industry standards (Figure 1).

Inorganic fertilisers produced more residual rhizomes (i.e., rhizomes remaining in the ground after harvesting sod) than organic fertilisers. Increasing application rates also increased residual rhizomes. Irrigation rate only affected residual rhizomes in Crop 1, where increasing the irrigation rate decreased residual rhizomes.

Concluding Comments

Optimising irrigation regimes not only maintains turfgrass growth, but maximises water use efficiency. Furthermore, high irrigation rates can be detrimental to turfgrass growth and colour during turfgrass establishment.

For turfgrass produced on a sandy soil, conventional (i.e., water-soluble) and control-release fertilisers produced better growth and colour than the pelletised poultry manure and pelletised biosolids. Furthermore, the rhizomes remaining in the soil for the next crop were also greater for the plots supplied with inorganic than the organic fertilisers.

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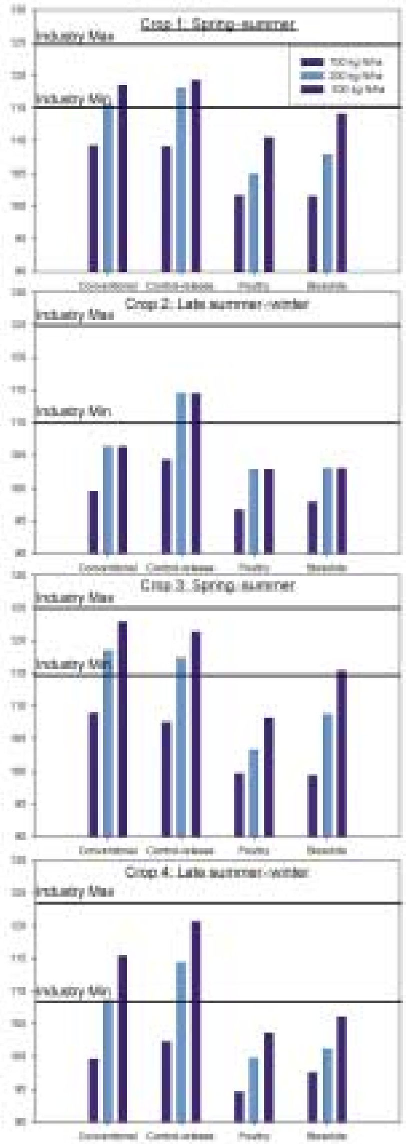

Figure 1. Colour (hue angle measured by chromameter) of turfgrass rolls at harvest. Increasing hue angle value indicates increasing "greenness". Graph includes maximum and minimum values measured from six turfgrass farms at time of harvests.

Figure 1.

Irrigating With Recycled Water in Queensland

Turf researchers in south-east Queensland have evaluated the use of recycled water or treated effluent to irrigate golf courses, sporting fields and council parks over the past three years. The research demonstrated that turfgrasses can be grown satisfactorily on tertiary-treated effluent, supplemented with nitrogen, with savings to sporting clubs and the environment.

Twenty grasses were grown in 100 litre bags for the effluent water study

Recent droughts along much of eastern Australia have forced governments to consider the long-term sustainability of current water use practices. The Queensland Water Recycling Strategy, managed by the Environmental Protection Agency, encourages recycling by government, industry and the community.

In Queensland, 15-20 per cent of treated effluent is used for irrigation compared with 11-14 per cent nationally and 60 per cent in California. In 1999, about 75 golf courses in Queensland used treated effluent, accounting for about 45 per cent of the municipal wastewater being recycled. There were also approximately 60 schemes irrigating sports fields, parks and gardens using over 5000 megalitres per year.

One of the factors adding to this debate is the increasing pressure to avoid the discharge of effluent into rivers, oceans and other waterways. In many parts of Australia, the discharge of this waste has exacerbated the decline of river ecosystems and estuaries and contributed to blooms of toxic blue-green algae.

In south-east Queensland, the Luggage Point Wastewater Treatment Plant (WWTP) near the mouth of the Brisbane River, along with the other WWTPs release 8.2 tons of nitrogen each day and 4.2 tons of phosphorus into Moreton Bay. These discharges will increase by 25-50 per cent over the next 30 years, leading to a further deterioration of the environment.

The Use of Recycled Water

Municipal effluent is ideal for the irrigation of turfgrasses because many areas in northern Australia permit the continuous growth of tropical species, allowing year-round use of the wastewater.

These grasses also have dense shoot and root systems that can remove nutrients and other pollutants from the water. Many species have high water and nutrient requirements and so can utilise a large volume of wastewater and the accompanying nutrients. There are also fewer concerns about health issues compared with the use of effluent on food crops.

The use of wastewater represents a saving to turfgrass managers, with the cost of effluent about half that of potable water. The nutrients in the water also mean that less fertiliser is needed. The price of water is likely to increase substantially in the next few years, putting added pressure on the Australian turfgrass industry. In some areas of the USA, such as California, it is mandatory to use wastewater if it is available.

Wastewater can contain various salts and toxic ions (Na, Cl, B, CO_3 and HCO_3) that need to be managed before they begin to affect the quality of the turf and soil. This needs to be assessed when considering the economic benefits of using effluent. Depending on the quality of the water in terms of human health, there may be restriction on the use of the golf course or park at certain times. Sporting clubs and other groups using effluent must also develop environmental plans to manage the effluent so that there are no impacts off-site.

The Trials

These trials examined the performance of the major turf types in northern Australia, including bermudagrass, Queensland blue couch, buffalograss, carpetgrass, zoysiagrass, paspalum and natives.

The effects of fertilisers and wastewater on the performance of 20 grasses growing in 100 litre bags were studied in Murrumba Downs in Pine Rivers Shire just north of Brisbane. From May to August 2001, control plots were fertilised every month, while unfertilised plots received no fertiliser (Experiment 1). From April to August 2002, control plots were irrigated with potable water and fertilised, while effluent plots received no fertiliser (Experiment 2).

In Experiment 3 from December 2002 to June 2003, control plots were irrigated with potable water and fertilised, while effluent plots were fertilised only with nitrogen. A field experiment also compared plots with potable water and mixed fertilisers, plots with effluent and mixed fertilizers, and plots with effluent and only nitrogen.

Information was collected on clipping weights, leaf nutrient concentrations and water quality. The data on shoot weight and leaf nutrient concentration were used to calculate the amounts of nutrients taken up by the various species. This was then related to the amounts of nutrients applied in the effluent and chemical fertilisers.

The Results

At the end of the first experiment, unfertilised plots were only 10 per cent of the weights of fertilised plots, with turf quality and colour declining as clipping weights were reduced. Centipede, buffalo, Japanese lawngrass and kangaroo grass were the best grasses among the unfertilised group.

Leaf nitrogen concentrations fell by 50 per cent in the unfertilised plots (3.3-1.6 per cent N), along with phosphorus, potassium, sulphur and magnesium. Maximum uptake of nutrients per hectare over a year was 324 kg N, 48 kg P and 238 kg K compared with typical applications of 500-800 kg N, 50-200 kg P and 250-800 kg K ha for tropical turf species. This data suggests that many sporting fields are being over-fertilised.

In Experiments 2 and 3, the electrical conductivity, ECw, of the effluent (0.7 dS per m) along with sodium (87 mg per L) and chloride (78 mg per L) were at the low end of the toxic range. The sodium hazard for the soil as determined by the sodium absorption ratio, SAR (3.8) and ECw of the effluent was low.

The residual sodium carbonate (RSC) indicated a slight excess of bicarbonate compared with calcium and magnesium (0.4). Concentrations of nitrogen (7 mg per L), potassium (18 mg per L), calcium (24 mg per L), and magnesium (10 mg per L) were in the low range for irrigation waters, while phosphorus (5 mg per L) was high.

At the end of the second experiment, the average clipping weight of the effluent plots (without fertilisers) was 15 per cent of that of the potable plots. Carpet, centipede, buffalo and kangaroo grass were less affected by the low nutrient supply than the other species.

Leaf nitrogen concentrations fell by 40 per cent in the effluent plots, along with phosphorus, potassium and sulphur. Nitrogen concentrations were below the optimum for turfgrasses (1.8 per cent), while phosphorus (0.46 per cent), potassium (1.6 per cent) and sulphur (0.28 per cent) were in the optimum range. The effluent supplied 13 per cent of the nitrogen required for maximum shoot growth, 70 per cent of the phosphorus and potassium, and 300-500 per cent of the sulphur, calcium and magnesium.

In Experiment 3, the average weight of the effluent plots (with nitrogen fertiliser) was close to the weight of the potable plots, suggesting that the grasses performed similarly on potable water or effluent. Leaf nutrient concentrations were also similar, suggesting that fertiliser applications (effluent plus chemical fertilisers) were optimum for plant growth.

In the field experiment, mean clipping weights and leaf nutrient concentrations were also similar in the three treatments (potable plus fertilisers, effluent plus fertilisers and effluent plus nitrogen), indicating that the grasses could be grown on effluent, supplemented with nitrogen.

Implications

When properly fertilised, the growth of the turfgrasses was similar on potable water or effluent. Low concentrations of nitrogen reduced the growth of the effluent plots when they were dependent on the wastewater for their nutrients. In contrast, the effluent supplied large amounts of phosphorus, potassium, sulphur, calcium and magnesium that could be used by the plants. The salinity and sodium hazards in the effluent were low.

There are significant benefits in the use of effluent for sporting clubs and the environment. The use of effluent represents savings in irrigation and fertiliser costs to turf managers, and reductions in the discharge of nitrogen and phosphorus to local waterways.

Effluent is currently about 50 per cent the cost of potable water, with a saving of about $8000 per hectare per annum in water costs for a typical sporting field. Specific recommendations for the use of recycled water include:

- Check the quality of the effluent to determine whether it is suitable for irrigation, especially in terms of salinity (electrical conductivity or total dissolved salts), and concentrations of specific toxic ions such as sodium, chloride and boron.
- Tertiary-treated effluent has inadequate concentration of nitrogen for most turfgrass species, and must be supplemented with chemical fertilisers.
- Effluent contains high concentrations of phosphorus, potassium, sulphur, calcium and magnesium that can be used to support plant growth. These nutrients represent savings in fertiliser costs.
- Fertiliser applications should be based on the results of regular leaf tests.
- Data on nutrient uptake indicate many examples of over-fertilisation, with reductions in fertiliser applications of 30-50 per cent appropriate in many situations.
- The salinity and sodium hazards in effluent need to be monitored and appropriate amendments applied to maintain long-term soil and turf quality. This will add to the cost of using effluent.
- Do not over-water, as this leads to increased growth and mowing costs, and the possibility of nutrients being leached off-site into rivers and waterways.

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Victorian Golf Association - Turf Research Trials

The entomopathogenic nematode species Heterorhabditis zealandica has proven to be an excellent controller of Winter Corby grubs (above)

NMIT's Phil Ford outlines research conducted by the Victorian Golf Association's Research and Advisory Board, including the use of entomopathogenic nematodes for insect control.

Over the past eight years the Victorian Golf Association Turf Research and Advisory Board has conducted a wide range of trials including low input fairway grasses, couchgrass establishment methods, insect control with entomopathogenic nematodes (ENs), dusting of greens and other topics.

The board tries to tackle issues that are not being investigated by other organisations (eg: US research), and of immediate relevance to its member clubs. It also concentrates on the more environmentally sensitive issues, and has contributed greatly to the widespread adoption of couchgrass fairways, dusting programs and the use of ENs for insect control at Victorian golf clubs.

Entomopathogenic Nematodes

The VGA is very keen to promote the concept of 'insecticide-free golf courses'. All currently used chemical insecticides are nerve toxins, and therefore present a hazard to any organism that has nerves (eg: birds, fish, golfers and superintendents!).

Entomopathogenic nematodes (ENs) have no off-target hazard, and offer an environmentally friendly solution to most insect problems. Previous research by the VGA had shown excellent (near 100 per cent) control on Argentine Stem Weevil and African Black Beetle, with the Black Beetle data being presented at the International Turfgrass Conference in Toronto, 2001. The turf industry now routinely and successfully uses ENs to control these two pests as well as Billbugs, Red Headed Cockchafers, Argentine Scarab and various cutworm pests.

A more recent trial (October, 2003) compared the EN species Heterorhabditis zealandica, Steinernema feltiae and the insecticide cyfluthrin for control of the webworm pest Oncopera rufobrunnea, commonly known as Winter Corby grub. In the final assessment, not one living Corby grub was found alive in the Heterorhabditis replicate plots, indicating a 100 per cent kill rate on all three replicates.

The report for this trial hasn't been finalised yet, but will be distributed to Victorian clubs and posted on the VGA website in the next few months. The authors intend to present this data at the International Turfgrass Conference in Wales, 2005.

Evaluation of New Warm-season Grasses in Victoria

As well as reducing the need for insecticide use, the other big topic for Victorian golf courses is water. The single biggest gain in reducing turf water use is by switching from cool-season to warm-season grasses, so the promotion of couchgrass has been a high priority. But it's pretty clear that many of the 'standard' couchgrasses used in Victoria had been around for many years. Were there new cultivars to challenge the standard ones?

In 2002 the VGA began a collaborative project with Dr. Don Loch to evaluate many new grasses and cultivars in our climate.

In October 2002, turf students from Northern Melbourne TAFE planted replicated plots of 16 couchgrass varieties on a nursery area kindly offered by Richard Forsyth and Metropolitan Golf Club. They also planted single plots of the new ultradwarf couches, and various zoysias and seashore paspalums.

Very few of these grasses had been grown in Victoria before. This research is ongoing, but within the first summer it was obvious that several breakthroughs had been made, including:

- The emergence of three new couchgrass varieties (Conquest, CD and No.9) with extremely high quality and good winter colour retention in our climate. The 2003 winter was quite cold in Melbourne and the colour retention figures in comparison to Santa ana and Wintergreen were excellent. Santa ana and Wintergreen, grown in Melbourne since the early 1980's, were still in the top group.
- The excellent performance of the seashore paspalums in our climate. Sea Isle 1 and Sea Isle 2000 were good, but the Western Australian variety 'Velvetene'™ (PBR TFWA02) performed even better. Its establishment rate was faster than any couchgrass, and its winter colour retention and turf quality were superior as well. This species has a remarkable salinity tolerance, but its performance here on normal town water show it to be a high quality turf species in its own right, with the salt tolerance a bonus.
- A hint of possibility for zoysias in our climate. Their establishment rate is extremely slow, although the varieties GGR and Zoyboy show some inclination to grow. But many varieties kept good colour over the winter, so it may be useful for a golf club to import zoysia turf from northern Australia for use in heavily shaded 'niche' areas.

The VGA couchgrass plots at Metropolitan Golf Club in Melbourne

The VGA putting green plots at Kerang Golf Club. The Velvetene plot is on the left.

The Metropolitan Golf Club trial will run for another two years, at which time a full report will be prepared. The excellent performance of Velvetene ™ has led to the establishment of this grass at other locations last summer.

In October 2003, NMIT students planted a practice putting green and a fairway area at Kerang Golf Club. These plantings have two purposes – to evaluate the potential for seashore paspalum (Sea Isle 2000 and Velvetene) and the dwarf couches (MS Supreme, TifEagle, Tifdwarf and Santa ana) as a putting green surface at 3mm or so, and to compare the salt tolerance of seashore paspalum (Sea Isle 1 and Velvetene) and couch (Santa ana) in a highly saline area of fairway.

Another planting was done on the small fairway (the 'betting hole') at the Shearwater Resort (Cape Schanck). Velvetene™ was line planted. In that deep, alkaline sand and using effluent water, this planting should present the seashore paspalum in its best possible light.

Superintendent Chris Grumelart reports that the grass is growing in well, and has used Kerb for *Poa* control in the establishment phase with excellent results and no injury to the paspalum.

More Velvetene™ plots were planted at Ballarat Golf Club. No offence to superintendent Geoff Powell, but the Ballarat site puts this variety in a much more challenging environment, exposed to winter frosts, compacted clay soil and some shaded areas. Geoff reports that establishment has been slow, with January and February being very cool. Will Velvetene survive a Ballarat winter? It will be interesting to see.

Many of the larger VGA projects have attracted dollar-for-dollar support from Horticulture Australia Ltd. Their ongoing support is currently under a cloud, however, as the turf industry doesn't have a formal levy system in place and Horticulture Australia's funding will increasingly favour levied industries (eg: strawberries, grapes etc).

Other funding sources are around, however – a submission has recently been made to Melbourne Water for some 'Smart Water' funded projects for next summer. The Victorian golf industry has already demonstrated a pro-active approach to water saving, but there is no doubt further work on water issues has the potential to save many thousands of megalitres of potable water in the state.

The success of the board's research has led the VGA to increase its turf research budget for 2004. This will allow the board to consider some larger and longer term projects into the future, continuing to focus on grass roots issues of immediate relevance to Victorian clubs and their superintendents.