Nutrition of sand greens

The nutrition of pure sand constructions raises a whole host of issues but there are a number of rules that are can be applied and can help guide you in the right direction. Sand-based putting greens are less forgiving than native soil greens when it comes to nutrient management, having inherently lower nutrient-holding and -buffering capacities and allowing large amounts of water to flow through them. As a result, they are prone to multiple, sudden and perhaps serious nutrient deficiencies.

Nitrogen management Nitrogen (N) stands apart from all other nutrients with regard to its impact on turfgrass growth. Turfgrass actually exhibits shoot-growth responses all the way up to 7.5kg N per 100m2 or more. However, for several reasons turf managers generally use just 1 to 2.5 kg per 100m2.

In reality, most turf managers maintain their sward in a constant state of N deficiency by adopting a 'lean and mean' fertiliser strategy.

Many factors affect the rate and frequency of N you apply to sand greens. Many turf managers follow the USGA Green Section recommendation of light, frequent N applications - generally in the range of 0.05 to 0.125 kg/100m2 every 7 to 14 days and using water soluble fertilisers.

The aim is to promote slow, steady shoot growth that favours the health of the turfgrass and stable putting conditions.

The appropriate interval between light N applications varies with factors such as weather as well as the criteria adopted by the manager. The two most commonly employed criteria are optimizing turfgrass colour and minimizing the amount of clippings produced.

In contrast due to staffing or temporal constraints many clubs are not able to allow for frequent N applications and so their alternative is less-frequent applications at higher rates, for example, 0.25 to 0.4kg /100m2 every 4 to 6 weeks. Superintendents following this strategy often use only granular products.

Both approaches to N application have their place. Light, frequent applications are the norm on courses where golfers demand fast putting greens. By contrast, mowing at heights that provide slower speeds results in conditions more compatible with the use of granular fertilizers and less frequent applications of higher N rates. To say that one N application strategy is better than the other ignores differences in the expected outcomes. Both can result in high-quality playing surfaces.

While it is true that high N rates stimulate shoot growth at the expense of root growth, it also is true that low N rates can lead to reductions in root growth. The annual N rate below which root growth declines is not clearly defined. Some evidence suggests that extensive foliar feeding of N at low rates adversely affects root growth compared to granular fertilizer applications.

Superintendents that apply 2 to 2.5kg/100m2 annually aim for high-density turf that rapidly heals from injury. This group of superintendents may also include those who have elected to live with *Poa annua.* Applying 2 to 2.5kg of N per season provides greater colour uniformity of bentgrass/ *Poa annua* putting greens.

A great deal of attention is devoted to the virtues of different N carriers with a constant battle being getting a preferred balance between the N-release pattern of the slow-release N material and the proportion of the water-soluble and slow-release components. Choice of N carrier comes down to personal preference although the particular release characteristics of any one carrier should be considered. Light, frequent applications are most convenient to apply in water-soluble form with a sprayer or through the irrigation system.

All slow-release N fertilizers contain some water-soluble N. The question often arises as to what is the best balance between water-soluble and slow-release N. The water-soluble component provides quick turfgrass greenup, and the slow-release component promotes uniform long-term colour. Research suggests that a 1:1 ratio of water-soluble to slow-release N best meets both of these criteria.

Golfer obsession with green speed has impacted the type of fertilizer superintendents apply. Mowing at 3mm or less to gain Stimpmeter speeds of 10 or more resulted in substantial mower pickup of granular fertilizers. Consequently turf managers have responded by shifting to spray applications of water-soluble fertilizers.

Fertilizer suppliers have addressed this by manufacturing smaller fertilizer particles, and many have adopted the practice of reporting the SGN of their products. SGN is the average particle diameter, expressed in millimeters and multiplied by 100. For example, if the average particle size is 1.5 mm, the SGN of the fertilizer is 150.

Mowing greens at 4mm or less calls for an SGN of no greater than 100 to keep mower pickup of the granules to acceptable levels. Now that fertilizers meeting this requirement are being manufactured, the choices of slow-release N carriers suitable for closely mowed greens have expanded. An important additional benefit of smaller fertilizer particle size is greater application uniformity at low rates.

For optimal growth to occur, the plant also must take up additional phosphorus (P) and potassium (K). This gives rise to what is known as "nutrient demand."

Several consequences of nutrient demand exist. First, what constitutes an adequate supply of P and K in sand greens varies with the rate of N application. The greater the amount of N you apply, the greater the demand for P and K.

Another consequence of nutrient demand is that when soil levels of P and K already are at levels that satisfy this demand, applying further amounts serves no purpose as although turf may take up these nutrients, a term called ‘luxury consumption’, it can in fact be detrimental and result in for example an induced magnesium deficiency.

Nutrient demand gives rise to a strong linkage among the concentrations of N, P and K in turfgrass shoots. In other words, the N:P:K ratio in the plant tissue is remarkably constant. It will vary somewhat with the time of year and weather, but on an annual basis, it stays close to 9:1:7 for a high-quality creeping-bentgrass putting green. In fertilizer terms, this equates to an N:P:K ratio of 4:1:3.

P Management

In the case of P of particular importance is the carbonate content of the sand used in the construction. Higher carbonate levels reduce P availability. Thus, higher soil-P levels are required to satisfy turf's demand when carbonates are present.

As a general rule of thumb consider 35 ppm (Bray) soil-test P to be a good target level for all sand greens . This avoids having to take into account the carbonate content of the sand. Of course, using this target level for sand greens with no or little carbonate will result in P levels higher than what the turf actually requires

By far the best time for adjusting sand greens to the optimum soil-test P level is during grow-in. If your sand has significant levels of carbonates, this may require monthly applications of starter fertilizer at an N rate approaching 500g N/100m2.

For established greens with suboptimal soil-test P levels, you should consider using starter fertilizer for your first application of the year. If soil tests are very low, starter-fertilizer application should be repeated late in the season as well. Whatever you choose to do, make sure that you keep close track of your soil-test P until you've reached optimum levels.

After you've adjusted soil-test P to its optimum level, the task is to keep it there. How much P you need to apply annually to accomplish this goal depends on how much P you're removing in the clippings. This is where the concept of nutrient demand comes back into the picture. How much P you're removing depends on your annual N rate.

Over time, this program will result in slowly declining soil-test P levels and an adjustment application of P will periodically be necessary. Occasional soil testing will tell you when this is necessary.

K management

Sand putting greens pose special challenges in the management of K levels. Compared to native-soil greens, sand greens have a low capacity to bond K as firstly sand greens, even with organic amendments, have low cation-exchange capacity (CEC). What little CEC exists largely comes from organic amendments, but these typically compose just a small fraction of the mix. Secondly the cation exchange sites in organic matter have a stronger preference for Ca and Mg than for K.

With the low CEC and preferential bonding of Ca and Mg in sand greens, there is a limit to the amount of K that you can load onto the cation exchange sites before leaching losses become excessive. Research has shown that when soil-test K levels rise much above 100 ppm, the concentration of K in the soil solution increases rapidly, and large amounts may leach from greens.

However, 100 ppm of exchangeable K is not enough to meet the full-season demand of turfgrass for K. This tells us that management of K in sand greens requires either multiple applications of the nutrient during the season, which means you have the task of determining frequency and rates of K application or utilising slow/controlled release forms.

To increase turfgrass tissue-K concentrations, an unsatisfied demand for K must exist, or you must create new demand through N application. Applying K alone or applying N and K late in the season (when turfgrass growth is suppressed by low temperatures) offers little chance of increasing shoot-K concentrations. To be effective, you must accompany late-season K applications by N and apply them when the turfgrass shoots are still growing.

The ratio that nutrients are removed by the plant and found in leaf tissue falls in an NPK range from 3:0.25:2 to 8:1:5 (Salisbury, 1995 Street, 1998) although the actual requirements vary depending on turf species and physical form of the fertiliser.

Handreck and Black (1994) proposed that annual NPK applications fall in the following range.

Table 1 Maximum and minimum proposed NPK ranges for optimal turf growth

NUTRIENT	MINIMAL ANNUAL NUTRIENT APPLICATION LEVELS THAT SUSTAIN TURF GROWTH kg/Ha	MAXIMUM ANNUAL NUTRIENT APPLICATION LEVELS THAT SUSTAIN TURF GROWTH. Kg/Ha
NITROGEN	160	400
PHOSPHORUS	30	50
POTASSIUM	80	240

Grass species

Not all grasses are the same and in the turf industry the choice can be either warm or cool season grasses depending on the situation of the site.

Cool season grasses include bent grass; perennial ryegrass and fescue grasses and these have differing nutrient and pH demands in contrast to the warm season grasses such as couch grass or kikuyu.

Table 2. Characteristics of common Australian turf grass species

SPECIES	SALT TOLERANCE	SHADE TOLERANCE	SOIL pH	NITROGEN REQUIRED
BENTGRASS			5.5-6.5	Low

This can be further demonstrated by looking at the actual N requirements per 100m2/growing month although this will also vary depending on time of year etc.

Table 3. Cool season grasses. N requirements g per 100m2/growing month (Carrow et al, 2001)

SPECIES	GENERAL TURF	RECREATIONAL TURF
COLONIAL BENTGRASS	146-244	195-390
CREEPING BENTGRASS	146-293	146-488
POA ANNUA	146-244	195-390

These differences extend beyond nitrogen as differeing grasses have differing requirements. For example perennial ryegrass has a much greater requirement for phosphate than browntop bent or fine leaved fescues. (STRI,1996).

The role of pH also plays an important role. Different species prefer different pH levels and in conjunction with this different fertilisers have differing effects on soil pH.

Table 5. Optimal pH ranges for common Australian turf grass species

TURFGRASS	MAIN pH RANGE FOR SUITABLE GROWTH
BROWNTOP BENTGRASS	5.0 - 6.0
CREEPING BENTGRASS	5.5 -6.5
ANNUAL MEADOW GRASS	5.5 - 7.5

These effects will be exaggerated on the pure sand constructed areas that you possess and have a low buffering capacity.

Table 6. Liming/acidifying properties of common fertilisers

MATERIAL	NITROGEN %	CACO3 EQUIVALENT PER 9KG OF NITROGEN
UREA	45	-16.4
AMMONIUM NITRATE (NITRAM)	33.5	-16.4
AMMONIUM SULPHATE	20.5	-16.4
C.A.N	20.5	0
MAP	11	-48.6
DAP	18-21	-32.3
POTASSIUM NITRATE	14	+16.4
MAP	48	-9.5
DAP	46-54	-12.7
POTASSIUM CHLORIDE	60-62	Neutral
POTASSIUM SULPHATE	50-53	Neutral
POTASSIUM NITRATE	44-46	+5

In Table 6 a minus sign indicates that the material tends to acidify the soil and a positive sign indicates that the material is basic and use will increase soil pH over time.

Cool season grasses achieve optimal growth within the range of 16-24°C and are severely restricted by periods of prolonged or severe high temperature or drought.

Nature of the rooting medium

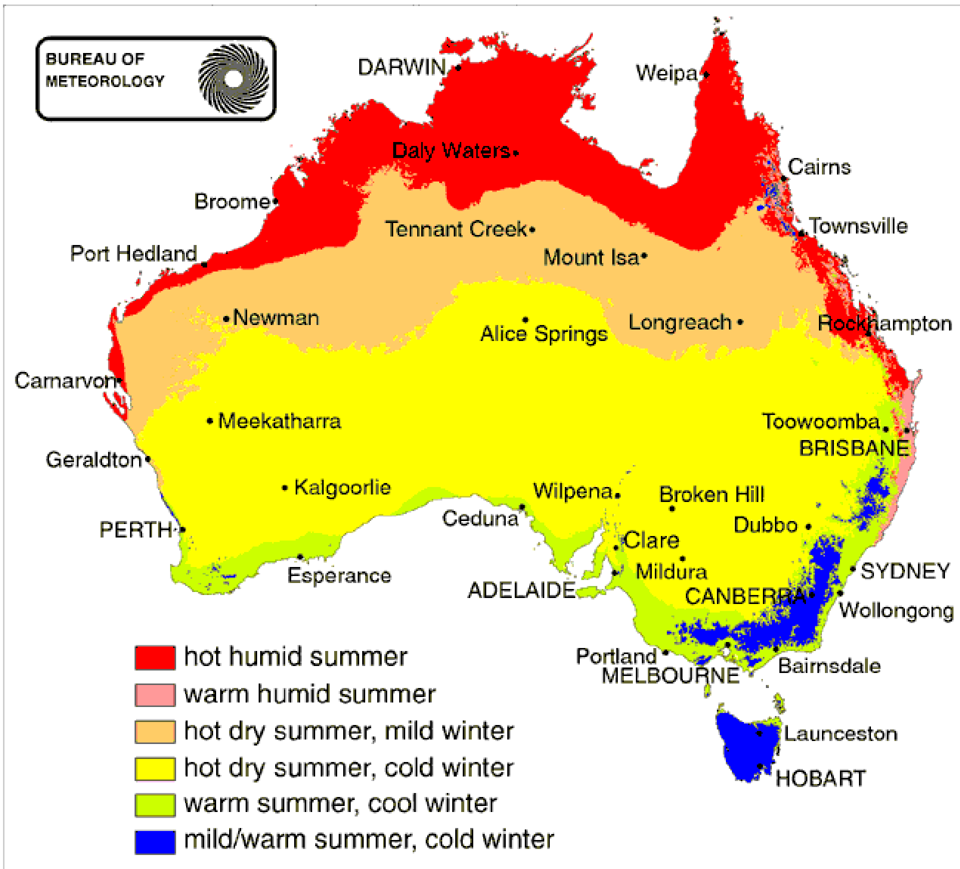
Sandy soils have very little in the way of inherent nutrient reserves. The very nature of the AGCSA specification for greens construction is that it drains extremely well and contains a minimal amount of organic matter. This characteristic further means that they are actually unable to retain soluble nutrients derived from fertilisers. The high rate of leaching means that nitrates, potassium and ammonium tend to pass through the profile into the underlying drainage water.

Soil nutrient status

Regularly soil tests are carried out in order to determine the nutrient status of your greens and this is especially important in the early days when you are attempting to establish the turf surface.

Timing of fertiliser applications

This is crucial and has a huge influence on the programme to adopt. Basically the considerations can be divided into pre and post establishment.



Map 1 shows the range of climatic zones within Australia. It can be seen that a wide range of macro and microclimates exist and these all have a direct influence.

Canberra can be classified as being in the cool temperate zone having mild/warm summers and cold winters.

Establishment

Once an area has been satisfactorily prepared the nutritional regime must be aimed at establishing a strong, vigorous sward as quickly as possible. Unfortunately this is a time where commonly turf managers fail to apply enough nitrogen and as a result see poor establishment.

For quicker establishment of 'Crenshaw' creeping bentgrass, liquid fertilizers tended to work better than the granular fertilizer. However, quality was highest at the end of the growing season for plants treated with the granular product. Plants grown on plots treated with lighter, more frequent applications provided higher visual quality ratings. This could be attributed to the higher N, P, S, Mo, and Zn concentrations in tissue of plants grown on plots treated eight times per month compared to those treated only twice (Michael B. Faust, Nick E. Christians, and Barbara R. Bingaman, 1998)

In the case of constructions with a high percentage of sand the initial problem is one of moisture retention. In order to overcome this organic amendments are added such as peat moss or poultry manure. Problems exist with both of these.

Peat moss is acidic possessing a pH of 4.5 and takes a considerable time to breakdown. Consequently if this is not incorporated thoroughly throughout the profile it can lead to a build up of a highly moisture retentive layer at depth and so encourage anaerobic soil conditions to develop.

An analysis of poultry manure shows that it does in fact contain low levels of organic matter and also can contain sodium in worrying levels depending on the source of manure. Preferable to both of these options is dried seaweed, composted sewage sludge or humic acid derivatives.

In relation to nutritional benefits from these amendments it is unlikely that these alone will lead to optimal growth of the respective grass species. To achieve this additional nutrients have to be added. Zontek (1990) showed that new sand based constructions required 500gN/100m2 in a soluble form and 500g N/100m2 in a slow release form to achieve optimal growth. If using soluble nitrogen sources other rates suggested are around 450g N/100m2 every 10-14 days (Davis. 1973).

Bearing this in mind if staffing or time is an issue slow release forms of nitrogen are preferable as Nelson 1987 showed that most of the nitrogen applied in a soluble form had gone within 72 hours of application with 50% having gone within the first 24 hours.

Bentgrass

Use soil test results as a guide to determine how much starter fertilizer to incorporate into the seedbed. A rule of thumb is to incorporate a 1-2-1 ratio starter-type fertilizer at a rate of approximately 450-500gN/100m2 of turf into the upper root zone just prior to seeding. Remember too try and use fertilisers which are safe to germinating seeds and have a low salt index. (Vavrek, B, 1999)

Post Establishment Fertiliser strategies

Once established, nutrition of bentgrass greens is aimed at encouraging strong disease and stress tolerant growth exhibiting a strong and vigorous root system.

Bent responds in different ways to different nitrogen fertilisers (Skogley, 1967) and also variations in behaviour occur between cultivars. For example browntop bent favours ammonium sulphate rather than sodium nitrate.

Extensive research carried out in the UK (Escritt and Lidgate, 1964) showed that ammonium sulphate applied at an equivalent rate to 1.1 kg N/100m2 applied in three dressings, was perfectly acceptable for satisfactory growth of a mixed bent/fescue turf. However, over time the acidifying nature of the ammonium sulphate lead to a build up of thatch. This rate of 1.1 kg N/100m2 should now be regarded as a minimum rate of application, and now the application rate is more likely to be in the range of 1.1-2.0 kg N/100m2 especially with some of the newer turf cultivars on the market.

On pure sand greens Lawson (1987) proposed an annual rate of 2.5 kg/100m2 provided adequate cover.

As a general rule Penncross and Pennlinks will require around 1.5kgN/100m2/season in Canberra and the surrounding areas. These figures are supported by the figures given out by Barenbrug (2001) for Regent and Bardot. They state four applications of 500g N / 100m2 / annum.

Green and Beard (1969) looked at changes in the carbohydrate reserve of creeping bentgrass in relation to nitrogen applications and found that any one application of more than 630g N/100m2 lead to a significant decrease in leaf carbohydrate. The significance of this is that grass uses this carbohydrate to recover from wear stress and for cold tolerance over the winter. This points to the final dressing of the year therefore not exceeding 600g N/100m2.

With newer constructions the aim is to produce pure bentgrass surfaces. However, over time wintergrass will undoubtedly invade the surface and if this does occur the options then are to manage it or adopt an eradication programme. With wintergrass the key is regular light applications of nitrogen at a rate of 250gN/month as this will encourage growth and recovery without the associated lushness that occurs with heavier applications.

As discussed in the 'establishment' section the low nutrient holding capacity inherent with sand-based systems makes it difficult to provide adequate nutrition to turf.

In an attempt to deal with this some course superintendents have adopted 'spoon feeding'. This means frequent applications of liquid fertilisers at low rates. This approach offers versatility and a high degree of control. However it can be extremely labour intensive.

Liquid fertilisers have been used for this purpose as they avoid the problem of ‘speckling’ that can occur with granular materials. When the latter are used at low rates they can cause in irregular green dots over stimulated turf.

Research has however been carried out into dry "spoon-feeding" using low analysis granular fertilisers. These can be produced in low nitrogen concentration formulations with other nutrients incorporated into the fertiliser, such as iron and magnesium.

Tissue analysis revealed that all the solid fertiliser treatments had total nitrogen contents higher than the liquid fertiliser treatment which is not surprising when by mowing and removing leaf tissue the main access point for liquid fertilisers into the plant.

While turf grown in the solid fertiliser treatment plots can take up more nitrogen from the rootzone, no nitrogen is available to the turf grown in the liquid fertiliser plots until subsequent applications of foliar sprays are made.

Nutrient applications

Table 7. **Recommended annual phosphate (P) applications (Bray P1-Extractable**

SOIL TEST G/M2	GENERAL TURF KG/100M2	HIGH MAINTENANCE TURF KG/100M2
VERY LOW <0.74	1.5	2
LOW 0.79-1.22	1.0	1.5
MEDIUM 1.27-1.97	0.5	1
HIGH 2.01-3.45	0	0.5
VERY HIGH >3.45	0	0

Based on figures supplied by Michigan State University Soil testing Lab

Table 8. **Recommended annual potassium (K) applications**

SOIL TEST G/M2	GENERAL TURF KG/100M2	HIGH MAINTENANCE TURF KG/100M2
VERY LOW <1.4	2.0	2.5
LOW 1.4-9.4	1.5	2
MEDIUM 9.4-16.3	1	1.5
HIGH 16.3-23	0.5	1
VERY HIGH >23	0	0.5

References are available upon request