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Management Guidelines for New Warm-Season Grasses in Australia

Final Report

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Agri-Science Queensland, a service of the
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~ Thank You ~

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The information obtained as part of the TU05001 study was the first of its kind to be undertaken on this scale across Australia. The four year collaborative project was initially the brainchild of former Queensland Primary Industries and Fisheries (QPIF) Principal Scientist, Dr Donald Loch and John Neylan, now General Manager of the Australian Golf Course Superintendents Association (AGCSA).

Initially it was anticipated that a centralised test facility would be constructed at the Queensland Department of Employment, Economic Development and Innovation (DEEDI) (formerly QPIF) Redlands Research Station and a series of regional trial sites would be setup on a smaller scale within each of the golfing regions. Regional sites were earmarked to be planted at strategic locations on a continuum from north Queensland to southern New South Wales, Victoria, South Australia and even south-east Asia (Bangkok and Kuala Lumpur) to extend the study into the humid low latitude tropics. However, the number of sites and clubs looking to participate in the study took a turn for the worst when the drought and the effects of El Niño took effect in 2006 just prior to the commencement of the study. The World Meteorological Organisation identified 2006 as the 6th hottest year on record globally and decent rainfall was nowhere on the horizon. As a result, one of the last things on a golf or bowls club's mind was to construct and manage a turfgrass trial.

For this reason our appreciation goes to the golf clubs, superintendents and committees who chose to remain involved in the study and host a regional trial site. They clubs include, Horton Park Golf Club, Indooroopilly Golf Club, Twin Waters Golf Club, Coolangatta Tweed Golf Club, Glenelg Golf Club, and Bermagui Golf Club. Recognition must also be given to Bruce Macphee of Chisholm TAFE on the Mornington Peninsula for his participation in the study. This brought forth not only a challenge to establish and maintain the selection of warm-season turfgrasses in a predominantly cool environment, but set a challenge for the students who assisted with the turf management of the research plots. I'm sorry the Queensland Blue Couch did not grow well in your environment as part of the collection. It would have been the first time one from Queensland crossed the border south and tried to live in your environment and instead of the other way around.

I would like to thank the leading superintendents and their specialist teams at each of the participating clubs which saw merit in the study and successfully had the request to be a collaborator in the project approved by their committee. The leading superintendents include: Charlie Gifford of the Indooroopilly GC, Peter Lonergan of the Coolangatta Tweed GC, Pat Pauli of the Horton Park GC, Daryl Sellar of the Glenelg GC, David Thomson of the Bermagui GC, and Gary Topp of the Twin Waters GC. Thanks also to Bruce Macphee at Chisholm TAFE who provided the students with a great opportunity to see how warm-season grasses perform on the Mornington Peninsula.

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It has been a pleasure working closely with members of the golf and bowls industry. Your passion and quest for knowledge makes it a rewarding experience to undertake turfgrass studies and bring forth our findings.



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MEDIA SUMMARY

After more than 30 years in which ‘Tifgreen’ and ‘Tifdwarf’ were the only greens-quality varieties available, the choice for golf courses and bowls clubs in northern Australia has been expanded to include six new *Cynodon* hybrid and at least four seashore paspalum grasses.

There are currently 1,530 golf courses and 2,011 lawn bowls clubs located in metropolitan and country areas of Australia. With the introduction of these newer grasses it has made a number of clubs consider converting their greens to provide their members and social players with a denser, smoother, faster playing surface. But how would these newer grasses handle tropical, subtropical and temperate climates and how differently do they need to be managed compared to ‘Tifgreen’ and ‘Tifdwarf’?

In a four year collaborative study lead by the Queensland Department of Employment, Education, Development and Innovation (DEEDI) and the Australian Golf Course Superintendents Association (AGCSA) their aim was to determine (a) the appropriate variety for different environments and budgets, and (b) best management practices for the new varieties.

Introduction of the newer *Cynodon* hybrids and greens quality seashore paspalums will be largely dependent on one component; thatch accumulation and successful management being undertaken from a very early stage in the establishment of the greens. Thatch accumulation can reduce the quality and playability of the turf. For this not to occur, preventative efforts rather than control are required. With the introduction of routine grooming and light topdressings thatch levels can be managed and contained.

Of the eight *Cynodon* hybrids and four seashore paspalums, not all varieties are suited for Australia’s diverse climatic conditions. There is a necessity for clubs wishing to change from the grass they currently have on their greens, to first trial a sample of the grass before undertaking a complete overhaul. This is primarily due to the climate variances and growth response, but to also provide their superintendent or greenkeeper with an opportunity to observe the grass in his or her growing environment.

The Australian Golf Industry had an annual economic value to the Australian GDP of AU\$2.7 billion and is by far the greatest sport industry contributor to the Australian economy. Between 2000 and 2009, thirty-six golf courses were opened in Australia and inevitably they had to make a decision on what variety to plant on their greens. Recommendations and best management practices (BMPs) acquired as a result of this study will provide future developments and existing golf and lawn bowls clubs with information that will assist in the successful setup and operation of these facilities. As such, the Australian public will be able to putt with confidence and have a roll, while continuing to enjoy two healthy recreational activities.

TECHNICAL SUMMARY

After more than 30 years in which ‘Tifgreen’ and ‘Tifdwarf’ were the only greens-quality varieties available, the choice for golf courses and bowls clubs in northern Australia has been expanded to include six new *Cynodon* hybrids [*Cynodon dactylon* (L.) Pers x *Cynodon transvaalensis* Burtt-Davy]. Five of these – ‘Champion Dwarf’ (Texas), ‘MS-Supreme’ (Mississippi), FloraDwarf™ (Florida), ‘TifEagle’ (Georgia), MiniVerde™ (Arizona) - are from US breeding programs, while the sixth, ‘TL2’ (marketed as Novotek™) was selected in north Queensland. The finer, denser and lower growing habit of the “ultradwarf” cultivars allows very low mowing heights (e.g. 2.5 mm) to be imposed, resulting in denser and smoother putting and bowls surfaces. In addition to the *Cynodon* hybrids, four new greens quality seashore paspalum (*Paspalum vaginatum* O. Swartz) cultivars including ‘Sea Isle 2000’, Sea Isle Supreme™, Velvetene™ and Sea Dwarf™ (where tolerance of salty water is required) expands the range of choices for greens in difficult environments.

The project was developed to determine (a) the appropriate choice of cultivar for different environments and budgets, and (b) best management practices for the new cultivars which differ from the *Cynodon* hybrid industry standards ‘Tifgreen’ and ‘Tifdwarf’. Management practices, particularly fertilising, mowing heights and frequency, and thatch control were investigated to determine optimum management inputs and provide high quality playing surfaces with the new grasses.

To enable effective trialling of these new and old cultivars it was essential to have a number of regional sites participating in the study. Drought and financial hardship of many clubs presented an initial setback with numerous clubs wanting to be involved in the study but were unable to commit due to their financial position at the time. The study was fortunate to have seven regional sites from Queensland, New South Wales, Victoria and South Australia volunteer to be involved in the study which would add to the results being collected at the centralised test facility being constructed at DEEDI’s Redlands Research Station.

The major research findings acquired from the eight trial sites included:

- All of the new second generation “ultradwarf” couchgrasses tend to produce a large amount of thatch with MiniVerde™ being the greatest thatch producer, particularly compared to ‘Tifdwarf’ and ‘Tifgreen’. The maintenance of the new *Cynodon* hybrids will require a program of regular dethatching/grooming as well as regular light dustings of sand. Thatch prevention should begin 3 to 4 weeks after planting a new “ultradwarf” couchgrass green, with an emphasis on prevention rather than control.
- The “ultradwarfs” produced faster green speeds than the current industry standards ‘Tifgreen’ and ‘Tifdwarf’. However, all *Cynodon* hybrids were considerably faster than the seashore paspalums (e.g. comparable to the speed difference of Bentgrass and couchgrass) under trial conditions. Green speed was fastest being cut at 3.5 mm and rolled (compared to 3.5 mm cut, no roll and 2.7 mm cut, no roll).

- All trial sites reported the occurrence of disease in the *Cynodon* hybrids with the main incidence of disease occurring during the dormancy period (autumn and winter). The main disease issue reported was “patch diseases” which includes both *Gaumannomyces* and *Rhizoctonia* species. There were differences in the severity of the disease between cultivars, however, the severity of the disease was not consistent between cultivars and is largely attributed to an environment (location) effect. In terms of managing the occurrence of disease, the incidence of disease is less severe where there is a higher fertility rate (about 3 kgN/100m²/year) or a preventative fungicide program is adopted.
- *Cynodon* hybrid and seashore paspalum cultivars maintained an acceptable to ideal surface being cut between 2.7 mm and 5.0 mm. “Ultradwarf” cultivars can tolerate mowing heights as low as 2.5 mm for short periods but places the plant under high levels of stress. Greens being maintained at a continually lower cutting height (e.g. 2.7 mm) of both species is achievable, but would need to be cut daily for best results. Seashore paspalums performed best when cut at a height of between 2.7 mm and 3.0 mm. If a lower cutting height is adopted, regular and repeated mowings are required to reduce scalping and produce a smooth surface.
- At this point in time the optimum rate of nitrogen (N) for the *Cynodon* hybrids is 3 kg/100m²/year and while the seashore paspalums is 2 to 3 kg/100m²/year.
- Dormancy occurred for all *Cynodon* and seashore paspalum cultivars from north in Brisbane (QLD) to south in Mornington Peninsula (VIC) and west to Novar Gardens (SA). *Cynodon* and *Paspalum* growth in both Victoria and South Australia was less favourable as a result of the cooler climates.
- After combining the data collected from all eight sites, the results indicated that there can be variation (e.g. turfgrass quality, colour, disease resistance, performance) depending on the site and climatic conditions. Such evidence highlights the need to undertake genotype by environment (G x E) studies on new and old cultivars prior to conversion or establishment.
- For a club looking to select either a *Cynodon* hybrid or seashore paspalum cultivar for use at their club they need to:
 - Review the research data.
 - Look at trial plots.
 - Inspect greens in play that have the new grasses.
 - Select 2 to 3 cultivars that are considered to be the better types.
 - Establish them in large (large enough to putt on) plots/nursery/practice putter. Ideally the area should be subjected to wear.
 - Maintain them exactly as they would be on the golf course/lawn bowls green. This is a critical aspect. Regular mowing, fertilising etc. is essential.
 - Assess them over at least 2 to 3 years.
 - Make a selection and establish it in a playing green so that it is subjected to typical wear.

CHAPTER 1

INTRODUCTION

Since the commencement of the Horticulture Australia funded project, Management Guidelines for Warm-Season Grasses in Australia (TU05001), the turfgrass industry found itself facing arguably its toughest period in decades. Drought and more recently fire, flooding and the financial crisis are just some of the hurdles the industry has had to deal with. In light of these challenging times it has been encouraging to see the golf, bowls and wider turf industry collaborate at a national level to undertake this study. Such a task is commendable and all parties involved should be congratulated for making this research possible.

The initiative has allowed for the detailed greens grass study to take place and enabled researchers and superintendents to work together to collect meaningful data on a range of *Cynodon dactylon* (L.) Pers. x *Cynodon transvaalensis* Burt-Davy (*Cynodon* hybrid) and *Paspalum vaginatum* O. Swartz (seashore paspalum) cultivars suitable for golf or lawn bowls use. The end result will provide superintendents and greenkeepers with the added knowledge to accompany their skills in managing or upgrading their greens to produce a denser, smoother and faster putting or bowls surface. However, neither turfgrass selection nor finely tuned management program will overcome unrealistic expectations (especially in relation to usage), poor growing environments, or limitations due to improper construction techniques (Bevard et al., 2005).

AUSTRALIAN GOLF AND BOWLS INDUSTRY

In a study undertaken by Ernst and Young et al. (2006) the Australian Golf Industry had an annual economic value to the Australian GDP of AU\$2.7 billion and is by far the greatest sport industry contributor to the economy (AGIC, 2009). The golf industry directly employs in excess of 23,000 people with many thousands more employed in industries that have an association with golf (AGIC, 2009).

The Australian Golf Industry Council (AGIC) in May 2009 indicated that there were 1,530 golf courses in Australia, with 19% of these located in the metropolitan area and 81% in regional areas (AGIC, 2009). Of these 1,530 golf courses, 36 were opened between 2000 and 2009. Inevitably these new facilities along with others undertaking resurfacing, would have had to make a decision on what cultivar to plant on their greens.

In 2009, there were 2,011 registered lawn bowls clubs located across Australia. In a study undertaken by Bowls Australia and the State and Territory Associations (STA's) in 2007, results showed that 79% of the lawn bowls surfaces are of natural turf with 21% being synthetic (Hook, 2007). Of the clubs with natural turf surfaces, 72% of the 717 respondents indicated that they have warm-season (e.g. 'Tifdwarf', 'Santa Ana', 'common') turfgrass, while only 14% had Bentgrass (*Agrostis* spp. a cool-season turfgrass) and the remaining 14% had a combination of the latter, or were listed as 'other' (Hook, 2007).

Of the 3,500 plus golf and bowls clubs located in Australia, the large majority of them are positioned along the eastern coast in New South Wales, Victoria and Queensland. This is not surprising given that a population of nearly 6.1 million people reside within this region (Table 1).

Table 1. Number of golf courses and lawn bowls clubs in Australia relative to the Australian population in 2009 [source (AGIC, 2009; Bowls Australia, 2009)].

State	Golf Courses	Bowls Clubs	Population '000
NSW	413	≈ 591	7,099.7
VIC	378	≈ 530	5,427.7
QLD	256	347	4,406.8
WA	231	217	2,236.9
SA	154	224	1,622.7
TAS	75	73	502.6
ACT	10	21	351.2
NT	13	8	224.8
Total	1,530	2,011	21,874.9 (a)

(a) Includes Other Territories comprising Jervis Bay Territory, Christmas Island and the Cocos (Keeling) Islands. Population data was acquired from the Australian Bureau of Statistics (2009).

PROJECT BACKGROUND

After more than 30 years in which ‘Tifgreen’ and ‘Tifdwarf’ were the only greens-quality cultivars available, the choice for golf courses and bowls clubs in northern Australia has been expanded to include six new *Cynodon* hybrids. Five of these – ‘Champion Dwarf’ (Texas), ‘MS-Supreme’ (Mississippi), FloraDwarf™ (Florida), ‘TifEagle’ (Georgia), MiniVerde™ (Arizona) - are from US breeding programs, while the sixth, ‘TL2’ (marketed as Novotek™) was selected in north Queensland. The finer, denser and lower growing habit of the “ultradwarf” cultivars allows very low mowing heights (e.g. 2.5 mm) to be imposed, resulting in denser and smoother putting and bowls surfaces. In addition to the *Cynodon* hybrids, four new greens quality seashore paspalum cultivars including ‘Sea Isle 2000’, Sea Isle Supreme™, Velvetene™ and Sea Dwarf™ (where tolerance of salty water is required) expands the range of choices for greens in difficult environments.

The hybrid *Cynodon* cultivars differ in their rates of vertical extension and lateral stem development, and in their shoot density. The finer, denser and lower growing new varieties result in a denser, smoother and faster putting surface under optimum management. However, these also require intensive management for thatch control and behave differently to the older standard (first-generation) varieties in terms of their response to mowing height, nitrogen fertiliser rates, and even winter over-seeding with ryegrass (*Lolium perenne* L.).

The first of the new generation *Cynodon* and *Paspalum* greens varieties from the US are now available commercially through Australian licensees, though licensing arrangements are still to be finalised for two of these, ‘Champion Dwarf’ and MiniVerde™. All of them however, are being grown by the Queensland Department of Employment, Economic Development and Innovation (DEEDI) turf research team

at Redlands Research Station, Cleveland, in agreement with the breeders and their Australian licences.

To enable effective evaluation of these new and old turfgrass cultivars it was essential to have a number of regional trial sites participating in the study along with the centralised test facility being constructed at DEEDI Redlands Research Station (Table 2). Industry contact was made by staff of the Australian Golf Course Superintendents Association (AGCSA) and DEEDI to seek interest from golf and bowls clubs to see if they wanted to be involved in the collaborative study. Drought and financial hardship of many clubs presented an initial setback with numerous clubs wanting to be involved in the study but were unable to commit due to their financial position at the time. The study was fortunate to have seven regional sites from Queensland, New South Wales, Victoria and South Australia volunteer to be involved in the four year Horticulture Australia Ltd (HAL) funded study.

By having numerous regional trial sites actively participate in the study it allowed superintendents, teachers, researchers and technical staff to assess the selection of warm-season turfgrasses being grown under a “typical” management regime. Management practices, however, often varied from the regime used on their existing greens and also from conditions imposed on the same or other varieties at other courses. A protracted period of trial and error by adjusting and fine tuning management regimes was common to allow for unjustified prejudices and debate about their relative merits, until rational assessments slowly emerged.

The opportunity to support this process was to construct a centralised test facility (at Redlands Research Station) keying it to regionally distributed comparisons of all varieties under similar management by experienced superintendents/greenkeepers at the regional trial sites. Rather than a protracted commercialisation process in which individual courses/clubs grow the new varieties under “typical” management regimes, this coordinated approach accelerated the rational assessment of the new cultivars and greatly improve understanding of their characteristics and management requirements such as nitrogen fertiliser rates, cutting height and grooming treatments.

The end result was to provide faster, more affordable determinations by each club/course/facility of the grow-in or replacement strategy which best met its requirements, together with a sound knowledge of these new greens grasses much earlier than would otherwise have been the case.

Table 2. Location of trial sites participating in the warm-season greens grass study.

Location of trial site	State
Glenclg Golf Club, Novar Gardens	SA
Chisholm TAFE, Mornington Peninsula	VIC
Bermagui Golf Club, Bermagui	NSW
Coolangatta Tweed Golf Club, Tweed Heads South	NSW
Indooroopilly Golf Club, Indooroopilly	QLD
Horton Park Golf Club, Maroochydore	QLD
Twin Waters Golf Club, Twin Waters	QLD
DEEDI Redlands Research Station, Cleveland	QLD

PROJECT AIMS

The project was developed to determine (a) the appropriate choice of cultivar for different environments and budgets, and (b) best management practices for the new cultivars which differ from the *Cynodon* hybrid industry standards 'Tifgreen' and 'Tifdwarf'. Management practices, particularly fertilising, mowing heights and frequency, and thatch control were to be investigated to determine optimum management inputs and provide high quality playing surfaces with the new grasses. Such practices would also have to sit favourably with the clubs budget and playing schedule.

IMPLICATIONS FOR INDUSTRY AND POTENTIAL IMPACT

In recent years the choice of greens quality grasses, either *Cynodon* hybrids or seashore paspalum, have expanded tenfold. Apart from the first-generation hybrid cultivars 'Tifgreen' and 'Tifdwarf' there are at least a further six *Cynodon* and four *Paspalum* cultivars available to produce denser, smoother and faster putting and bowls surfaces under optimum management.

These newer cultivars require more intensive management for thatch control and behave differently to the older standard varieties in terms of their response to management variables.

By linking a network of regionally located varietal comparisons with a rigorous detailed study at one location (Redlands Research Station) in which the responses of each variety to management variables are determined, the results obtained from this study will enable golf and bowls managers to make more informed choices about the most appropriate greens cultivar(s) or different resource levels and environments earlier than would otherwise occur, and to optimise their management of each cultivar. Other benefits achieved by undertaking the study include:

- Education and training of superintendents or greenkeepers who have inspected the trial sites or who have had a first hand opportunity to manage the new generation grasses. For some of these varieties it was the first time the turfgrass industry has had the opportunity to observe their growth and undertake detailed management activities of them outside a simulated (research) environment.
- Information (e.g. history, morphology, management) will be made available to the turfgrass industry about the newer cultivars available for license and commercial sale within Australia
- Having conclusive information on the comparison of management practices and playability (ball roll distance) of *Cynodon* hybrid and seashore paspalum cultivars. The available information will hopefully be able to inform a person who is undecided between choosing one of the two taxa.

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CHAPTER 2

TURFGRASS CULTIVARS EVALUATED

INTRODUCTION

After more than 30 years in which first-generation ‘Tifgreen’ and ‘Tifdwarf’ were the only greens-quality varieties available, the choice for golf courses and bowls clubs in northern Australia has been significantly expanded. There are now the old industry standards (‘Tifgreen’ and ‘Tifdwarf’), along with six second-generation *Cynodon dactylon* (L.) Pers x *Cynodon transvaalensis* Burt-Davy (*Cynodon* hybrid) cultivars and at least four *Paspalum vaginatum* O. Swartz (seashore paspalum) cultivars suitable for use on a golf or bowls facility maintained at greens height.

Over the years in Australia greens have been surfaced with both warm- and or cool-seasons grasses depending on the clubs geographical location, playing requirements, water availability and budget. Cool-season grasses such as Bentgrass (*Agrostis* spp.) were a preferred option because of their playability, aesthetics and climatic adaptation. Prior to the introduction of ‘Tifgreen’ which was first reported to be introduced into Australia in 1956 by Doug Corbett, (McMaugh, 2008) and ‘Tifdwarf’ in 1968 by greenkeeper Cliff Meredith (McMaugh, 2009), common green couch [*C. dactylon* (L.) Pers.] and in Queensland, Queensland Blue Couch (*Digitaria didactyla* Wild.) was predominantly used. Around the same time a seashore paspalum cultivar trademarked as Adalayd® (US Pat No. 3.939) was being widely used in Australia as a lawngrass and to a limited extent on bowling greens (Duncan, 2002). Adalayd® was also used around the golf course scene in the US since the mid-70s, but it was only used on a limited basis because of its inferior turf quality (Bevard et al., 2005) and production of off-types. Two such mutants selected from within planting of Adalayd® include Sealsle Supreme™ and SeaDwarf®.

New and improved *Cynodon* hybrid and seashore paspalum cultivars offered a higher shoot density and finer leaf texture than older industry standards or common turf selections. Additional advantages of the seashore paspalum are that it can withstand a wide variety of cutting heights, is capable of growing in areas of high salinity and it can tolerate poor-quality irrigation water. From studies conducted by the DEEDI Turf Research team, ‘Sea Isle 2000’ proved to have a slightly higher salt tolerance of the paspalums, while FloraDwarf™, ‘Champion Dwarf’, Novotek™ and ‘TifEagle’ were found to be the most salt tolerant of the *Cynodon* hybrids (Bauer et al., 2009). These days when water quality and availability is at the forefront of the decision making process about whether to resurface a green or convert from a cool- to predominantly warm-season turfgrass, both the newer cultivars of *Cynodon* and *Paspalum* offer great opportunities.

CULTIVARS TESTED AT TRIAL SITES

Following discussions between superintendents at the regional trial sites, the Australian Golf Course Superintendents (AGCSA) staff and Queensland Department of Employment, Economic Development and Innovation (DEEDI) scientists, it was in the end up to the individual clubs (superintendents, committees etc) to decide which genus and cultivars they wanted to trial. *Cynodon* proved to be the preferred option to trial, particularly the newest cultivars MiniVerde™ and ‘MS-Supreme’. However, at least two seashore paspalum cultivars were trialled at each of the seven regional sites with the exception of Indooroopilly Golf Club, Queensland.

Each of the six *Cynodon* hybrid and four seashore paspalum cultivars were trialled at the centralised test facility located at DEEDI Redlands Research Station, Queensland. However, ‘Champion Dwarf’, FloraDwarf™, and SeaDwarf™ were not included in the formal replicated study, as insufficient space was available in the already 2052 m² purpose built facility.

For a list of the cultivars trialled at each of the seven regional trial sites and DEEDI Redlands Research Station refer to Table 3.

Table 3

Table 3. The range of *Cynodon* hybrid and seashore paspalum cultivars trialled

Trial Site	<i>Cynodon dactylon</i> x <i>C. transvaalensis</i> (<i>Cynodon</i> hybrid)								<i>Paspalum vaginatum</i> (seashore paspalum)			
	Champion Dwarf	MiniVerde™	FloraDwarf™	TifEagle	Tifdwarf	Tifgreen™	Novotek™	MS-Supreme	Sea Isle 2000	Velvetene™	Sea Isle Supreme™	SeaDwarf®
Bermagui GC	X	X		X	X	X		X	X	X		X
Chisholm TAFE		X		X				X	X	X		
Coolangatta Tweed GC		X		X	X	X		X	X	X		
Glenelg GC	X	X	X	X	X			X	X		X	X
Horton Park GC	X	X		X	X	X		X	X	X		
Indooroopilly GC		X	X				X	X		X	X	
Twin Waters GC		X	X	X	X	X	X	X				
DEEDI RRS	X	X	X	X	X	X	X	X	X	X	X	X

GC = Golf Club; RRS: Redlands Research Station

DISTRIBUTION OF GREENS QUALITY GRASSES IN AUSTRALIA

Cultivars such as ‘Tifgreen’ and ‘Tifdwarf’ are commercially available in most if not all states by select turf producers which supply warm-season turfgrass. However, often the way superintendents or greenkeepers obtain vegetative material of these two non-protected varieties is by obtaining sprigs following scarification of a green at a facility in close proximity to their own. Such practice cannot be undertaken with the majority of the newly released cultivars because they are often protected by a form of intellectual property, mainly Plant Breeder’s Rights (PBR) here in Australia.

Unauthorised commercial propagation or any sale, conditioning, export, import or stocking of propagating material of any PBR variety without consent from the breeder or licensee, is an infringement under the *Plant Breeder's Rights Act 1994*. The Act which is governed by legislation offers protection of plant material for a period of 20 years from the date of grant. If PBR is breached the title holder is entitled to seek damages or an account of profits, which can range from AU\$55,000 for individuals to AU\$275,000 for companies.

Breeders or turf producers who have cultivars that are protected by PBR must ensure reasonable public access to plant material from within a maximum two year period from date of grant. If cultivars are not made available, the industry (via, say the AGCSA and/or Bowls Australia) or a person thereof would be justified in approaching the Australian PBR Registrar (Mr Doug Waterhouse) seeking the grant of a compulsory licence under Section 19 of the *Australian Plant Breeder's Rights Act 1994*.

S. 19 (1) Subject to subsection (11), the grantee of PBR in a plant variety must take all reasonable steps to ensure reasonable public access to that plant variety.

S. 19 (4) If, at any time more than 2 years after the grant of PBR in a plant variety, a person considers:

(a) that the grantee is failing to comply with subsection (1) in relation to the variety; and

(b) that the failure affects the person's interest;
the person may make a written request to the Secretary to exercise a power under subsection (3) in relation to the variety.

If the latter does not occur following a request to obtain or purchase plant material, the PBR Office can intervene and make sufficient material available to the public. Should either the breeder or the turf producer not wish to oblige, they risk losing PBR protection of their cultivar.

For further information on plant protection and which turfgrass cultivars are protected by PBR, visit the IP Australia web site (<http://www.ipaustralia.gov.au/pbr/index.shtml>).

Australian PBR was granted for 'Champion Dwarf' in 2002, but no Australian licensee has yet been appointed despite earlier correspondence between former DEEDI Principal Scientist Dr Loch and the US breeders highlighting the need for this to happen. Depending on the response from superintendents and greenkeepers on the performance of 'Champion Dwarf' in the TU05001 study, it may be worthwhile pursuing this matter further in reference to the *Plant Breeder's Rights Act 1994* as listed above.

FloraDwarfTM is not covered by PBR, and cannot now be submitted for PBR protection because it is more than 4 years since the date of first commercial sale in the US. Foundation material of this cultivar is growing at DEEDI Redlands and vegetative material can be made available upon request.

Approaches to the US owners of MiniVerdeTM were successful and an application was submitted to the Australian Plant Breeder's Rights (PBR) office following trials at DEEDI Redlands to formerly register the cultivar in Australia (as 'P18'). Further discussions are continuing with DEEDI staff and the owners about making the cultivar commercially available in Australia by licensing it to an

Australian turf producer. This will hopefully occur in the not to distant future and the Australian turfgrass industry will be kept informed of any developments.

Novotek™ is commercially available from Tropical Lawns Pty Ltd, Gordonvale, Queensland. For more information visit their web site (http://www.tropicalawns.com.au/page/golf_sports.html).

‘TifEagle’ and ‘MS-Supreme’ are commercially available from Twin View Turf Pty Ltd, Wamuran, Queensland. For more information visit their web site (<http://www.twinviewturf.com.au/turf-varieties/specialist-grasses.php>).

‘Sea Isle 2000’ is commercially available from three Queensland and three New South Wales turf producers, and one Victoria producer. Contact details of each supplier are available from the Sea Isle web site (http://www.seaisle-australia.com/seaisle_sales.htm).

Environmental Turf, Inc., Florida, USA, in 2007 granted Orara Turf, Coffs Harbour, New South Wales a licence to commercially grow and sell SeaDwarf™ in Australia. At the request of Environmental Turf, SeaDwarf™ will be grown under certification in Australia, under an AOSCA-based scheme which was set up in 2001.

In 2007, political pressure from the Sea Isle Supreme Growers group in Georgia (USA) led to an embargo through the University of Georgia and Georgia state legislature on licensing of Sea Isle Supreme™ (and indeed all intellectual property [IP] developed by the University of Georgia) internationally and even outside the state of Georgia for a period of 8 years. In effect, this means that Sea Isle Supreme™ at this point in time will not become available in Australia until 2015. However, following this decision the University of Georgia submitted a Plant Breeder’s Rights application through DEEDI and registered ‘SI98’ through the Australian PBR office. This has been a significant development and DEEDI staff are continuing discussions with personnel from the University of Georgia and the Georgia Seed Development Commission. Hopefully common sense will prevail and Sea Isle Supreme™ will be made available in Australia in the not to distant future.

Velvetene™ is commercially available from three turf producers in Western Australia, five producers in Queensland, two in New South Wales and one in South Australia. Contact details of each supplier are available from the Velvetene Pty Ltd web site (<http://www.velvetene.com.au/Suppliers.htm>).

HISTORY BEHIND THE CULTIVARS TRIALLED

The following contains a description of the current (1950s to 2009) *Cynodon* hybrid and seashore paspalum cultivars trialled in this study. Detailed information has been sourced in relation to the origin and development of the grasses which are suitable for use on golf and bowling greens, and with the seashore paspalum cultivars, areas where they can be mown at higher levels e.g. planting “wall-to-wall” of a golf course. Such detail provides an interesting picture of the source of proliferation of newer cultivars and how the Australian industry has evolved with the introduction of overseas and Australian selected cultivars.

For a quick overview of each cultivar trialled, including release date, reported origin, Intellectual Property and alternative names used, refer to Table 4 for the *Cynodon* hybrids and Table 5 for the seashore paspalum cultivars.

Table 4. Origin, release and proprietary protection of *C. dactylon* x *C. transvaalensis* greens quality grasses in Australia.

Cultivar	Release Date [†]	Reported Origin	United States Plant Patent	Australian PBR Application #	Registered Name (PBR/PP)	Experimental Name	References
Champion Dwarf	(1996)	Spontaneous mutation from Tifdwarf	PP9,888	1996/203	Champion Dwarf	-	(Kaapro, 1999) (Roche and Loch, 2005)
FloraDwarf	1995	Spontaneous mutation from Tifgreen	PP9,030	-	FHB-135	FHB-135	(Dudeck, 1995) (Dudeck and Murdoch, 1998) (Roche and Loch, 2005)
MS-Supreme	1999	Spontaneous mutation from Tifgreen	PP11,781	2002/305	MS-Supreme	MSB-40	(Krans et al., 1999) (Loch and Roche, 2003d)
Novotek	(2003)	Spontaneous mutation from Tifgreen	-	2002/268	TL2	TL2	(Loch and Roche, 2003a) (Roche and Loch, 2005)
MiniVerde	2005	Spontaneous mutation from Tifdwarf	PP12,084	2007/179	P18	P18	(Kaerwer, 2001) (Roche and Loch, 2005) (Roche and Loch, 2008c)
TifEagle	1997	Irradiation of Tifway II	PP11,163	2001/062	TifEagle	TW-72	(Hanna and Elsner, 1999) (Hanna) (Loch and Hanna, 2001)
Tifgreen	1956	Seedling cross	-	-	-	Tifton 328	(Hein, 1961) (Roche and Loch, 2005)
Tifdwarf	1965	Spontaneous mutation from Tifgreen	-	-	-	-	(Burton and Elsner, 1965) (Roche and Loch, 2005)

[†] For informal releases, dates of first commercial use are shown in parentheses.

Table 5. Origin, release and proprietary protection of *Paspalum vaginatum* greens quality grasses in Australia.

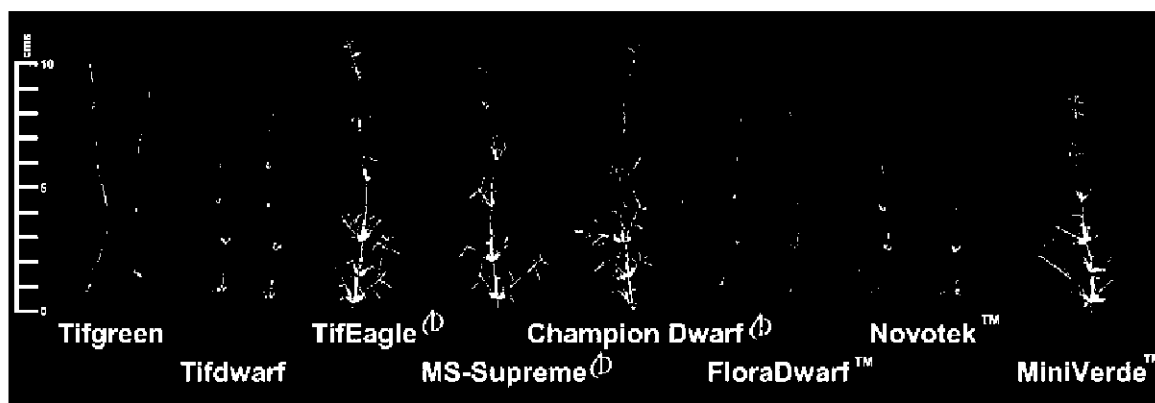
Cultivar	Release Date [†]	Reported Origin	United States Plant Patent	Australian PBR Application #	Registered Name (PBR/PP)	Experimental Name	References
Sea Isle 2000	(2002)	Spontaneous mutation from Adalayd	PP12,625	2002/167	Sea Isle 2000	-	(Duncan, 2002; Loch and Roche, 2003c)
Sea Isle Supreme	2004?	Natural selection	PP18,869	2008/073	SI98	SI98/OC03	(Duncan, 2008; Roche and Loch, 2008a)
SeaDwarf		Spontaneous mutation from Adalayd	PP13,294	2006/160	SDX-1	SDX-1	(Roche and Loch, 2008b)
Velvetene	(2002)	Spontaneous mutation from Saltene	-	2002/223	TFWA02	TFWA02	(Loch and Roche, 2003b)

[†] For informal releases, dates of first commercial use are shown in parentheses.

? lacking reliable information

Cynodon dactylon x *Cynodon transvaalensis* (*Cynodon* hybrid) cultivars

Plate 1. Stolon comparison of (left to right) ‘Tifgreen’, ‘Tifdwarf’, ‘TifEagle’, ‘MS-Supreme’, ‘Champion Dwarf’, FloraDwarf™, Novotek™ and MiniVerde™



Champion Dwarf

‘Champion Dwarf’ was selected from a ‘Tifdwarf’ *Cynodon* hybrid golf green that had been planted in 1969 (Kaapro, 1999) by Richard Morris Brown in Walker County, Texas in 1987 (Miller and Edenfield, 2002). Work to develop the triploid ($2n = 27$) selection and conduct independent research of the turf performance was undertaken by Coastal Turf, Inc. of Bay City, Texas, USA (Brown et al., 1997; Kaapro, 1999).

The selection from the ‘Tifdwarf’ patch was based on the advantageous characteristics of vertical leaf extension rate, lateral stem development, turf recuperative rate, shoot density, leaf blade width and terminal height (Kaapro, 1999). ‘Champion Dwarf’ was first sold in the United States in March 1996 (Brown et al., 1997).

In 2001 Kaerwer referred to one of the more unique traits of ‘Champion Dwarf’ as one that does not routinely form a seedhead and that no inflorescences of any kind had been observed in comparative trials conducted in Bay City, Texas, USA since 1993. This included testing ‘Champion Dwarf’ with three other cultivars (‘Tifway’, ‘Tifgreen’, and ‘Tifdwarf’) grown in test plots, glass-house and in large-acre production fields with varying management practices, over a minimum eight year period and still no inflorescences were observed (Kaerwer, 2001).

In addition to the side-by-side comparisons in Bay City, the four cultivars have been grown in US locations with dissimilar climates, such as Palm Desert, California, and Auburn, Atlanta; yet no inflorescence development had been observed in the ‘Champion Dwarf’ plots in these locations either (Kaerwer, 2001).

However, in field trials conducted by the DEEDI Turf Research team, Redlands Research Station, Queensland, Australia seed heads were observed and recorded in two trials (spaced plant and sward). Both experiments were setup to obtain morphological-agronomic characteristics as listed by Roche (2009) for the purposes of a Plant Breeders Right’s comparative testing. The first, a sward trial planted on 7 June 2002 tested the greens quality grasses ‘Champion Dwarf’,

'FloraDwarf', 'MS-Supreme', 'TifEagle', 'Novotek', 'Tifgreen' and 'Tifdwarf'. DEEDI researchers recorded 'Champion Dwarf' as having produced inflorescences with a mean number of 0.67 per plot [1 plot measuring 1 x 0.9 m by 3 replicates (=3 plots)] with a minimum number of 0 and maximum number of 2 inflorescence counts at 343 to 344 days post planting (DPP) when using a 0.1225m² quadrat. In the second experiment, a spaced plant trial planted on 13 Feb. 2006 tested 'Champion Dwarf', MiniVerde™, 'MS-Supreme' and 'TifEagle'. 'Champion Dwarf' at 192 and 195 DPP was recorded as having produced inflorescences with a mean number of 11.73 per plant [5 plants measuring up to 1 x 1 m by 6 replicates (=30 plants)] with a minimum number of 0 and maximum number of 61 inflorescence present within a 0.1225m² quadrat.

Foundation material of 'Champion Dwarf', approximately 70m², is held at DEEDI, Redlands Research Station.

FloraDwarf™

The cultivar FloraDwarf™ was assigned by Dudeck and Murdoch (1998) as being a *Cynodon* sp., but following morphological and agronomic studies by Roche and Loch (2005) the fine textured turfgrass would be better identified as a *Cynodon* hybrid [*Cynodon dactylon* (L.) Pers. x *C. transvaalensis* Burt-Davy]. FloraDwarf™ was one of 224 selections of couchgrass collected throughout the state of Hawaii, USA during 1988 (Dudeck and Murdoch, 1999). The accession was collected from the practice green on the Wailua Municipal Golf Course located on the island of Kauai, Lihue, Hawaii by Dr Albert E. Dudeck on 28 June 1988 (Dudeck and Murdoch, 1998; Dudeck and Murdoch, 1999; Miller and Edenfield, 2002). The 'Tifgreen' (Tifton 328) practice green from where the material was selected was thought to have been planted in 1977 (Dudeck and Murdoch, 1999).

From 1989 to 1999, FloraDwarf™ was tested as Florida Hawaii Bermudagrass accession 135 (FHB-135) (Dudeck and Murdoch, 1999) and was characterised as a sterile, fine textured, inconspicuous flowering, low growing stoloniferous grass that does not produce rhizomes. FloraDwarf™ was released by the Florida Agricultural Research Station on 24 January 1995 (Brown et al., 1997; Dudeck and Murdoch, 1998; Dudeck and Murdoch, 1999) and is suitable for use on golf course putting greens and lawn bowls greens.

Foundation stock of FloraDwarf™ is grown under certification standards governed by the Southern Seed Certification Association, Auburn, Alabama, USA with stock obtainable upon request from Florida Foundation Seed Producers, Inc., Greenwood, Florida, USA (Dudeck et al., 1994).

Material of FloraDwarf™ sent from the University of Florida arrived in Australia and was planted at DEEDI Redlands Research Station, Cleveland, Queensland in the facility's turf demonstration plots on 18 October 2001. Vegetative material was later taken from the 7m² observational plot to vegetatively (asexually) propagate approximately 70m² of foundation turf which is currently being held at DEEDI Redlands.

MiniVerde™ (P18)

'P18' trademarked as MiniVerde™ was first produced in 1992 by the late Howard Kacwerc as part of a breeding program designed to develop improved varieties of seed producing *Cynodon sp.* MiniVerde™ is a mutant obtained from a *Cynodon* line believed to be 'Tifdwarf' which was grown in a greenhouse owned by H&H Seed Company in Yuma, Arizona, USA (Kacwerc, 2001). MiniVerde™ possesses a high shoot density and tolerates continuous close mowing required for use in the golf and lawn bowls industry. The variety was selected for its extremely fine leaf texture, rapid growth rate, uniform dark green colour (Roche and Loch, 2008c) and excellent low temperature colour retention. MiniVerde™ does not exhibit purple leaf coloration due to anthocyanin production typical of 'Tifdwarf' bermudagrass exposed to low, non-freezing temperatures (White, no date). Uncontaminated MiniVerde™ was first sold in the United States on 19 July 2005 (Roche and Loch, 2008c).

Material of MiniVerde™ which was sent by Turfgrass America arrived in Australia and was planted at DEEDI Redlands Research Station, Queensland on 8 Jun. 2006. Foundation material of 'P18' (approximately 100m²) was planted at DEEDI Redlands on 10 November 2006 to multiply and supply to the Australian licensee(s) but is not expected to be commercially available within Australia until mid to late 2010.

The first bowling green to be supplied planting material of MiniVerde™ was Coorparoo Bowls Club, Coorparoo, Queensland on 14 September 2009 to sprig their number two (eastern) bowling green. Following permission from John Holmes, Global Sales Manager, of Phillip Jennings Turf Farm, Sandersville, Georgia, USA, DEEDI supplied material to contract greenkeeper Darryl Bain (Professional Greens Management Pty Ltd) of the club following discussions with Queensland Bowls who wanted to upgrade one of their two greens. The purpose of this was not only to improve the problematic green, but it was also to supply a potentially improved turfgrass to what is now the Bowls Queensland Centre of Excellence for lawn bowls. The centre is part of Bowls Queensland's high performance program being run in conjunction with the Queensland Academy of Sport, Australian Sports Commission and Bowls Australia in an effort to be acknowledged as the number one elite bowling state in Australia.

MS-Supreme

The 'MS-Supreme' hybrid was discovered in 1991 by breeder Jeffrey V. Krans as a mutant plant in the No. 14 'Tifgreen' putting green that had been planted in 1964 at the Gulf Shores Country Club, Gulf Shores, Alabama, USA (Krans et al., 1999). 'MS-Supreme' developed in 1998 is a high-density, fine-textured, fast prostrate growing cultivar that can withstand a sustained 3.2 mm cutting height. Krans et al. (1999) made the selection as it maintained a darker green colour and higher shoot density than the surrounding 'Tifgreen' during extended periods of wet, overcast weather. Other selection characteristics included its narrow leaves and prostrate growth habit. 'MS-Supreme' was first sold in the United States on 9 June 1999 (Loch and Roche, 2003d).

Vegetative material of 'MS-Supreme' was obtained from Mississippi State University and later planted at DEEDI Redlands Research Station, Queensland in their turf demonstration plots on 13 February 2001.

Novotek™ (TL2)

Vegetative material was taken from a disease resistant mutant plant by Terry Anderlini on the No. 15 green at Novotel Palm Cove resort course near Cairns, Queensland, Australia in 1996 (Loch and Roche, 2003a). Later designed 'TL2' the triploid ($2n = 27$) (Loch and Roche, 2003a) interspecific hybrid was included in an on-going program of selection and testing of promising 'Tifgreen' (Tifton 328) mutants by Tropical Lawns Pty Ltd. Novotek™, first sold commercially in Australia in 2003 "produces a healthy vigorous growth during the tropical wet season, dense fine-textured appearance under close mowing, and dark green leaves. In subsequent trials conducted by Terry Anderlini, Novotek™ was identified as the outstanding plant among selections of mutant 'Tifgreen' genotypes from other north Queensland sites in terms of colour, texture and density for greens use (Loch and Roche, 2003a).

DEEDI Redlands holds a supply of Novotek™ in their turf demonstration plots which was planted in May 2000.

Tifdwarf

There were two sources of vegetative material produced of 'Tifdwarf', being for a test plot at the Georgia Coastal Plain Experiment Station and subsequently for commercial production.

In 1962 the test plot selection was found occupying an area of about 457.2 mm (18 inches) in diameter by T. M. Baumgardner and Marion McKendree on the No. 2 green of the Plantation Course (Moncrief, 1967), Sea Island Country Club, Sea Island, Georgia and by James Moncrief on the No. 12 green (Moncrief, 1967) at Florence Country Club, Florence, S.C. (Anderson and Sharp, 1995). The source for a commercial nursery came from the No. 6 green at Glen Arven Country Club, Thomsaville, Georgia also in 1962 (Moncrief, 1967).

A careful evaluation of all evidence indicates that 'Tifdwarf' is a vegetative mutant that occurred in 'Tifgreen' (Tifton 328) at Tifton, Georgia, USA, before the first planting stock was sent out in 1954 for preliminary evaluation (Anderson and Sharp, 1995). It is believed that the golf courses at Florence and Sea Island Country Club, each received a sprig or two of this original natural mutation that occurred at Tifton Experimental Station. 'Tifdwarf' underwent three years of research under the late Dr Glen W. Burton and graduate students, and two years of field testing against its comparator 'Tifgreen' (Moncrief, 1967) and was later officially released by the Georgia AES, Tifton, and Crops Research Division, U.S. Department of Agriculture in April, 1965 (Anderson and Sharp, 1995; Hanna and Elsner, 1999; Moncrief, 1967). 'Tifdwarf' is a dwarf type with small, short leaves, stems, internodes, and seedheads and provides a dark green colour throughout the warmer months. However, when temperatures drop 'Tifdwarf' takes on a purplish cast that is aesthetically objectionable to some. Such discolouration is a result of anthocyanin pigmentation.

'Tifdwarf' was mistakenly identified as 'Tiffany Grass' by bowling greenkeepers in northern New South Wales, but their Queensland counterparts were

quick to recognise its unique growth habits and limited seed head production (Beehag, 2006). Ocean Shores Golf Club, Ocean Shores, New South Wales was an early residential golf course in Australia and Beehag (2006) suggests the golf club can lay claim to having the oldest 'Tifdwarf' golf greens in Australia planted from 1970 (Beehag, 2009a). The material imported by greenkeeper Cliff McCreddith (McMaugh, 2009) was provided to Vic Phelps in 1968 to establish a nursery at his home for use at the then development of Wendell West, which is now called Ocean Shores golf course; Vic at the time was the greenkeeper at the Byron Bay Golf Club, Byron Bay, New South Wales (Beehag, 2009a). Broadwater Bowling Club, New South Wales first planted the hybrid 'Tifdwarf' on a full sized bowling green in 1973 using the same source of material as Ocean Shores (Beehag, 2009a). Roy Hulbert (who at the time was the greenkeeper at Bangalow Bowling Club, Bangalow, NSW assisted Ron Mathews (greenkeeper at Byron Bay Bowling Club) to plant 'Tifdwarf' into the worn corner of the number one green which was then bentgrass (*Agrostis* spp.) of the Byron Bay Bowling Club in May 1969. The latter green was re-grassed completely to 'Tifdwarf' on 13 September 1973 using material from the same source as was Broadwater Bowling Club (Beehag, 2009a). The green was in play on 21 November 1973 (Beehag, 2009b). Broadwater Bowling Club was the first full-sized green to be planted on the New South Wales North coast in April/May 1973 which had been planted by Rex Gulding before the Byron Bay Bowling Club, but was not in-play until after the latter club (Beehag, 2009b).

Commercial 'Tifdwarf' planting material in the early days came from Banora Lawn Turf, Banora Point, New South Wales which was operated by Ray Jarred, Roy Hulbert's brother-in-law (Beehag, 2009b).

Pennant Hills Golf Club, Sydney, New South Wales planted a practice putting green (which has now been removed) as early as 1975 (Beehag, 2006). Vegetative material to source planting stock for this green was allegedly brought into Sydney ex Tifton, USA in May 1966 through the mail (Beehag, 2009b).

'Tifdwarf' was used on a 9-hole Darwin golf course in 1978; In South Australia, 'Tifdwarf' was first planted at the Holdfast Bowling Club in 1975 (Beehag, 2009b).

'Tifdwarf' was used in far north Queensland from the late 1960s at Edmonton Bowling Club, Edmonton and has been the source of the cultivar in this region (information ex Rod Cade); it was also planted at the Gold Coast Ladies Bowling Club, the first on the Gold Coast to use the hybrid couchgrass in the early 1970s (Beehag, 2009a). In Brisbane, an early club that had changed to 'Tifdwarf' was Salisbury Bowling Club, Salisbury, Queensland (information ex Les Rowan) (Beehag, 2009b).

Foundation plant material of 'Tifdwarf' is maintained by the Georgia Coastal Plain Experiment Station, Tifton, Georgia. Mr Ray Jensen of Tifton, Georgia claimed in 1993 that he had the only true supply of 'Tifdwarf' which he maintained as uncut plant material to prevent it from mutating; Mr Jensen believed that if the highly unstable 'Tifdwarf' plant was cut short in the field it had a greater chance of producing new forms [off-types] than that by irradiation, or hybridisation, in the laboratories (Burton, 1993).

TifEagle

'TifEagle' is a fine-textured cultivar suited for golf and bowling greens and other applications requiring regular close mowing. The "off-type" (Mutant No. 2) was selected from 48 such mutant plants (Hanna, 1998) in 1990 from a plot established from dormant stolons of the 'Tifway II' cultivar (*C. dactylon* x *C. transvaalensis*) previously treated with gamma radiation on 12 January 1988 (Hanna and Elsner, 1999). 'TifEagle' is a dense, fine-textured triploid ($2n = 27$) (Hanna, 1999; Hanna, ; Loch and Hanna, 2001) that produces more shoots per unit area that are shorter with narrower leaves, better turf quality and colour and greater resistance to the tawny mole cricket (*Scapteriscus Vicinus*) than 'Tifdwarf' (Hanna, 1999). Test plantings on experimental plots and putting greens since 1991 indicate that 'TifEagle' can withstand routine cutting height of 3.0 mm and due to its canopy, can ensure a golfer's ball rolls quickly in the direction it was putted (Hanna, 1998). 'TifEagle' was cooperatively released by United States Department of Agriculture – Agricultural Research Services (USDA-ARS) and the University of Georgia Coastal Plain Experiment Station in Aug. 1997 (Miller and Edenfield, 2002). 'TifEagle' was first sold in the USA in May 1999 (Loch and Hanna, 2001) and foundation material is maintained by the USDA-ARS, Coastal Plain Experiment Station, Tifton, Georgia.

Material of 'TifEagle' arrived in Australia and was planted at DEEDI Redlands Research Station, Queensland in their turf demonstration plots on 13 Feb. 2001. The greens quality 'TifEagle' is handled by the Australian sole licensee Twin View Turf Pty Ltd, Wamuran, Queensland and was first sold to the North Lakes Golf Club, Mango Hill, Queensland, Australia to establish their 18 hole golf course which opened in 2002.

Tifgreen (Tifton 328)

During 1946, W. G. Thomas, Chairman of the Green Committee, and Walter Harkey, Superintendent of the Charlotte Country Club, N. C., observed a fine-textured bermudagrass growing in their No. 4 green (Robinson and Latham, 1956). The selection was collected and planted in the turf plots at Tifton, Georgia, for further observation. In the spring of 1951 (Robinson and Latham, 1956), the common, fine-textured, superior Charlotte Country Club, North Carolina strain (*C. dactylon*) was hybridised with a fine-leaved South African bermudagrass (*C. transvaalensis*) [Hanson (1959) says it was from East Lakes Golf Course, Atlanta, Georgia; while Hanna and Anderson (2008) says it was from Egypt]. The result was a completely sterile F₁ hybrid [triploid ($2n = 27$) (Anderson and Sharp, 1995; Hein, 1961)] tested as Tifton 328 and later registered as 'Tifgreen'.

'Tifgreen' was developed and released by the Georgia AES, Tifton, and Crops Research Division, ARS, USDA, in 1965 (Anderson and Sharp, 1995; Hein, 1961). Twelve years after release Hanna and Anderson (2008) reported that more than 8,000 greens had been converted to 'Tifgreen' in the US.

Vegetative material of 'Tifgreen' was first reported to be introduced into Australia in 1956 by Doug Corbett, former teacher of greenkeeping at the Ryde School of Horticulture, New South Wales (McMaugh, 2008). However the cultivar suffered its ill-fated demise following mishandling and poor labeling similar to that of the introduction of 'Tiffine' into Australia. A undisclosed golf course architect informed Gary Beehag (2009b) many years ago that he had brought vegetative

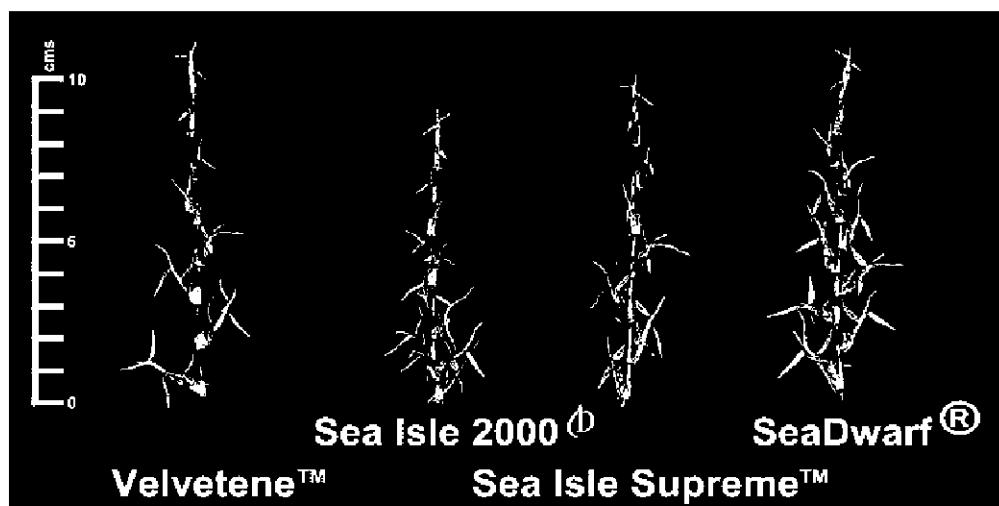
material of 'Tifgreen' from Hawaii into Sydney in 1969; some of this material was then used as planting material at the Pennant Hills Golf Club, Sydney in the practice green (which has since been removed) (Beehag, 2009b).

Material of 'Tifgreen' was planted at the Gold Coast Burleigh Golf Club, Burleigh Heads, Queensland in 1974 (Beehag, 2009a), replacing the endemic species Queensland blue couch (*Digitaria didactyla*) as was used on up to 50% of the golf putting greens at the time (Beehag, 2006). One year later 'Tifgreen' had become widely used on putting greens on the Gold Coast and in Brisbane (Beehag, 1992).

Foundation or breeder material of 'Tifgreen' is maintained at the Georgia Coastal Plain Experiment Station, USA. Suitable material can also be obtained from turf growers, golf and or bowls club (e.g. following dethatching) within Australia.

Paspalum vaginatum (seashore paspalum) cultivars

Plate 2. Stolon comparison of (left to right) Velvetene™, 'Sea Isle 2000', Sea Isle Supreme™, and SeaDwarf®



Sea Isle 2000

'Sea Isle 2000' is a putative mutant derived from the *Paspalum vaginatum* cultivar Adalayd®. 'Sea Isle 2000' was originally selected by Dr Ronny R. Duncan, University of Georgia, Griffin, GA, USA in July 1993 as one of 16 variants from darker green patches in a Adalayd® green planted 12 years earlier at Alden Pines Golf Course, Bokeelia, Florida, USA (Loch and Roche, 2003c). The selected mutant was chosen from the initial collection because of its fine-texture having smaller leaves and shorter internodes than the parental variety Adalayd®, which is an intermediate-textured variety. Subsequent selection criteria included being able to mow the turfgrass to greens height, its dark green colour, and high tolerance of salinity (Loch and Roche, 2003c).

Vegetative material of 'Sea Isle 2000' was introduced into Australia and released from quarantine in October 2001 into the hands of DEEDI staff at Redlands. Soon after vegetative material was asexually propagated to have on hand approximately 100m² of certified material to supply foundation material to

Jimboomba Turf Group Pty Ltd, Jimboomba, Queensland. Jimboomba Turf Group Pty Ltd was the producer licensed by the University of Georgia to grow this cultivar in Australia. Foundation material located at Redlands was also used back in 2002 to supply plugs (several hundred thousand) for golf course planting overseas because the cultivar at the time was in extremely short supply around the world. The original foundation material sent to Australia is still being grown and maintained at DEEDI Redlands.

Sea Isle Supreme™ (SI98)

‘SI98’ which is trademarked as Sea Isle Supreme™ was selected from a worldwide collection of 300 accessions of seashore paspalum collected by Dr Ronny R. Duncan, University of Georgia, Griffin, GA, USA (Roche and Loch, 2008a). Selections by Ron Duncan were made primarily from seashore paspalum plantings on golf courses as variants in growth habit, leaf texture, and level of salt tolerance, having potential for improved turf type selections (Roche and Loch, 2008a). Sea Isle Supreme™ was collected as a finer textured genotype with a denser, more prostrate growth habit than the surrounding wild ecotype. The original samples were vegetatively propagated and evaluated first in the greenhouse at Griffin, GA, USA, and later expanded to field evaluations at Griffin under mowing heights ranging from 4.8 mm to 50 mm. ‘SI98’ was included in the USA National Turf Evaluation Program (NTEP) Bermuda Grass trial at Griffin established during 2002 and evaluated for turf quality and related characteristics during 2002-2004. Sea Isle Supreme™ was established and evaluated on the Griffin greens and fairway plots during 2002-2004, and was included in replicated seashore paspalum turf evaluations established at Jay, FL, USA in 2003 and in Griffin and Tifton, GA in 2004. The selection was also evaluated for suitability as a greens grass on two premier golf clubs in Florida and South Carolina for one year in 2006-2007.

Vegetative material of Sea Isle Supreme™ was released from quarantine and planted at DEEDI Redlands in January 2005. As a result of the studies conducted above, vegetative material was asexually propagated to supply material for the (TU05001) warm-season greens grass project. Approximately 300m² of Sea Isle Supreme™ was propagated and currently resides at DEEDI Redlands. At the time of publication no turf producer within Australia has been appointed with a license to commercially grow or supply the cultivar. Discussions are still being held between DEEDI staff and the University of Georgia in relation to this matter.

Velvetene™ (TWA02)

‘TWA02’ which is trademarked as Velvetene™ is a result of a mutant plant (or perhaps a chance seedling) with superior turf qualities found growing among Saltene™ in Turf Farms, Western Australia by K. Craig Flugge, Turf Farms (WA), Wanneroo, WA (Loch and Roche, 2003b). The cultivar is a fine-textured variety with smaller leaves and shorter internodes than Saltene™ which is an intermediate-textured variety. Subsequent selection criteria included having a high turf quality and density, finer stems and dark green colour (Loch and Roche, 2003b).

Velvetene™ like that of the other seashore paspalum cultivars trialled can be used “wall-to-wall” or for plantings which require the turf to be maintained at a higher cut.

SeaDwarf® (SDX-1)

'SDX-1' which is trademarked as SeaDwarf® was discovered as a chance seedling in an old green of Adalayd® seashore paspalum (US Plant Patent 3939) surrounded by an undefined local ecotype of the same species (Roche and Loch, 2008b). SeaDwarf® was finer textured and had a denser, more prostrate growth habit than its putative parents, which are Adalayd® (maternal) and an undefined parental genotype growing among the surrounding local ecotype (Roche and Loch, 2008b). SeaDwarf® was compared with other promising seedlings discovered similarly at the same time, and was selected on the basis of its dwarf growth habit, tolerance of low cutting height, turf density, fine-textured growth, and apparent salt tolerance under field conditions (Roche and Loch, 2008b).

Vegetative material of SeaDwarf® was introduced into Australia and released from quarantine in December 2005 into the hands of DEEDI staff at Redlands for trial and observational work. Foundation material was propagated and approximately 400m² was on hand by mid July 2007. Following negotiations between Orara Turf Pty Ltd, Coffs Harbour, New South Wales and Environmental Turf, Florida, USA, the 400m² of foundation material which had been grown on at Redlands was supplied to Orara Turf Pty Ltd for subsequent growing on and further multiplication in early January 2009.

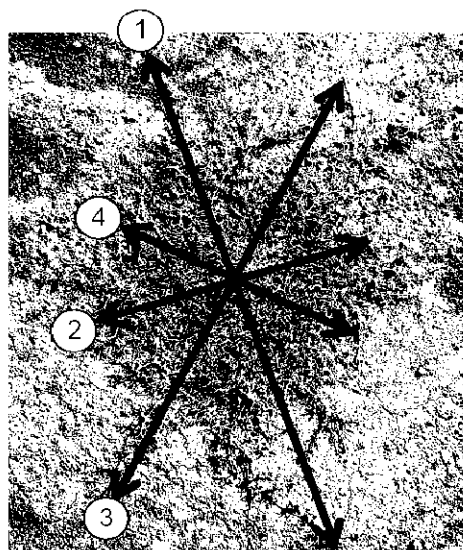
TURFGRASS MORPHOLOGY AND DEVELOPMENT

Various morphological and developmental parameters have been measured on a number of *Cynodon* hybrid and seashore paspalum cultivars in a series of Plant Breeder's Rights trials undertaken at Redlands Research Station between mid-2002 and late 2008. Two morphological attributes which are influential to the growth, development, management and playability of the two taxa include (i) lateral spread and (ii) branching.

LATERAL SPREAD

Diameter of spread measurements were conducted on the *Cynodon* hybrids between the following dates: 7 Jun. and 19 Sep. 2002; 4 Mar. and 21 Aug. 2003; 25 Aug. and 21 Nov. 2003; 15 Apr. and 2 Nov. 2004; 13 Feb. and 18 Jul. 2006 and for the *Paspalum* cultivars: 7 Jun. and 4 Dec. 2002 (data not shown); 27 Apr. and 26 Sep. 2006. Depending on the conditions of each trial, there were 30 plants (6 blocks each with 5 plants) or 15 plants (3 blocks) per cultivar. Successive lateral spread measurements (4 measurements per plant) were taken per plant using a tape measure. For each plant, mean diameter was determined by averaging the following four measurements (i) the widest diameter of spread taken from stolon tip to stolon tip across the centre of the plant (0° to 180°), (ii) the diameter at right angles to the first measurement (90 to 270°), and (iii) two intermediate measurements (45° to 225°, 135° to 315°) between the first two defining measurements (Plate 3) (Roche and Loch, 2005).

Plate 3. Four lateral spread measurements are taken per plant with the average of these four measurements representing the mean diameter of spread.



Five lateral spread experiments were carried out between 2002 and 2006 to evaluate the morphological and developmental attributes of the *Cynodon* hybrid cultivars ‘Tifgreen’, ‘Tifdwarf’, ‘Champion Dwarf’, FloraDwarf™, ‘MS-Supreme’, ‘TifEagle’, Novotek™ and MiniVerde™ (Figures 1 to 5).

There is significant difference in lateral spread between the interspecific *Cynodon* hybrid grouping and seashore paspalum grouping. At comparable times (autumn to spring) the seashore paspalum is 56 % faster than the *Cynodon* hybrids spreading 8.1 mm/day versus 4.5 mm/day on average. This is a considerable difference and is one reason why seashore paspalum cultivars need to be managed more intensively than the majority of the *Cynodon* cultivars because of the accelerated growth.

Of the *Cynodon* hybrids ‘Tifgreen’ ranked consistently as the fastest spreading cultivar. An exception to this was when under warmer spring conditions (Figure 3) Novotek™ which was selected from a tropical environment (North Qld.) spread significantly faster than all the other cultivars, except ‘Tifgreen’. ‘MS-Supreme’ was a consistent performer often ranking second to the other cultivars tested. Differences in diameter of spread among ‘TifEagle’, ‘Champion Dwarf’, FloraDwarf™ and ‘Tifdwarf’ were not significant, although ‘Tifdwarf’ and FloraDwarf™ ranked consistently as the slowest growing cultivars when measured during the same experiment.

Details of one *Paspalum* experiment is shown following a trial carried out in 2006 to assess the candidate varieties SeaDwarf™ and Sea Isle Supreme™ for the purposes of Plant Breeder’s Rights (Figure 6). Lateral spread measurements conducted over the 152 day trial indicated there was no significant difference between the four cultivars trialled, however SeaDwarf™ was marginally slower when measurements were taken at each testing date.

Figure 1. Diameter of lateral spread (cm) data for *Cynodon* hybrids recorded from 7 June to 19 September 2002 (104 days post planting).

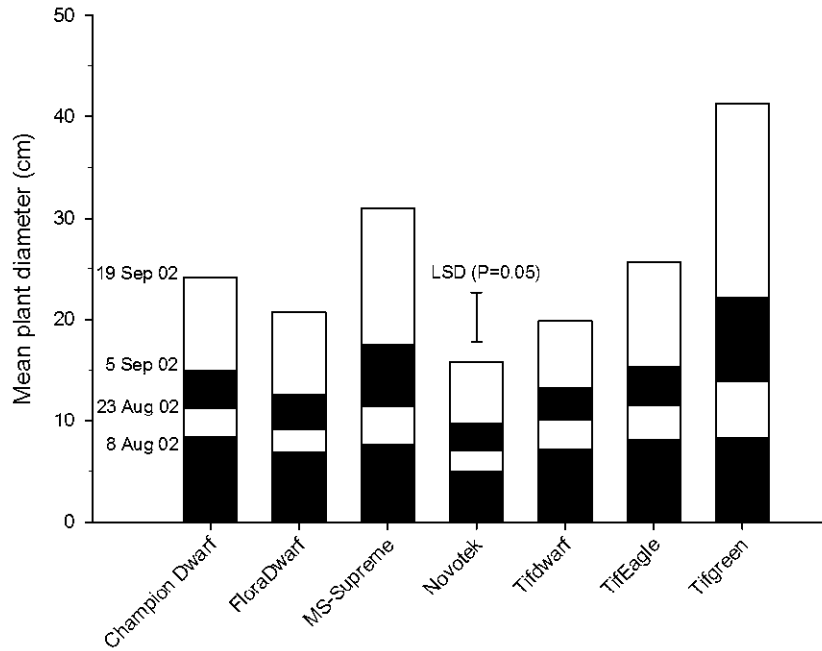


Figure 2. Diameter of lateral spread (cm) data for *Cynodon* hybrids recorded from 4 March to 21 August 2003 (170 days post planting).

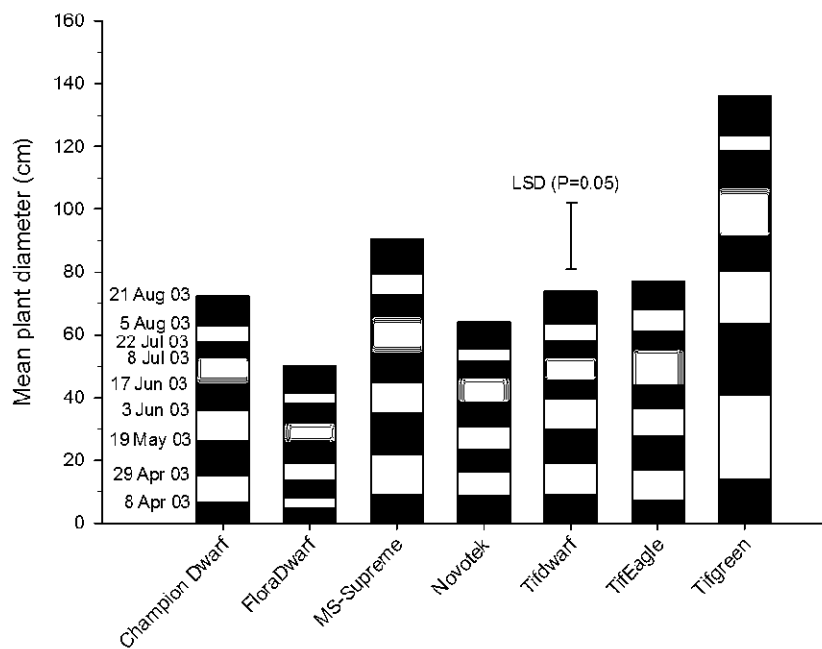


Figure 3. Diameter of lateral spread (cm) data for *Cynodon* hybrids recorded from 25 August to 21 November 2003 (88 days post planting).

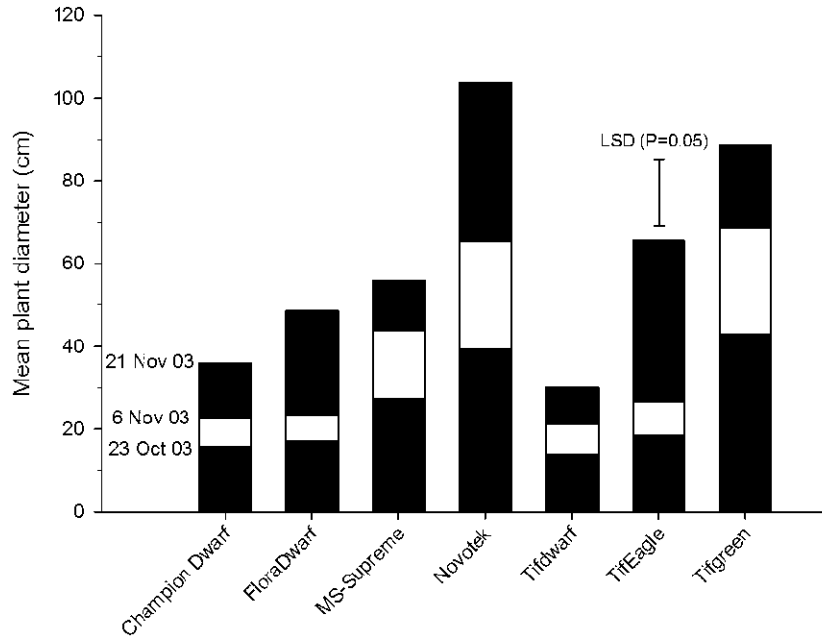


Figure 4. Diameter of lateral spread (cm) data for *Cynodon* hybrids recorded from 15 April to 2 November 2004 (201 days post planting).

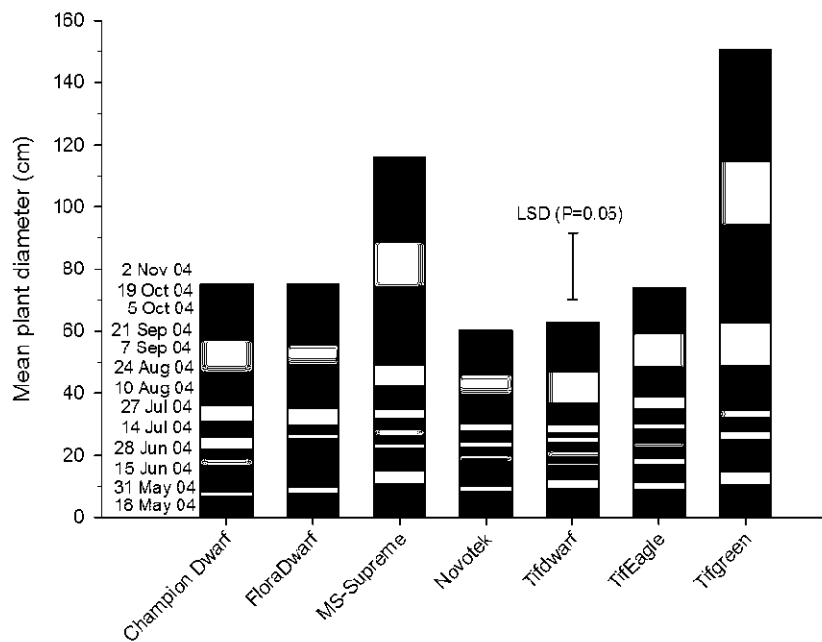


Figure 5. Diameter of lateral spread (cm) data for *Cynodon* hybrids recorded from 13 February to 18 July 2006 (155 days post planting).

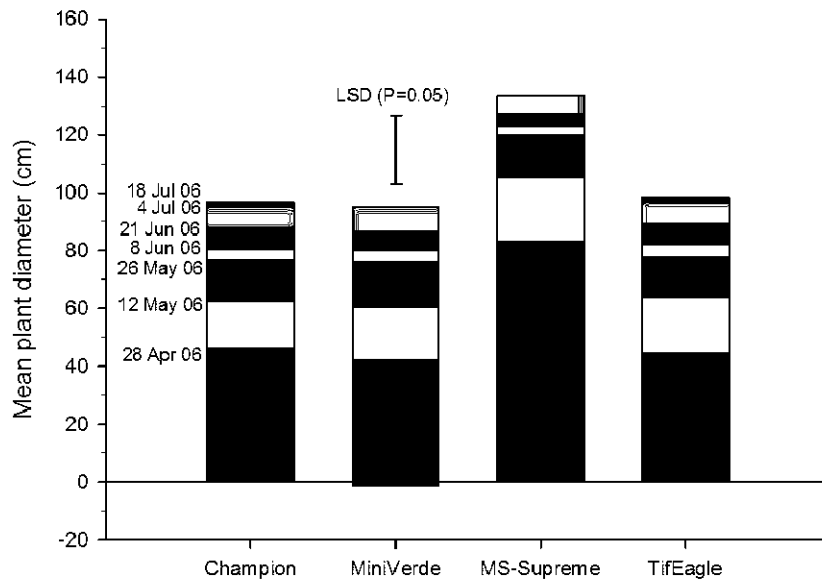
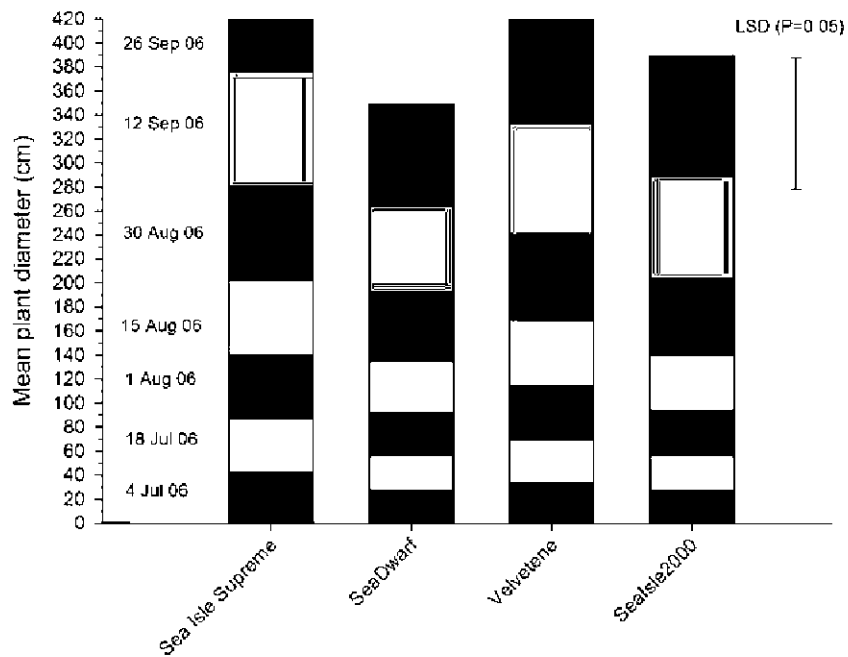


Figure 6. Diameter of lateral spread (cm) data for seashore paspalum cultivars recorded from 27 April to 26 September 2006 (152 days post planting).



BRANCHING

Branching (i.e., the number of branches present at a vegetative node) has been measured for both *Cynodon* hybrid and seashore paspalum cultivars tested since 2002. Four experiments where branching was measured on the cultivars that were trialled in this study are shown in Figures 7 to 9. Branching is an important attribute, encouraging faster development of a strong sward facilitating faster recovery from scaring and following removal of turf through divoting or scarification.

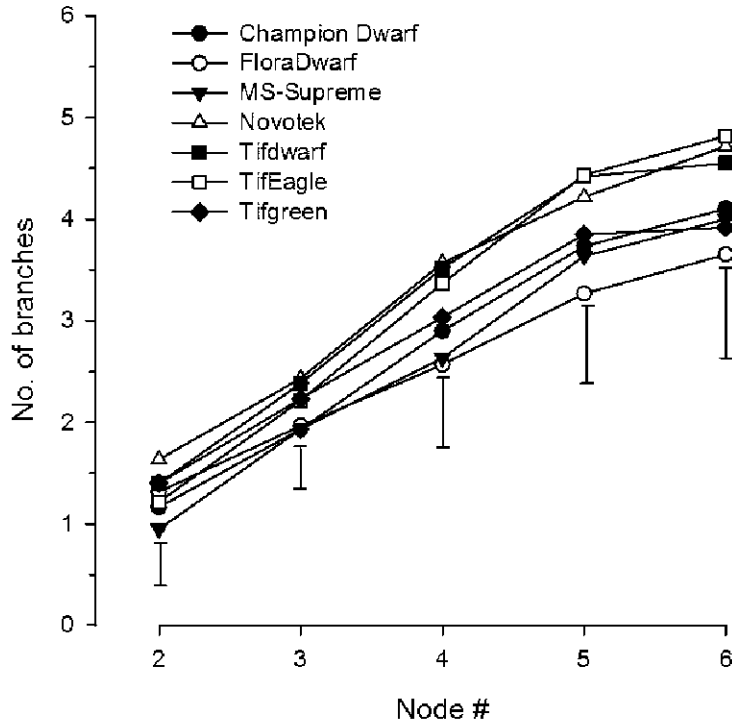
Cynodon hybrids produce compound nodes with up to 3 leaves each subtending a compressed simple node. Each of the three compressed nodes within a visible stolon node can produce primary branches, which in turn produce secondary branches, and so on (Roche and Loch, 2005). In the experiments undertaken, as shown in Figures 7 and 8, the *Cynodon* cultivars showed a rapid increase in branch numbers from stolon node 2 to stolon nodes 6. Figure 7a shows the old industry standards ‘Tifgreen’ and ‘Tifdwarf’ plateauing between node 5 and 6. Initial thoughts were that the first generation cultivars would continue to level out, while the “ultradwarfs” would continue to rise. To test this hypothesis a further experiment was undertaken between the 9 and 15 Nov. 2004 and as Figure 7b shows this was not the case. All cultivars from node 11 onwards continue to rise, with the exception of ‘MS-Supreme’. MiniVerde™ which did not arrive at DEEDI Redlands until early 2006 was trialled against ‘Champion Dwarf’, ‘MS-Supreme’ and ‘TifEagle’ later the following year.

Results indicated that across the three experiments, Novotek™, ‘TifEagle’, and ‘Tifdwarf’ ranked as having the highest numbers of branches present at older stolon nodes, with significant differences between these cultivars and the lowest-ranked FloraDwarf™ at nodes 4 to 6 in the 2002 study (Figure 7a) and at nodes 9 to 15 in the 2004 study (Figure 7b) (with the exception of Tifdwarf at node 14). From the results obtained in the 2007 study, it would be likely that MiniVerde™ would also have a greater number of nodes compared to ‘Tifgreen’ and ‘Tifdwarf’.

Of the seashore paspalum cultivars trialled in 2006 there were significant differences between the number of branches present at nodes 2 and 6 with Velvetene™ producing a higher number of branches. Interestingly, between nodes 3 and 5, each of the four cultivars produced approximately 1 branch.

Figure 7. Branching at visible nodes 2 to 6 recorded between 29 October to 15 November 2002 (a) and nodes 2 to 15 recorded between 9 to 15 November 2004 (b) on developing stolons of *Cynodon* hybrid cultivars, with LSDs ($P=0.05$) shown as vertical bars.

(a)



(b)

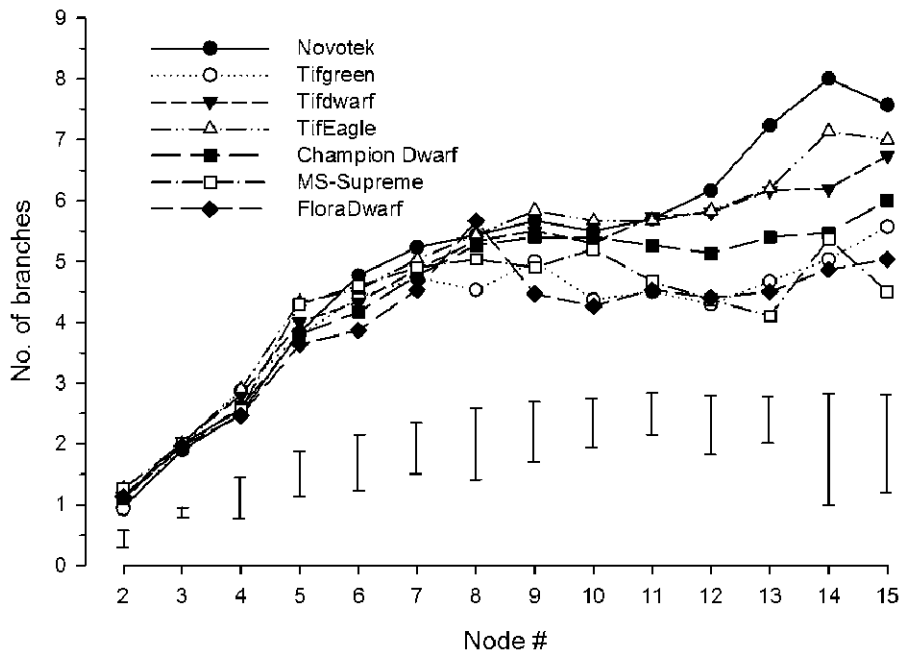


Figure 8. Branching at visible nodes 2 to 6 recorded between 4 to 7 December 2007 on developing stolons of *Cynodon* hybrid cultivars, with LSDs (P=0.05) shown as vertical bars.

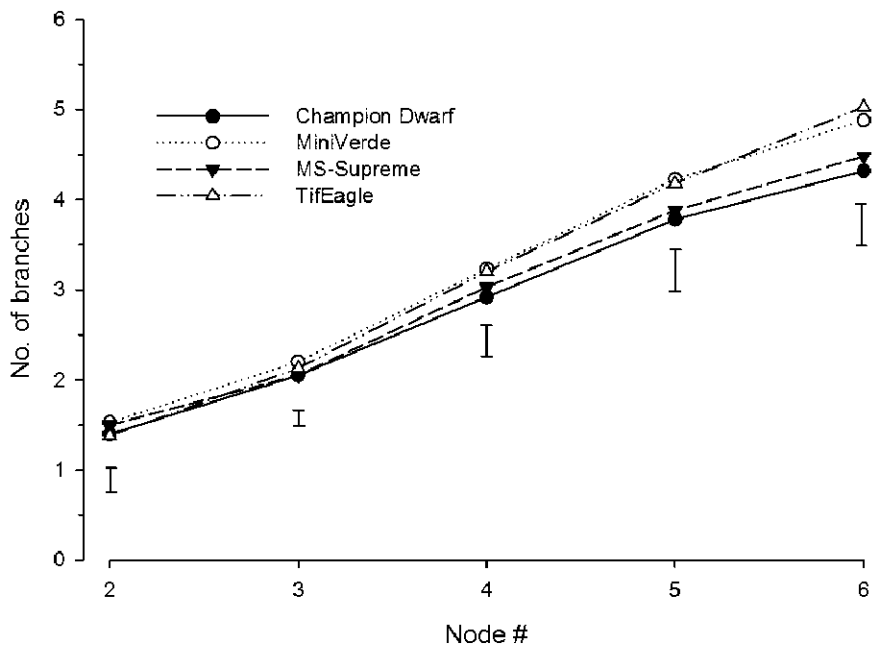
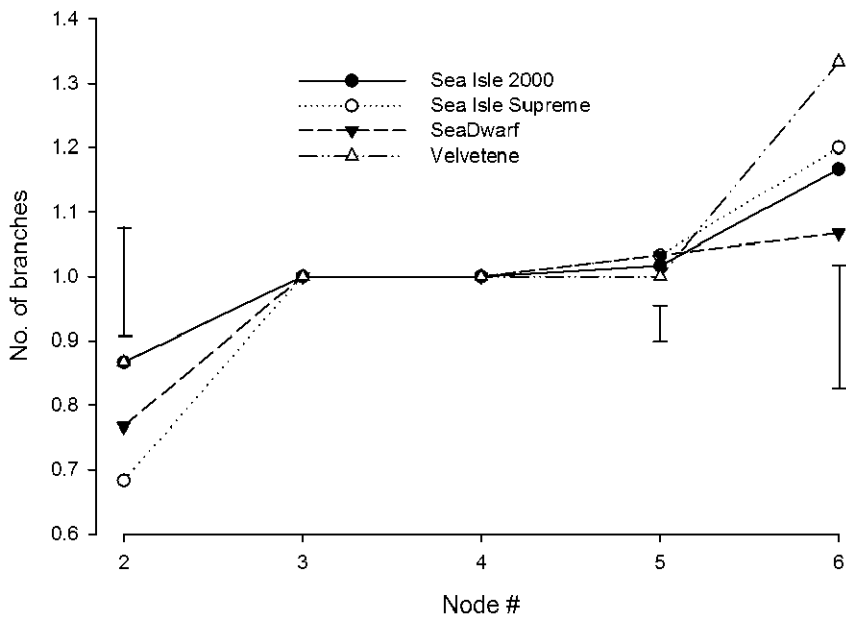


Figure 9. Branching at visible nodes 2 to 6 recorded between 11 to 18 September 2006 on developing stolons of seashore paspalum cultivars, with LSDs (P=0.05) shown as vertical bars.



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CHAPTER 3

CLIMATIC CONDITIONS EXPERIENCED AT TRIAL SITES

INTRODUCTION

The major limiting factor on warm-season C4 grass growth is temperature. Maintaining both suitable air and ground temperatures are important for plant growth given that both the *Cynodon* hybrids and seashore paspalums (Duncan and Carrow, 2000; Morton, 1973; Webster, 1987) spread by stolons and rhizomes.

Differences in freezing tolerance among a number of vegetative and seeded *Cynodon* spp. cultivars have been determined by Anderson et al. (2002) and Anderson and Taliaferro (2002). Such information assists turf managers and or homeowners to choose a suitable cultivar for a cool-season growing environment. An unfavourable characteristic of growing couchgrass in a cool-season environment (several degrees above freezing) the turfgrass discolours and becomes dormant. Youngner (1959) explained that couchgrass development is associated with an interaction of low temperature and high light intensity. This interaction appears to create a situation within the grass blades where the rate of chlorophyll degradation exceeds the rate of chlorophyll synthesis producing the typical winter discolouration of couchgrass (Youngner, 1959). With seashore paspalum, the scaling back on irrigation during the autumn months will force the paspalum rhizomes deeper and improve its winter hardiness; but in warmer environments like that of Queensland, maintaining field capacity during the winter months will minimise cold temperature injury (Duncan and Carrow, 2000). In the past, dormancy would have been a significant turn off for consumers in predominantly C3 cool-season growing areas (e.g. Melbourne, Sydney). However, given the more recent effects of El Niño, and an emphasis on water preservation, the drought hardiness of *Cynodon* has seen clubs weigh up their options and search for a sustainable alternative, even if at times a dormant turf surface is unavoidable.

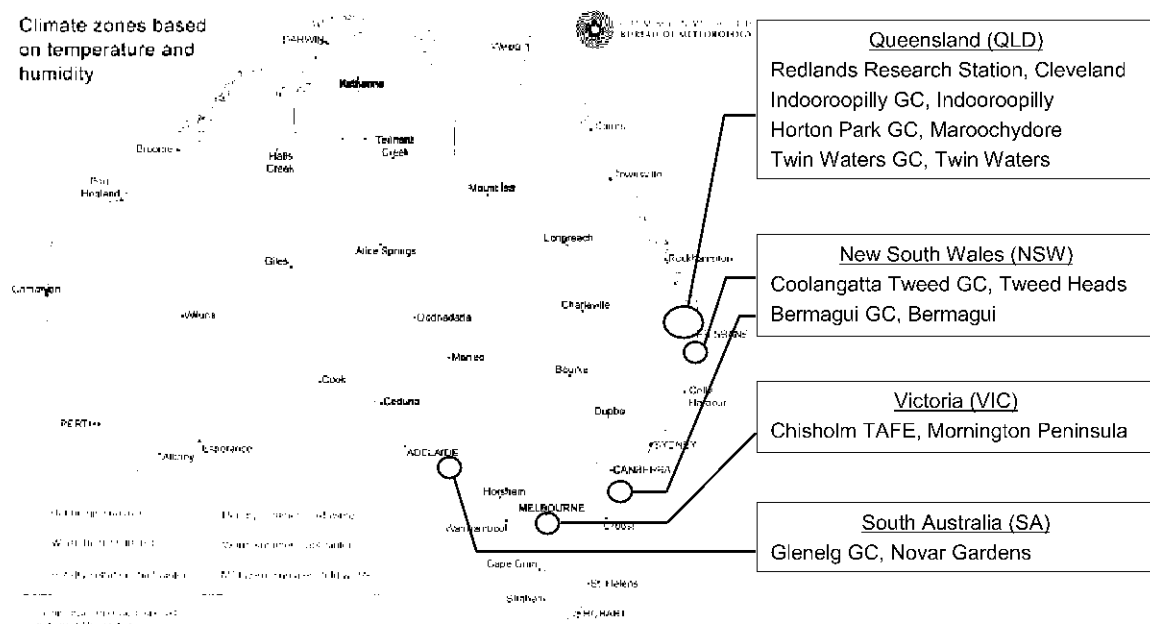
While freezing tolerance is an important factor, so too is the threshold temperature for active growth. Sherman (1994) classified turfgrass species with growth optimums at soil temperatures of 27 - 35°C as warm-season turfgrasses. This range was very much different from the temperatures listed for active growth of turfgrass in general literature; Carrow et al. (2001) and McCarty and Miller (2002) refer to 13°C minimum air temperature and between 10 - 15°C soil temperature. In a controlled experiment undertaken by Stanford et al. (2005) over a 3 to 4 day period the authors concluded that one may expect faster coverage from newly planted 'Tifdwarf' sprigs and faster recovery from disruptive cultural activities when the daytime temperatures are 27°C or less as compared with daytime temperatures at 30°C or above.

Earlier work by Roche and Loch (2005) showed that the critical threshold levels for active growth by first- and second-generation *Cynodon* hybrid cultivars occurs at air temperatures of about 9 - 10°C or at soil temperatures (10 cm below ground) of 15 - 16°C. Below these levels, very little or no growth takes place and either freezing or chilling stress can occur. At temperatures above the threshold levels,

active growth will inevitably increase, but a cut off will follow with temperatures being too extreme causing heat stress to the turf.

Depending on the geographic location where the turfgrass is to be planted, because of climatic temperatures and humidity, some environments may prove more challenging than others. Australia can be split into six climate zones: (i) hot humid summer, warm winter zone, (ii) warm humid summer, mild winter zone, (iii) hot, dry summer, warm winter zone, (iv) hot, dry zone with cool winter, (v) warm summer, cool winter (temperate zone), and a (vi) mild to warm summer, cold winter (cool temperature zone) (Figure 10) (Bureau of Meteorology, 2009h). Each particular zone, whether it be suitable for a warm- or cool-season turfgrass will inevitably affect how the turfgrass will perform. As such, a suitable turfgrass that will meet these conditions should be sought.

Figure 10. Location of the trials sites in Australia depicting the climatic zones based on temperature and humidity (Bureau of Meteorology, 2009h).



METHODOLOGY

Temperature ($^{\circ}\text{C}$) data was collected by two methods (i) using mean monthly maximum and minimum historic data collated by the Bureau of Meteorology (BOM) at sites located in close proximity to each trial site and (ii) through the use of Thermocron temperature buttons which were used only at the Redlands trial site. Rainfall figures were also made available for each of the regional trial sites and the Redlands trial site.

Mean historic temperature and rainfall data was collected from seven BOM sites for the eight trial sites located in QLD (4), NSW (2), VIC (1), and SA (1). The two trial sites, Horton Park Golf Club and Twin Waters Golf Club had their temperature data taken from the same BOM site at the Maroochydore Aerodrome site (#40861) (Bureau of Meteorology, 2009a) due to their close proximity to each other

and that no alternate BOM sites were nearby. Available BOM temperature and rainfall data was on hand from 1994 to 2009. For the Glenelg Golf Club, temperature and rainfall data was acquired from the BOM Adelaide Airport site (#23034) (Bureau of Meteorology, 2009b) which held records between 1955 and 2009. Temperature data for the Chisholm TAFE trial site was acquired from the BOM Mornington site (#86079) (Bureau of Meteorology, 2009c) which held records between 1919 and 1975, whereas the rainfall data was on hand from 1868 to 2009. Data for the Bermagui Golf Club was acquired from the BOM Narooma Royal Volunteer Coastal Patrol (RVCP) site (#69022) (Bureau of Meteorology, 2009d) which held rainfall data as far back as 1910 and temperature data from 1965 to 2009. Coolangatta Tweed Golf Club had temperatures and rainfall data acquired from the BOM Coolangatta site (#40717) (Bureau of Meteorology, 2009e) which held data which had been collected between 1982 and 2009. The Indooroopilly Golf Club trial site had data acquired from the BOM Archerfield Airport site (#40211) (Bureau of Meteorology, 2009f) which held rainfall data since 1929 and ten years later held temperature data until 2009. The only site fortunate enough to have its own BOM weather station was that of Redlands Research Station (site # 40265) (Bureau of Meteorology, 2009g) where rainfall data dates back to 1899 and temperature data since 1953 to 2009

To calculate which climatic zone each trial site is located in the following information is required – the average January maximum temperature (°C), the average January 3 pm water vapour pressure (kPa) and the average annual heating degree days (AAHDD) (Figure 11) and the values must what is represented in Table 6. The vapour pressure (in hectopascals) is calculated from the mean 3 pm dewpoint temperature (°C) via the equation seen in Figure 12. Dewpoint temperature values were obtained from the Bureau of Meteorology web site <http://www.bom.gov.au>.

Figure 11. Average annual heating degree days (AAHDD) using the base temperature of 18°C (Bureau of Meteorology, 2010).

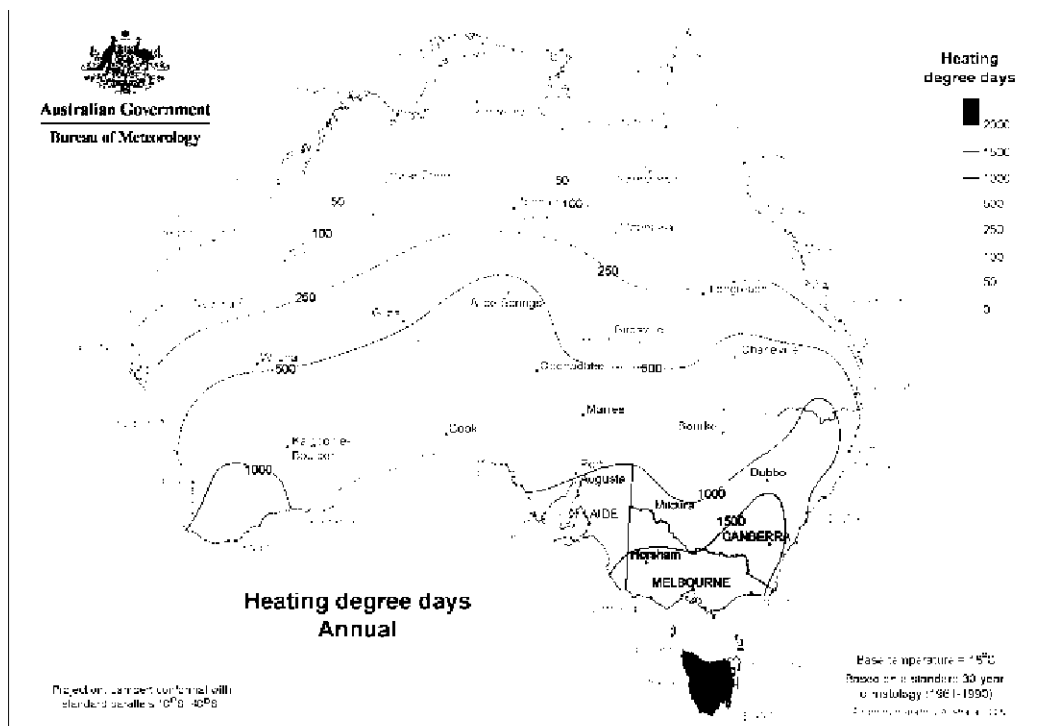


Figure 12. Vapour pressure equation (Bureau of Meteorology, 2009h).

$$\text{vapour pressure} = \exp(1.8096 + (17.269425 * \text{dewpoint}) / (237.3 + \text{dewpoint}))$$

Table 6. Temperature ranges for the month of January which is associated with Australian climatic zones (Bureau of Meteorology, 2009h).

Australian Climatic Zone	January Range (°C)	July Range (°C)	AAHDD ¹	Water Vapour Pressure (kPa)
hot humid summer, warm winter zone	≥ 30	-	-	≥ 2.1
warm humid summer, mild winter zone	≤ 30	-	-	≥ 2.1
hot, dry summer, warm winter zone	> 30	≥ 14	-	≤ 2.1
hot, dry zone with cool winter	> 30	≤ 14	-	≤ 2.1
warm summer, cool winter (temperate zone)	≤ 30	-	≤ 2000	≤ 2.1
mild to warm summer, cold winter (cool temperature zone)	≤ 30	-	≥ 2000	≤ 2.1

¹ using base temperature of 18°C

The Thermocron buttons (Plate 4) manufactured by Arrow Scientific Pty Ltd, Lane Cove, NSW, were used to log temperatures at two hour defined intervals commencing 16 Jan. 2006 to 22 Sep. 2009. The stainless steel temperature recording device which is 17.35 mm in diameter and 5.89 mm thick is capable of storing 2048 readings (a log duration of 34 hours or 362 days) at one to 255 minute intervals and is accurate to within 0.5°C (range -45° to +80°C). Two Thermocron buttons were installed in the Redlands trial site, with one positioned 1.5m above ground inside a Stevenson Screen atop a star picket and the other buried 100 mm below the soil surface on the green.

Plate 4. Thermocron temperature loggers (Arrow Scientific, 2005).



RESULTS AND DISCUSSION

Temperature is an important factor in the growth of warm-season C4 turfgrass and little can be done by the turf manager to significantly alter the temperatures in a particular environment. Different turfgrasses within the same taxa grow and perform differently in different environments making each facility unique. Information and data which was collected from each of the eight trial sites located in Queensland (4), New South Wales (2), Victoria (1) and South Australia (1) indicate that the turf performance of both the *Cynodon* hybrids and seashore paspalum cultivars was diverse due to the variation depending on the site and climatic conditions. From observation of the temperature and rainfall data obtained, either on site or from the Bureau of Meteorology this confirms that sometimes subtle, yet significant variation is present even if trial sites are located within the same state.

The Glenclg Golf Club (Table 7) experienced an annual mean maximum temperature of 21.4°C and annual mean minimum temperature of 11.4°C and is positioned within the warm humid summer, mild winter zone where the annual rainfall was the lowest recorded of the eight trial sites with 445.5 mm. The BOM site situated near Chisholm TAFE (Table 8), experienced an annual mean maximum temperature of 18.9°C and annual mean minimum temperature of 10.1°C which was the lowest recorded of the eight trial sites and is positioned within the warm humid summer, mild winter zone where the annual rainfall is 732.8 mm. The Bermagui Golf Club (Table 9) site experienced an annual mean maximum temperature of 19.9°C and annual mean minimum temperature of 11.8°C and is positioned within the warm humid summer, mild winter zone where the annual rainfall is 905.8 mm. The Coolangatta Tweed Golf Club (Table 10) experienced an annual mean maximum temperature of 24.5°C and annual mean minimum temperature of 15.9°C and is positioned within the warm humid summer, mild winter zone where it has the highest historic annual rainfall of 1463.6 mm.

Of the Queensland sites, Indooroopilly Golf Club (Table 11) had data taken from Archerfield Airport which recorded an annual mean maximum temperature of 26.1°C which was the highest recorded of the eight trial sites and annual mean minimum temperature of 14.3°C, with an annual rainfall of 1059 mm. Due to the mean January temperature exceeding 30°C at the Archerfield Airport where temperature data was referenced, the Indooroopilly site was classified in the hot, dry summer, warm winter zone. Horton Park and Twin Waters Golf Club (Table 12) which were grouped together because of their close proximity experienced an annual mean maximum temperature of 25.2°C and annual mean minimum temperature of 15.8°C and is positioned within the warm summer, cool winter climatic zone where it has the highest historic annual rainfall of 1361.6 mm. The Redlands Research Station (Table 13) site which was the only trial site to be fortunate enough to have its own BOM weather station experienced an annual mean maximum temperature of 25.1°C and annual mean minimum temperature of 14.4°C and is positioned within the warm summer, cool winter climatic zone where it has the highest historic annual rainfall of 1463.6 mm.

Following are tables which provide mean daily maximum and minimum temperature and mean rainfall data for each of the seven trial sites. Immediately following the table are graphs, which contain the same content as displayed in the tables, however they have been shown for visual reference.

Table 7. Historic climatic data relevant to Glenelg Golf Club, SA

Month	Mean daily max. temperature (°C)	Mean daily min. temperature(°C)	Mean rainfall (mm)
January	28.0	15.9	17.7
February	28.1	16.0	18.1
March	25.4	14.3	20.8
April	22.1	11.7	35.1
May	18.5	9.5	54.1
June	15.9	7.6	55.6
July	14.9	7.0	59.6
August	15.9	7.5	49.6
September	18.1	8.9	46.0
October	21.0	10.6	38.2
November	23.8	12.7	25.6
December	25.6	14.5	24.2

Table 8. Historic climatic data relevant to Chisholm TAFE, VIC

Month	Mean daily max temperature (°C)	Mean daily min. temperature(°C)	Mean rainfall (mm)
January	25.0	13.4	44.3
February	25.0	13.9	42.7
March	23.3	12.9	49.2
April	19.4	10.9	62.3
May	16.2	9.1	69.3
June	13.5	7.2	70.4
July	12.8	6.5	69.2
August	13.8	6.9	70.9
September	15.9	8.1	71.7
October	18.1	9.5	69.3
November	20.3	10.7	59.5
December	23.1	12.1	54.2

Table 9. Historic climatic data relevant to Bermagui Golf Club, NSW

Month	Mean daily max. temperature (°C)	Mean daily min. temperature(°C)	Mean rainfall (mm)
January	23.6	16.3	91.9
February	23.6	16.6	86.7
March	22.7	15.3	103.6
April	21.0	12.8	79.8
May	18.7	10.1	78.2
June	16.6	7.8	88.6
July	16.0	6.7	49.5
August	16.8	7.3	49.8
September	18.2	8.9	60.8
October	19.4	11.2	71.5
November	20.5	13.0	72.2
December	21.9	15.0	72.7

Table 10. Historic climatic data relevant to Coolangatta Tweed Golf Club, NSW

Month	Mean daily max. temperature (°C)	Mean daily min. temperature(°C)	Mean rainfall (mm)
January	28.1	20.9	140.8
February	28.1	20.8	168.1
March	27.0	19.6	175.5
April	25.2	16.9	171.3
May	23.0	14.1	149.9
June	21.0	11.3	132.7
July	20.5	10.2	74.8
August	21.3	10.6	53.1
September	23.1	13.4	41.2
October	24.3	16.0	85.0
November	25.5	17.9	137.6
December	27.0	19.7	140.7

Table 11. Historic climatic data relevant to Indooroopilly Golf Club, QLD

Month	Mean daily max. temperature (°C)	Mean daily min. temperature(°C)	Mean rainfall (mm)
January	30.3	20.2	134.4
February	29.6	20.0	151.6
March	28.7	18.2	124.1
April	26.4	15.0	80.4
May	23.9	11.9	75.7
June	21.4	9.2	67.2
July	21.1	7.4	49.7
August	22.5	8.0	36.8
September	25.1	10.9	35.8
October	27.0	14.3	77.2
November	28.2	17.0	100.8
December	29.5	19.0	125.1

Table 12. Historic climatic data relevant to Horton Park and Twin Waters Golf Clubs, QLD

Month	Mean daily max. temperature (°C)	Mean daily min. temperature(°C)	Mean rainfall (mm)
January	28.6	21.3	118.2
February	28.6	21.2	176.6
March	27.6	19.8	119.8
April	25.7	16.8	153.9
May	23.3	13.7	181.5
June	21.3	11.4	118.9
July	20.8	9.3	67.0
August	21.8	9.9	75.8
September	24.1	12.9	62.1
October	25.5	15.6	72.3
November	26.7	17.9	92.2
December	28.1	19.8	136.5

Table 13. Historic climatic data acquired from Redlands Research Station, QLD

Month	Mean daily max. temperature (°C)	Mean daily min. temperature(°C)	Mean rainfall (mm)
January	28.9	19.9	153.3
February	28.6	19.9	162.2
March	27.7	18.6	160.9
April	25.9	15.7	103.4
May	23.2	12.5	113.5
June	21.0	9.7	88.9
July	20.5	8.1	62.1
August	21.5	8.3	51.3
September	23.6	11.0	38.5
October	25.3	14.2	81.0
November	26.8	16.7	105.3
December	28.2	18.6	138.6

Figure 13. Historic climatic data relevant for Glenelg Golf Course, Novar Gardens, SA

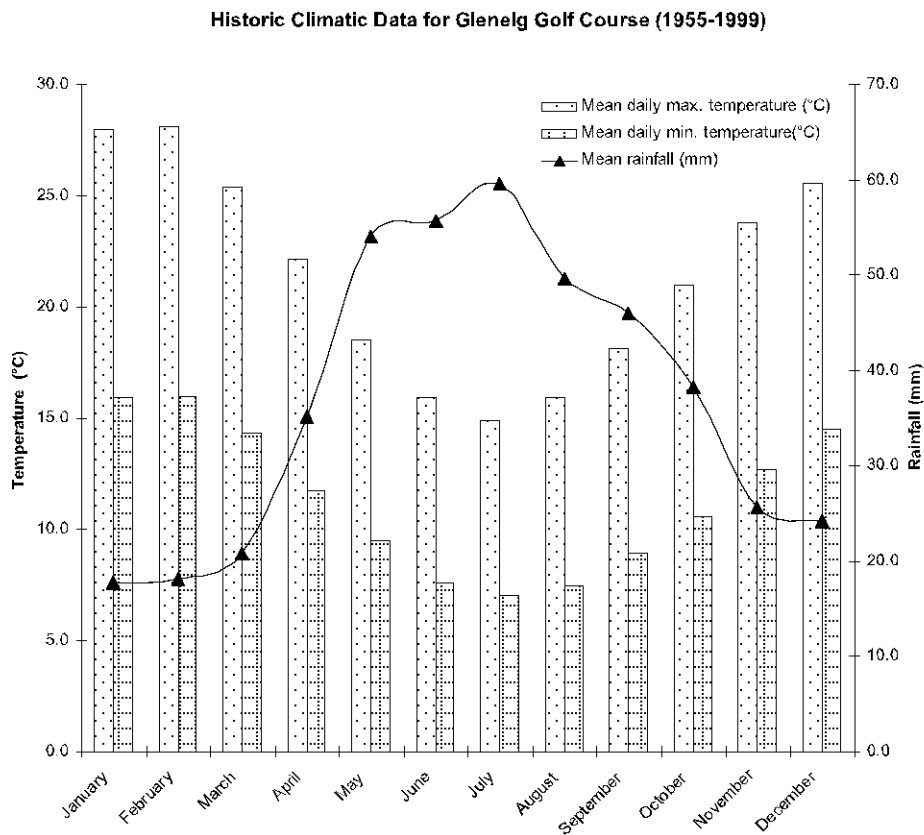


Figure 14. Historic climatic data relevant for Chisholm TAFE, Mornington Peninsula, VIC

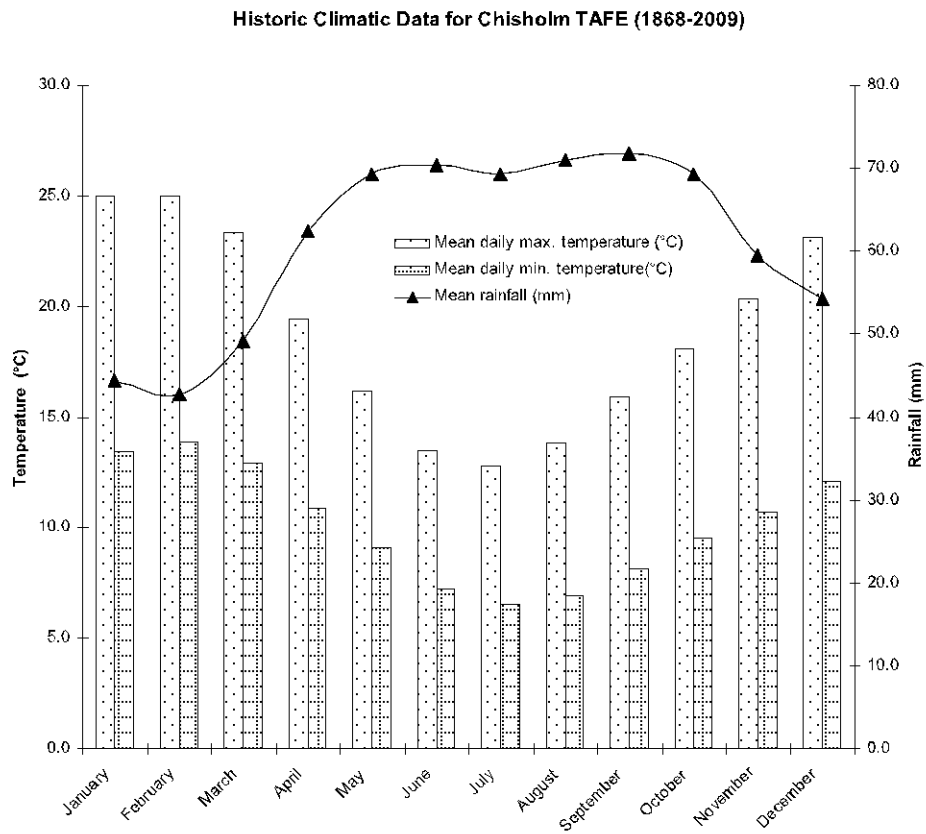


Figure 15. Historic climatic data for Bermagui Golf Club, Bermagui, NSW

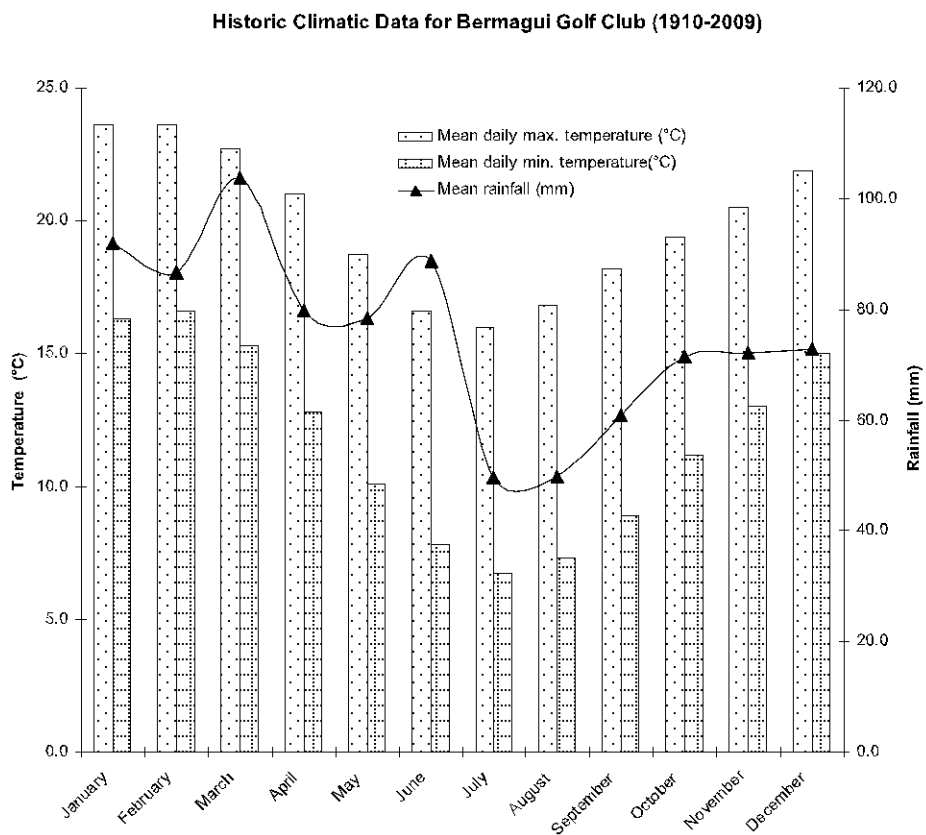


Figure 16. Historic climatic data for Coolangatta Tweed Golf Club, Tweed Heads South, NSW

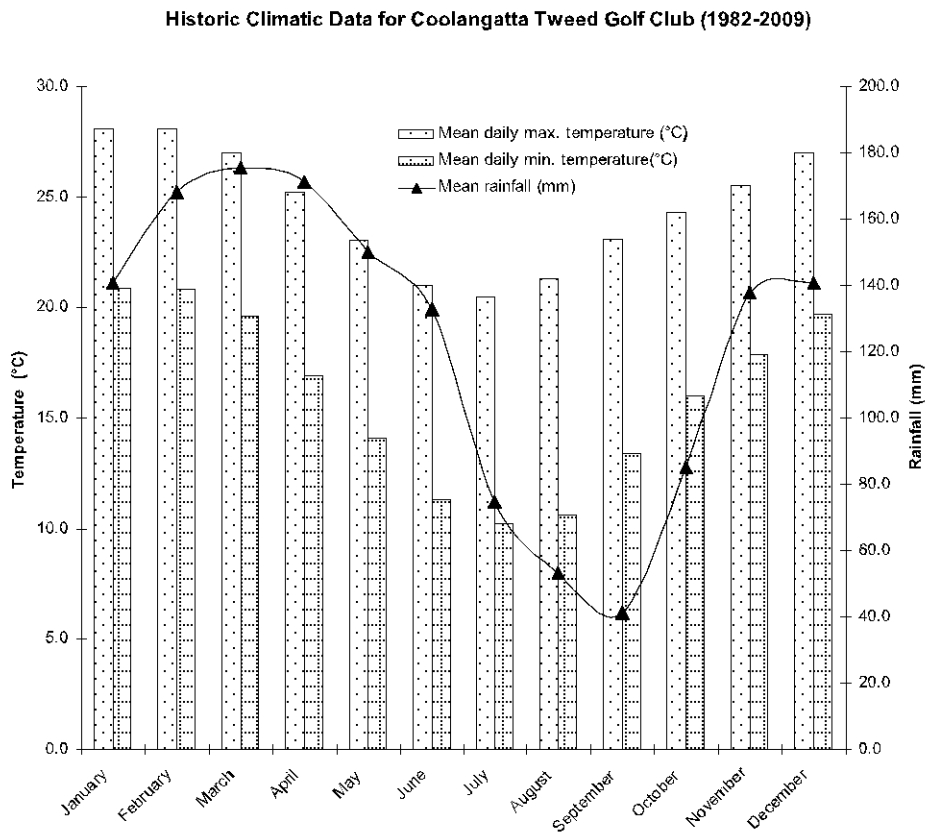


Figure 17. Historic climatic data for Indooroopilly Golf Club, Indooroopilly, QLD

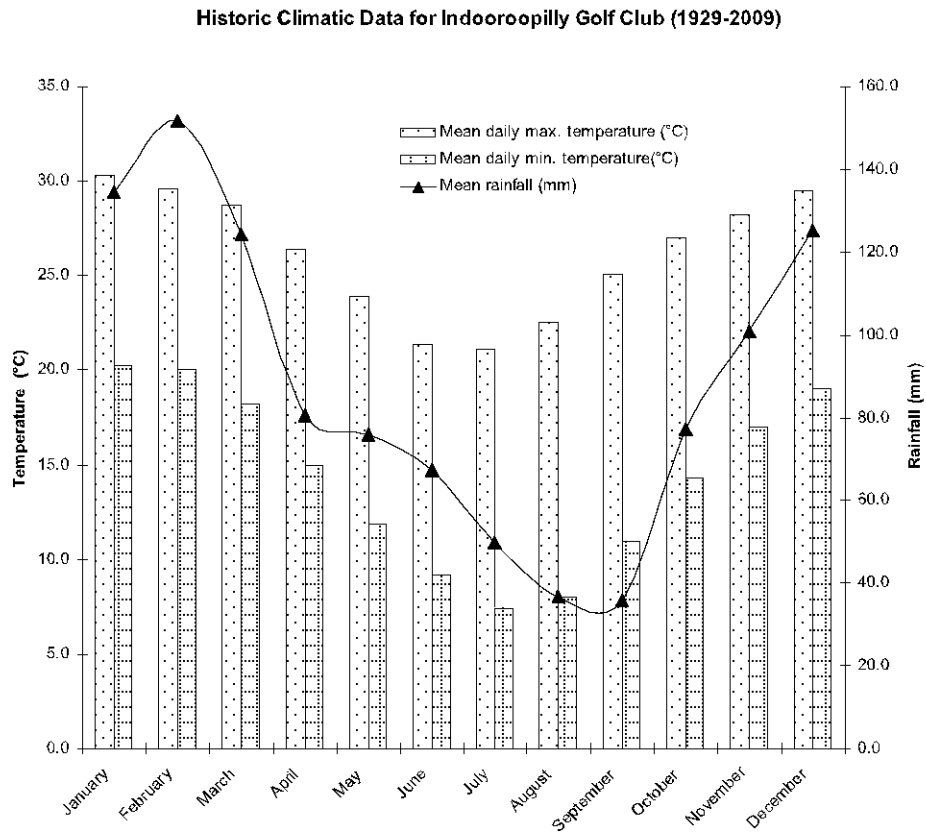


Figure 18. Historic climatic data for Horton Park Golf Club, Maroochydore and Twin Waters Golf Club, Twin Waters, QLD

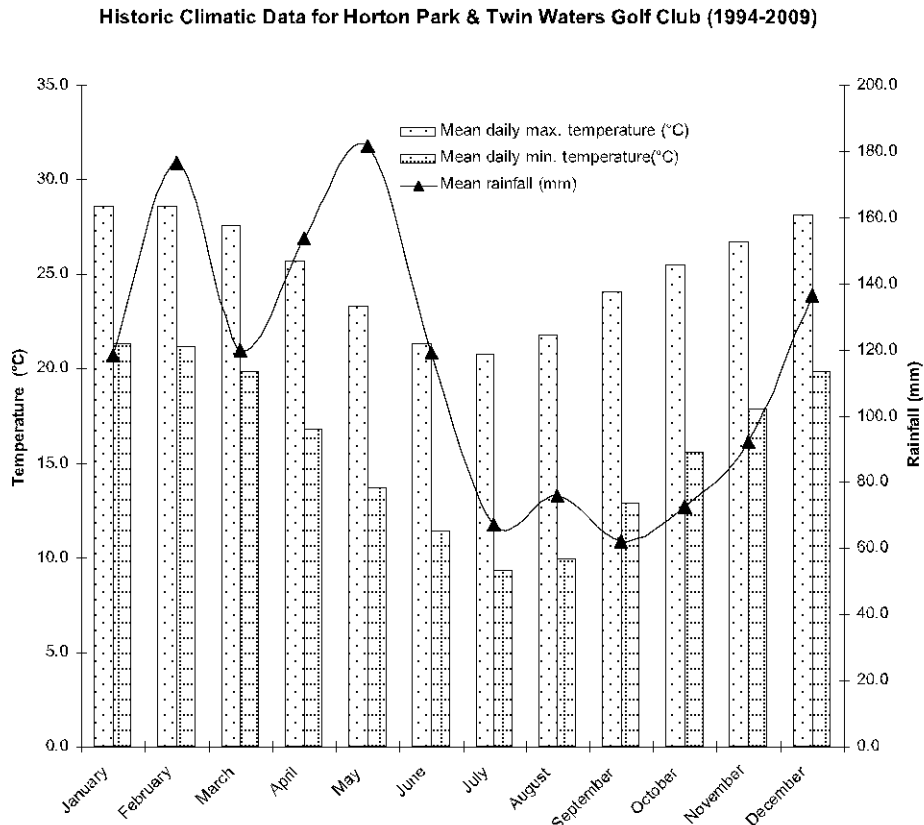


Figure 19. Historic climatic data for Redlands Research Station, Cleveland, QLD

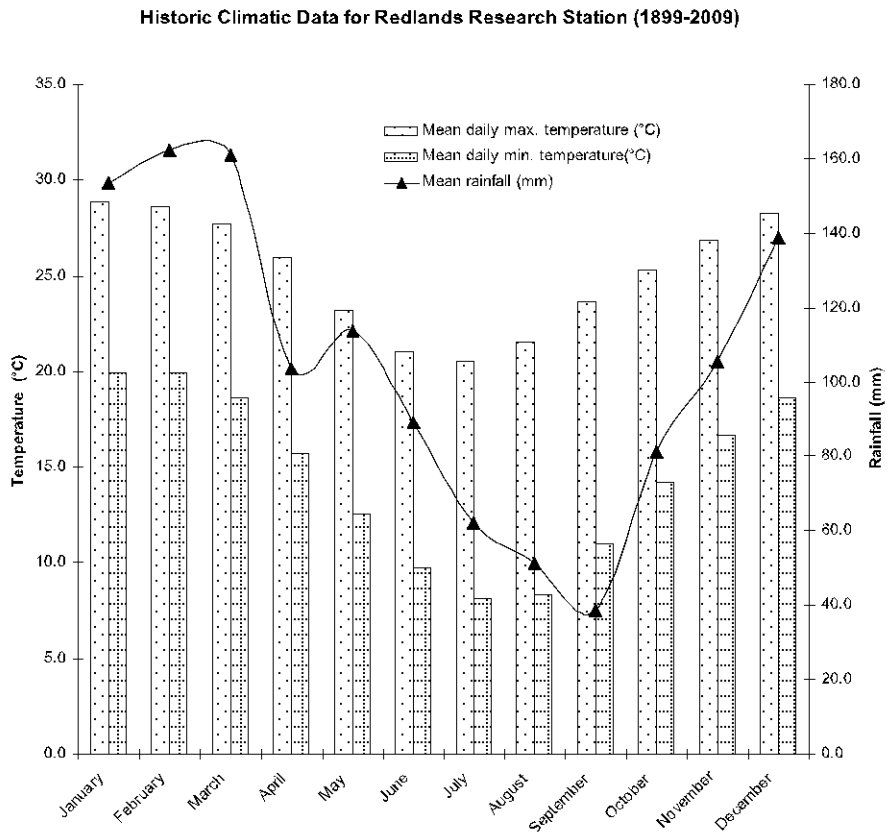


Figure 20. The Legend for Figure 21 which represents the collection of historic climatic data for all trial sites

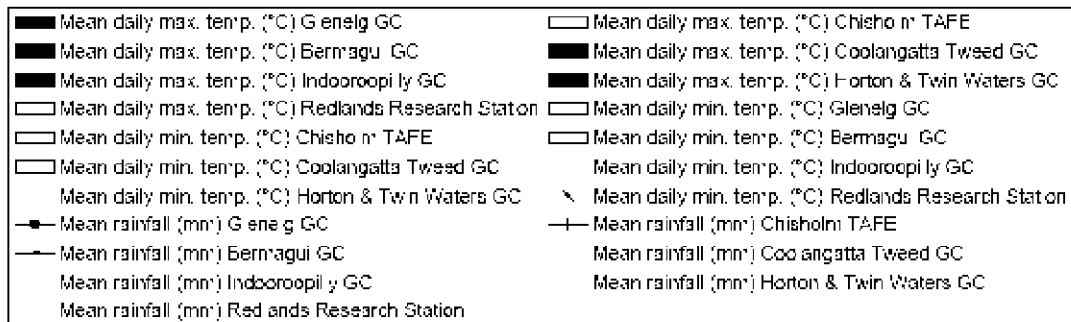
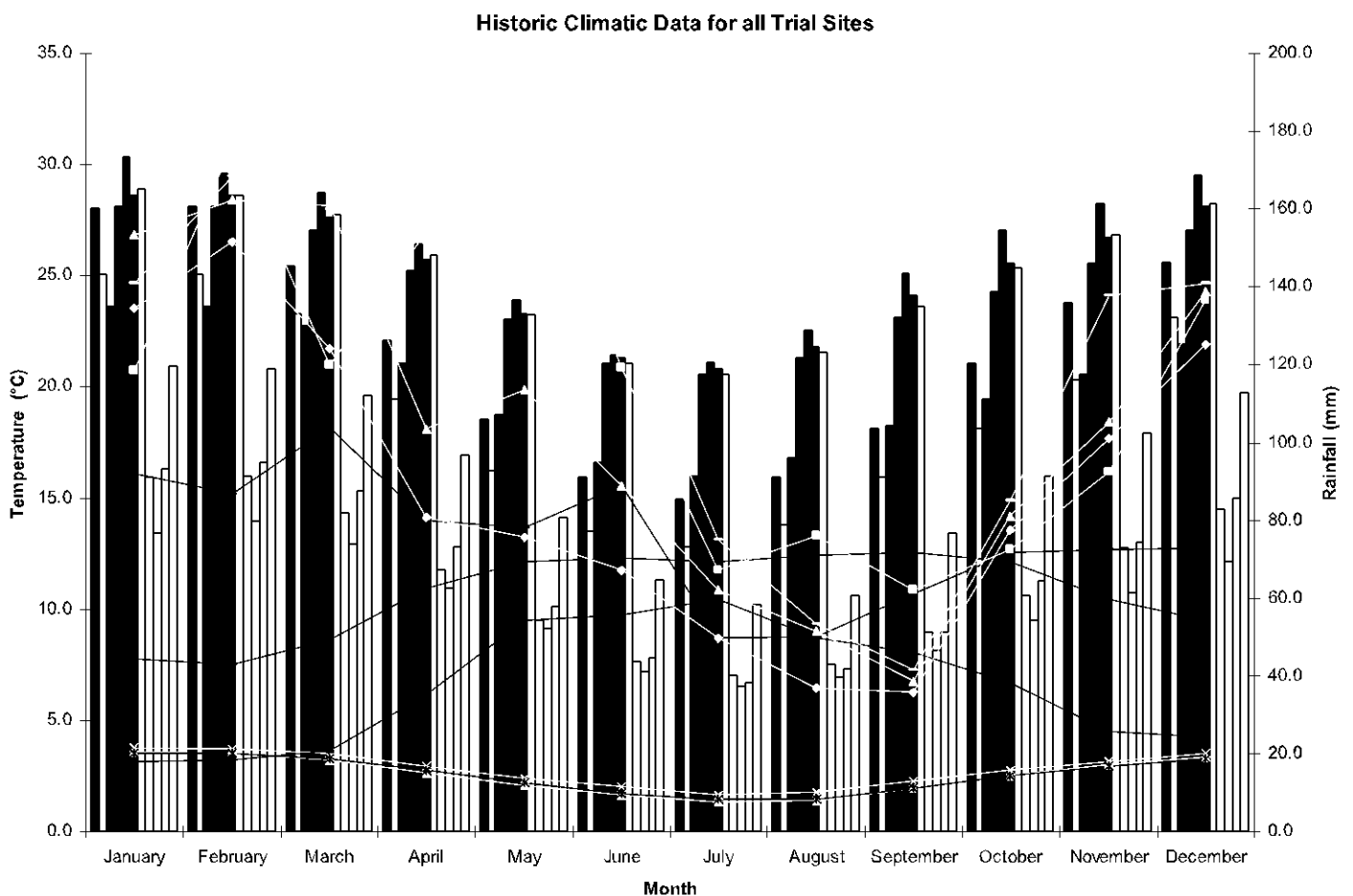


Figure 21. Historic climatic data for all trial sites

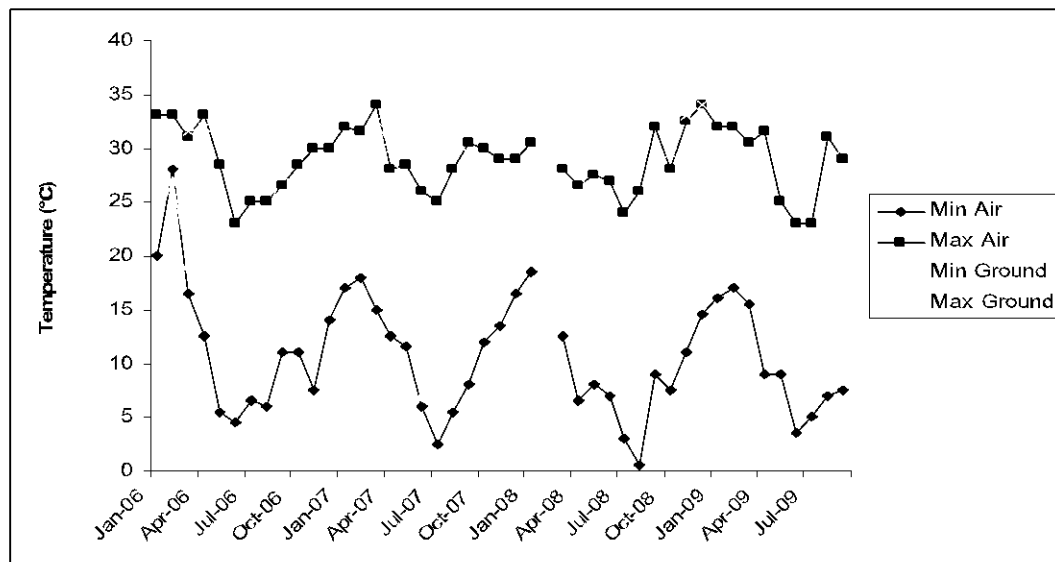


Air and ground temperatures were recorded at two hourly intervals between January 2006 and September 2009 (Figure 22). Minimum soil and air temperatures were obtained during winter and were as low as 0.5°C and 5°C respectively. The maximum soil and air temperatures were obtained during the peak of summer at 34°C and 35°C. Soil temperatures were on the most part were continually higher (+ 1 - 4°C) than the air temperatures.

Duncan and Carrow (2000) indicate that high soil temperature is detrimental to summer maintenance of grass roots and is strongly associated with aerial temperatures, humidity, non-irrigated turf, limited air drainage and low soil oxygen. Soil temperature particularly during late winter is influential in assisting with spring 'greenup' and plant development.

The Thermocron buttons are a great way to monitor temperatures and provide site specific values. Care and maintenance of the temperature buttons must be undertaken to ensure the quality of the data is preserved.

Figure 22. Minimum and maximum air and ground temperatures obtained between January 2006 and September 2006 using Thermocron temperature buttons.



Note: broken curves are a result of missing data due to technical problems with the Thermocron temperature buttons.

Cultivar response including turf growth and performance is largely dependent on suitable climatic conditions. Each trial site, even though there were moderately few in number, was well positioned in varied environments facing a mixture of annual heating degree days and rainfall. As such, warm-season seashore paspalum and *Cynodon* hybrid grasses had to adapt and conform to routine management practices.

From the results shown (Chapters 4 and 5) turfgrass colour, quality and root growth of both the seashore paspalum and *Cynodon* hybrid cultivars studied were significantly affected by the change in seasons, particularly with decreasing temperatures. Low temperatures not only slow turf growth (roots and stolons), but also pose the threat of making the turfgrass become dormant and lose colour. Such

activity is seen less in the seashore paspalum cultivars with temperatures needing to reach about -3.3°C for them to completely shut down and go into full winter dormancy (Duncan and Carrow, 2000). Studies by Roche and Loch (2005) indicated that *Cynodon* hybrids were non-active when temperatures were below 9°C. The difference in cold/chill tolerance of the two taxa are significant.

Of the seven trial sites only one, DEEDI Redlands was fortunate enough to have access to a Bureau of Meteorology (BOM) weather station on their facility. For the regional trial sites it was necessary to obtain climatic data from the nearest BOM weather stations. In the case of Indooroopilly Golf Club the closest was located at Archerfield Airport which is 11.2 km away. Given the distance away from the BOM weather station and considering the Indooroopilly Golf Club is situated in close proximity to the Brisbane River, temperatures may be a little lower than provided in Table 11 and Figure 17. As such the trial site would then be within the warm humid summer, mild winter zone and not the hot, dry summer, warm winter zone as calculated.

Dormancy occurred on all *Cynodon* hybrid cultivars. In Victoria and South Australia dormancy is very strong and spring greenup does not occur until at least mid-September (SA) – October (VIC). In Victoria ‘MS-Supreme’ and MiniVerde™ are the earliest cultivars to go into dormancy in winter. ‘Tifgreen’ performed better in the Victorian climate holding its colour longer and staying active for greater periods compared to the second-generation hybrids. MiniVerde™ was the cultivar that held its colour the longest. Of the seashore paspalums, all cultivars were affected by dormancy. However, they do not go brown like that of the couchgrasses and they still manage to hold some colour particularly in New South Wales and Queensland and to a lesser extent in Victoria and South Australia. Velvetene™ and SeaDwarf™ have a greater loss of colour compared to ‘Sea Isle 2000’.

With the temperature variation effecting turf performance of both the *Cynodon* hybrid and seashore paspalum cultivars across the series of trial sites it highlights the need for genotype by environment (G x E) studies. Temperature variation will also inevitably affect green speed. This will be news to many social golfers and or bowlers who think that the greens they are playing on are not up to “standard” from being either to fast or to slow. The player’s observation is often highlighted because they are not playing as well this time around, or playing as well as they did on the course or at the club they played at a week earlier in the neighbouring state.

With new or old cultivars of any turf species, it is important to understand what their strengths and weaknesses are, including geographical adaptation. It would be naive to think that one or all turfgrasses are suitable to such an array of climatic conditions as experienced in Australia.

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CHAPTER 4

DEEDI REDLANDS TEST FACILITY

INTRODUCTION

Turf research groups like that of the US Department of Agriculture-Agricultural Research Service (USDA-ARS) and the University of Georgia have worked tirelessly over the years to research the strengths and weaknesses of their cultivars and ultimately position them in environments that are compatible. Since the reported introduction of 'Tifgreen' and 'Tifdwarf' in 1956 through Doug Corbett (McMaugh, 2008) and in 1968 by Cliff Meredith (McMaugh, 2009) respectively, few clubs have deviated from the use of these first-generation grasses.

Between 2000 and 2006 Dr Donald Loch former Principal Scientist of the Department of Employment, Economic Development and Innovation (DEEDI) Turf Research Team imported from the US the available finer and denser cultivars among others for trialling in Australia. This included the *Cynodon* hybrids, 'TifEagle', 'MS-Supreme', 'Champion Dwarf', FloraDwarf™ and MiniVerde™, and the seashore paspalums, 'SeaIsle 1', 'Sea Isle 2000', Sea Isle Supreme™, and SeaDwarf™. Since their introduction into Australia and informal testing being undertaken at DEEDI Redlands, of these cultivars listed above, only 'TifEagle', 'MS-Supreme', 'SeaIsle 1', 'Sea Isle 2000' and SeaDwarf™ are available commercially. As such, there has been little opportunity for golf and bowls clubs to trial these newer cultivars to see if they meet not only the clubs requirements but are also suited to their environmental conditions.

Since the newer cultivars have had little exposure within the Australian golf and bowls industries it provided an excellent opportunity to trial these grasses against the old industry standards; and what better way to obtain first hand evidence of what the grasses were capable of than to trial them with superintendents or greenkeepers at various clubs across Australia. This decision would later not only provide cultivar specific information such as best management practices, but it would also identify which climatic region(s) they were best suited to grow (G x E). However, AGSCA and DEEDI staff were cautious of not wanting to place additional burden on the clubs resources by trialling large numbers of cultivars, particularly ones that were already thought to be not well suited for the environment. To assist with the collection of data, it was decided to trial a large contingent of the cultivars within a centralised test facility at DEEDI Redlands Research Station.

The formal experiment at DEEDI Redlands compared six *Cynodon* hybrids (MiniVerde™, 'MS-Supreme', Novotek™, 'Tifdwarf', 'TifEagle' and 'Tifgreen') and three seashore paspalum cultivars ('Sea Isle 2000', Sea Isle Supreme™ and Velvetene™), three mowing (M) regimes [M1: 3.5 mm cut (no rolling), M2: 3.5 mm cut and rolled; M3: 2.7 mm cut (no rolling)], three nitrogen (N) levels (N1: 1 kg N per 100 m² per year, N2: 2 kg N per 100 m² per year and N3: 4 kg N per 100 m² per year), and their interactions.

A detailed testing program was routinely carried out testing the M x N interactions. With such a complex design, the two formal experiments containing the *Cynodon* and *Paspalum* cultivars encompassed a total of 324 subplots. Therefore collecting a significant amount of data was unavoidable. Results included in this chapter have for that reason been divided into eight components (i) subjective colour, (ii) subjective quality, (iii) subjective thatch, (iv) quantitative thatch, (v) rooting depths (vi), stimpmeter testing, (vii) turfgrass management and (viii) disease (note: each component will comprise their own introduction, materials and methods and results and discussion).

MATERIALS AND METHODS – TRIAL DESIGN

Construction of the greens testing facility at DEEDI Redlands (27°32'S lat, 153°15'E long, 25 masl), Queensland, started as early as 2004. However, funding was not made available until 2006 when the project formally commenced. The perimeter of the immediate trial area (green) was separated from the surrounds by the use of Root Barrier® (Root Barrier, Windsor, Queensland) to help prevent encroachment and deterioration of the research plots. The Root Barrier® which is 0.75 mm thick made of a high density polyethylene material was installed to a depth of 300 mm and positioned into 50 mm of 100 mm thick sodium bentonite to provide a seal (Plate 5). The cultivars trialled (Table 14) were planted as spaced rooted plugs c. 15 cm apart between 21 December 2005 and 3 January 2006 on a sand profile green constructed to meet United States Golf Association (USGA) specifications.

The design was unavoidably complex to encompass both taxa of turfgrass. The *Cynodon* and *Paspalum* cultivars were grouped and considered separate experiments for statistical purposes because the grasses differ somewhat in management practices (e.g. dusting, grooming) required to produce a good quality greens surface. The design was a complicated version of a strip-strip-plot design in blocks. There were 4 blocks in a 2 m x 2 m array. Within each block there were 9 plots in a 3 m x 3 m array. The central 12 plots in a north-south direction were planted with the *Paspalum* cultivars (that is the northern plots of the blocks in the southern half and the southern plots of the blocks in the northern half), with the 3 cultivars randomly allocated to the 3 plots in each block. The outer 24 plots in a north-south direction were planted with the *Cynodon* hybrids, with the 6 hybrids randomly allocated to the 6 plots in each block (Figure 23).

Table 14. Turfgrass cultivars included in the formal trial at DEEDI Redlands

<i>Cynodon dactylon</i> x <i>C. transvaalensis</i> (<i>Cynodon</i> hybrid) cultivars:		
Tifgreen	TifEagle	Novotek™
Tifdwarf	MS-Supreme	MiniVerde™
<i>Paspalum vaginatum</i> (seashore paspalum) cultivars:		
Sea Isle 2000	Sea Isle Supreme™	Velvetcene™

Mowing was along an east-west axis. Within a block the 3 most southerly plots were labelled the first strip, the next 3 most southerly the second strip, etc, giving 3 strips in each block, 12 strips in total, 8 strips planted with *Cynodon* and 4 strips with *Paspalum*. Each strip was divided into 3 substrips, with each substrip going across 3 plots (either all *Cynodon* or all *Paspalum*) and running from east to west, or alternatively west to east depending on the direction of mowing. The three mowing treatments were randomly applied to the 3 substrips within each strip (Figure 24).

The original plan was to allow for three different mowing heights, however following the attendance of former QPIF Principal Scientist Dr Don Loch at the Golf Industry Show in Anaheim, USA (February 2007) this was modified. In educational sessions on both seashore paspalum and *Cynodon* hybrids, the instructors highlighted the possibility of being able to achieve green speeds comparable to mowing at the low cutting heights favoured for many years on the new cultivars by instead combining regular rolling with a slightly higher cutting height. Based on this and subsequent discussions with the initial Project Advisory Committee (comprising experienced representatives from the Golf Course Superintendents' Association of Queensland and Bowls Queensland), the mowing treatments were adjusted to meet the new techniques. The mowing treatments (including rolling) commenced as part of the formal experiment on 26 October 2007. Mowing was carried out three times per week and rolling once per week at the following levels:

- M1.** 3.5 mm cut (no rolling)
- M2.** 3.5 mm cut and rolled
- M3.** 2.7 mm cut (no rolling)

The allocation of nitrogen treatments was in a similar fashion to the allocation of mowing treatments except that they were applied along a north-south axis. Thus within a block the 3 most westerly plots became the first strip (called strap to differentiate from strips in the other direction), the next 3 most westerly the second strap, etc, giving 3 straps in each block, 12 straps in total, each strap consisting of 2 plots of *Cynodon* and 1 plot of *Paspalum*. Each strap was divided into 3 substrips (called substrips to differentiate from substrips in the other direction), with each substrap going across 3 plots (2 *Cynodon* and 1 *Paspalum*) and running from south to north. The three N treatments were randomly applied to the 3 substrips within each strap (Figure 25).

The fertiliser treatments (N) which commenced application on 9 January 2008 were applied at right angles across the mowing treatments were as follows:

- N1.** 1 kg N per 100 m² per year
- N2.** 2 kg N per 100 m² per year
- N3.** 4 kg N per 100 m² per year

In addition to the cultivars in the two formal experiments as listed above, two 3 m x 3 m replicates of the *Cynodon* hybrid cultivars 'Champion Dwarf' and FloraDwarfTM and one additional seashore paspalum, SeaDwarfTM were established. The three cultivars only consisted of two replicates and were unable to accommodate all the mowing (M) x nitrogen (N) treatment combinations. The plots were positioned along the western end of the research green and used primarily for observational

purposes. The data that has been collected of these cultivars has been excluded from this report. However, results and recommendations will be made available to the wider turfgrass industry through forthcoming trade magazines and or scientific papers.

Figure 23. Layout of the seashore paspalum (centre) and *Cynodon* hybrid (left and right) cultivars at the DEEDI Redlands greens test facility. Four blocks or replicates are *in situ* of each cultivar in the formal experiment.

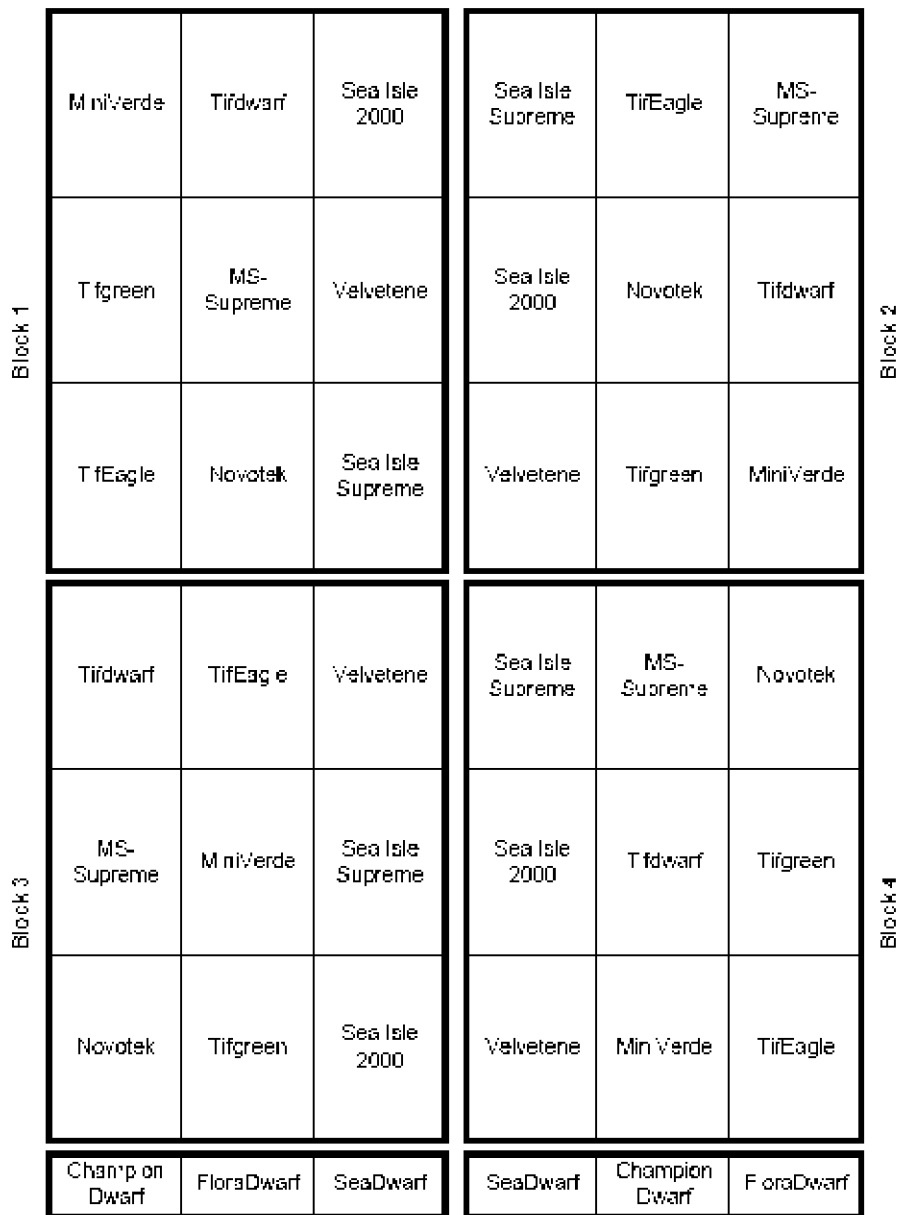


Figure 24. Redlands test facility depicting the mowing (M) treatments which run from east to west or alternatively west to east.

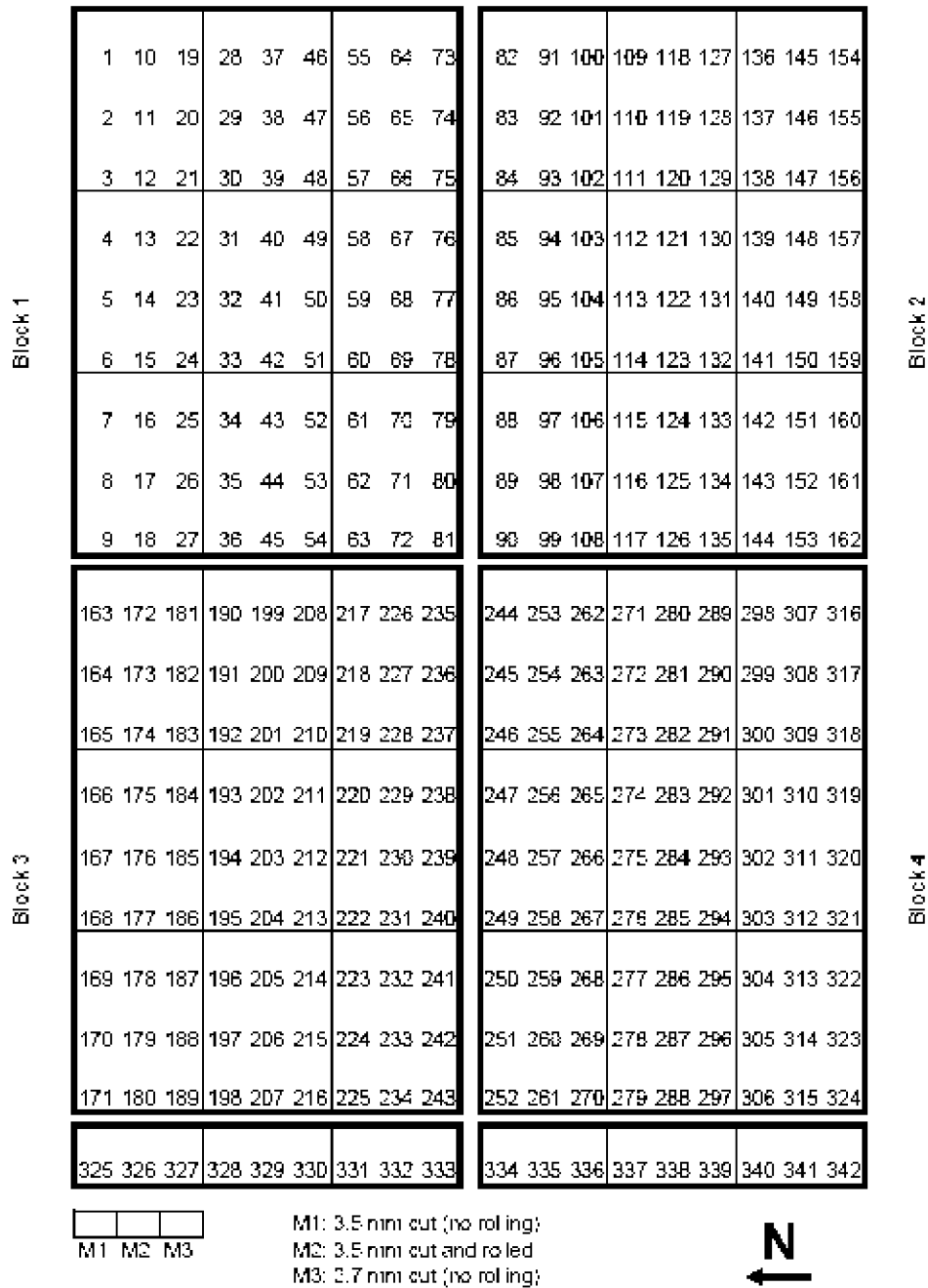


Figure 25. Redlands test facility depicting the nitrogen (N) treatments which run from south to north or alternatively from north to south.

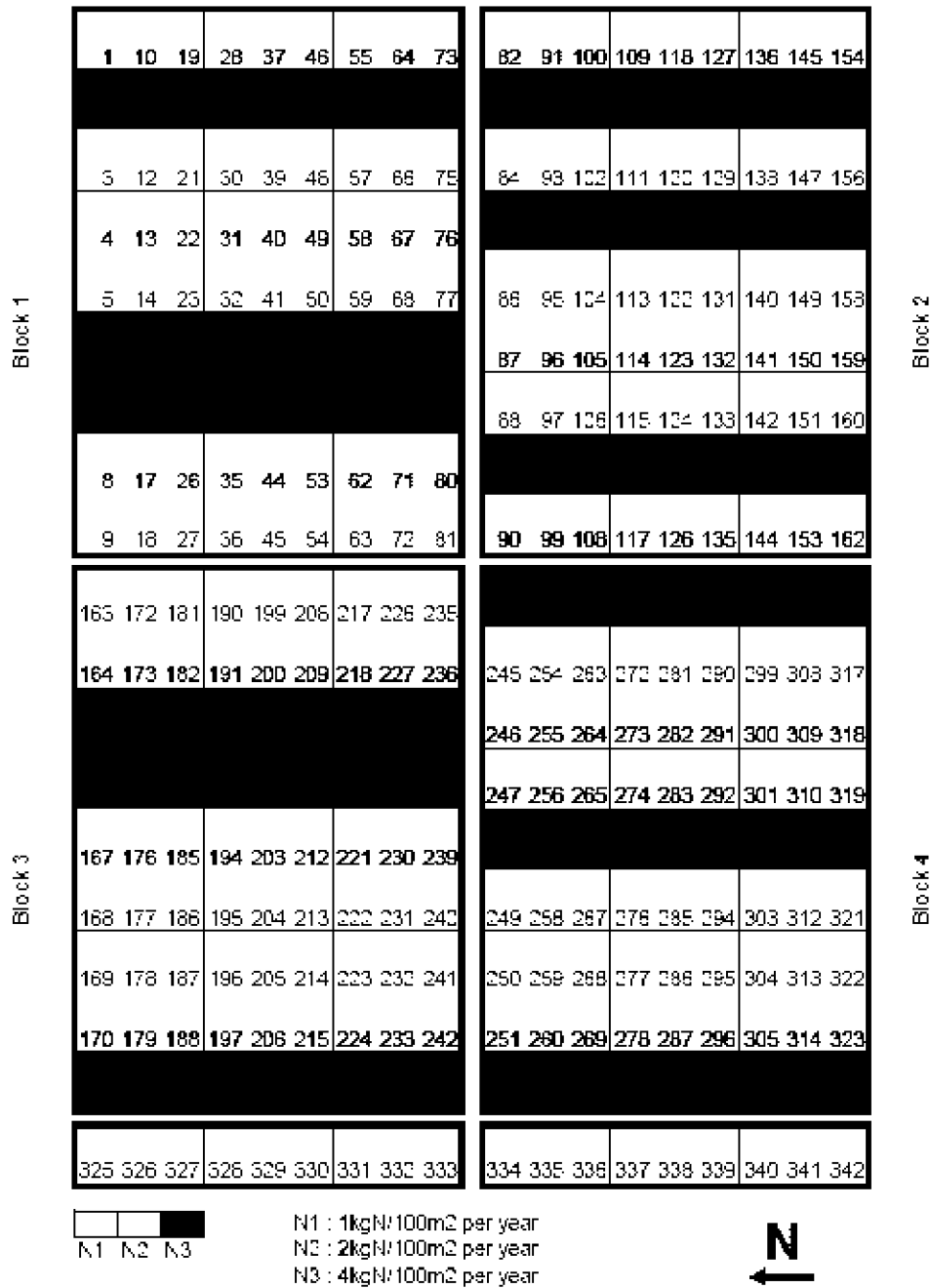


Plate 5. Installation of Root Barrier® and sodium bentonite (sealant) around the perimeter of the DEEDI greens test facility to stop encroachment from green surrounds.



Plate 6. Overview of the Redlands research green looking east to west on 6 January 2006. The image shows the fast lateral development of the *Paspalum* cultivars (centre) compared to the *Cynodon* cultivars (left and right).

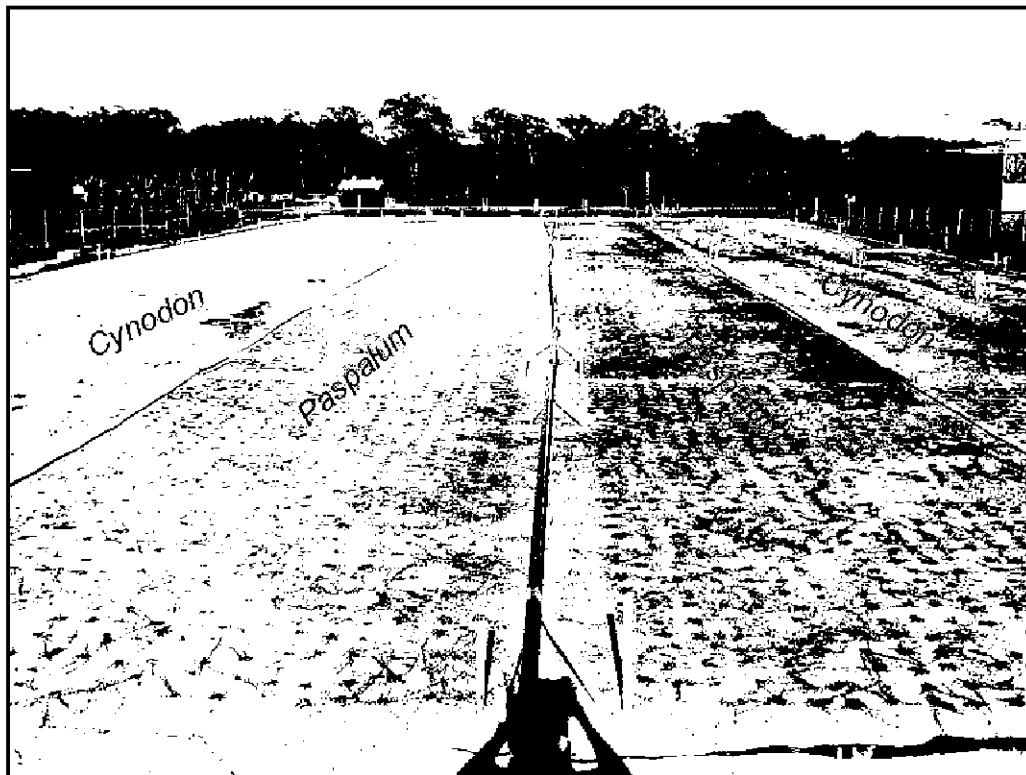


Plate 7. Overview of the Redlands research green looking east to west on 4 January 2009. Subplots can be identified by the yellow spots which are a result of spraying Finale[®] (glufosinate ammonium).

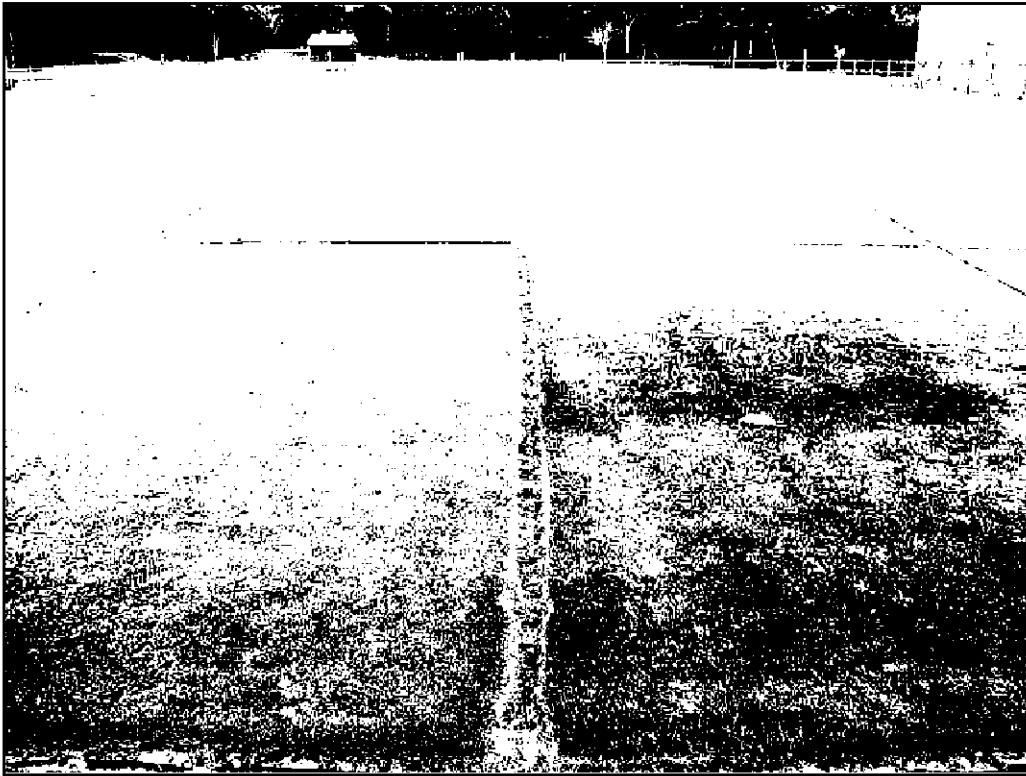
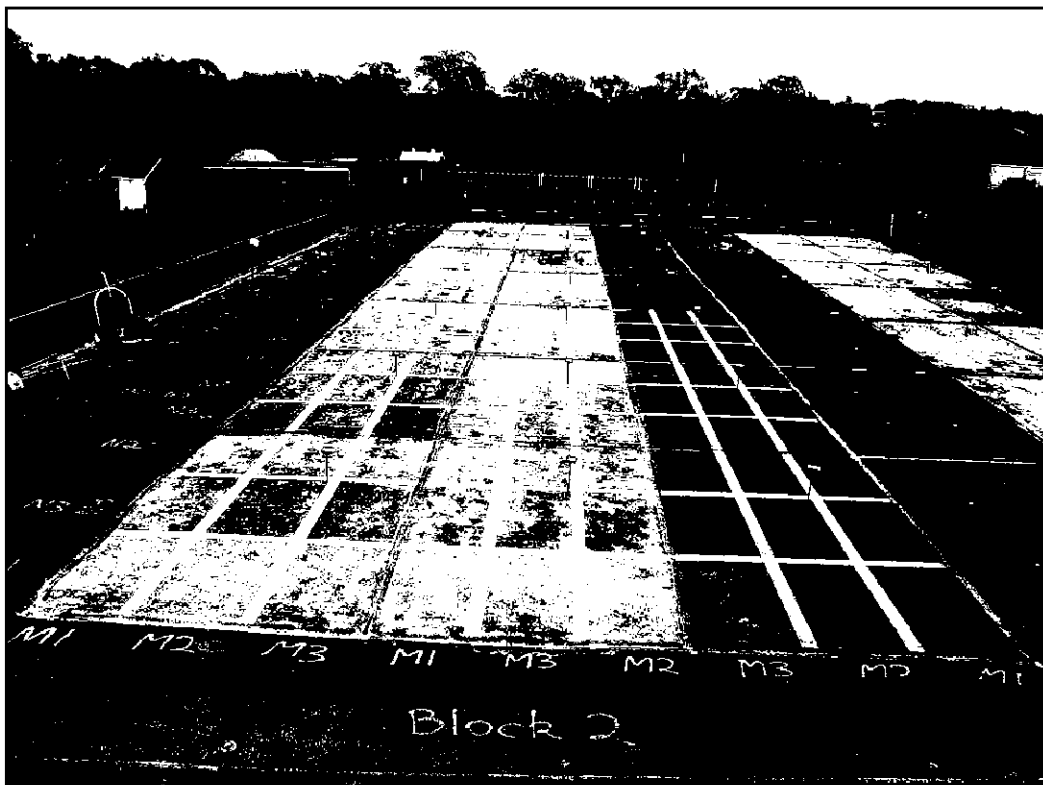


Plate 8. Aerial photo of Block (replicate) 2 of 4 showing the subplots and the direction of mowing (M) treatments (bottom to top of image) and direction of nitrogen (N) treatments right to left (starting in the middle of Blocks 1 and 2 and working out to prevent over spray into the adjacent block).



Cultivar ratings (colour, quality, thatch etc.) of plots did not commence until 5 June 2007. It was not possible to undertake ratings any earlier than this or apply M x N treatments because the plots had not yet fully established (provided a sufficient sward). This was largely to do with how the plots were established, being planted by rooted plugs. The establishment method differs from normal practices on golf and bowls greens where sprigs are spread heavily on the surface and then watered regularly until rooting occurs. Because 6 x 3 m plots of 9 different cultivars were being established on the one green, rooted cuttings that couldn't blow or otherwise move around from plot to plot were used to ensure the absolute integrity of each of the 36 cultivar plots (located in the formal trial area). Also, given that some of the cultivars that were trialled (e.g. MiniVerde™) were in limited supplies following the entry of vegetative material into Australia through AQIS, this was the only means possible.

Cultivar ratings continued until October 2007 when intensive scarification was undertaken of the plots to supply vegetative material to the regional trial sites. As a result, no testing was undertaken in the months of November and December 2007. The application of mowing and nitrogen treatments to measure cultivar effects commenced on 26 October 2007 and 9 January 2008 respectively. As a result, monthly or routine testing to assess cultivar and M x N treatment effects commenced 16 January 2008.

Data or graphs shown in this chapter which was collected between 16 January 2008 and 2 October 2009 has been displayed to show the cultivar (C) x mowing (M) and cultivar (C) x nitrogen (N) interactions. The following single components (C, M, N) or interactions (C x M x N and M x N) have not been displayed.

i) SUBJECTIVE COLOUR ASSESSMENTS

Introduction

Arguably, colour is the first thing that is noticed when a green is inspected or played on. Unfortunately many social or competitive players still believe that colour is the most significant indication of its playing quality. A fitting quote was provided by Alender Radko, former National Director of the United States Golf Association (USGA) Green Section: "Green is not great – golf is played on grass, not colour" (Section, 2003). However, turf colour is a key component of aesthetic quality and a good indicator of water and nutrient status (Beard, 1973; Karcher and Richardson, 2003). Colour can change quickly depending on the temperature. Knowing when a turfgrass may become inactive or dormant from historic data (refer to chapter 3 for further information) is very important as to is 'spring greenup' (when a turf regains its colour following low winter temperatures). By being aware of these timeframes and what to expect, you can tailor your management plan to try and maximise or hold a darker green colour turfgrass for longer. This can be assisted with physical techniques, but is largely influenced by how much nutrition is applied and when.

As part of the detailed study, subjective colour ratings were undertaken of the *Cynodon* and *Paspalum* cultivars to determine colour differences between the cultivars and between the taxa throughout the various growing seasons.

Materials and Methods

Subjective colour ratings were undertaken to assess the changing characteristics of the *Cynodon* and *Paspalum* cultivars under different management regimes (mowing/rolling and nutrition). This was of particular importance during the change in seasons (e.g. autumn into winter and winter into 'spring greenup'). Ratings conducted between 5 Jun. (6 Jul., 2 Aug., 5 Sep.) and 29 Oct. 2007 were prior to the application of M x N treatments, whereas between 16 Jan. 2007 (14 Feb., 12 Mar., 10 Apr., 7 May, 3 Jun., 2 Jul., 31 Jul., 27 Aug., 24 Sep., 22 Oct., 20 Nov., 19 Dec. 2008; 15 Jan., 12 Feb., 11 Mar., 11 Apr. 8 May, 3 Jun., 3 Jul., 26 Aug.) and 25 Sep. 2009 researchers were directly able to assess the implication of the treatments that had been applied. Turfgrass colour ratings [0 (= no green colour) to 9 (= dark green colour); 6 = acceptable colour] were undertaken by one to three, usually two DEEDI research staff. Observations of turf colour in areas that are discoloured from disease or management practices such as scalping were avoided where possible as these were assessed when turfgrass quality was measured.

Analysis of colour data was undertaken using residual maximum likelihood of the averaged visual rating data collected by DEEDI staff. *Cynodon* and *Paspalum* were analysed separately. Treatment effects considered were cultivar (C), mowing regime (M), nitrogen level (N), and all interactions of these factors. For the *Cynodon* analyses blocking effects considered were blocks, strips within blocks, plots and substrips within strips, straps within blocks and substrips within straps. For *Paspalum* analyses blocking effects reduced to blocks, plots and substrips within blocks and substrips within plots (blocks and strips were synonymous for these analyses, as were plots and straps). In cases where the estimate of a variance component was negative this term has been omitted from the model and data reanalysed. Where appropriate, pairwise comparisons were made using the protected least significant difference procedure at $P=0.05$. All analyses were using GenStat® Release 11.1 for PC/Windows. Graphs were constructed using Microsoft® Office Excel 2003.

Results and Discussion

A series of visual assessments were undertaken during 2007 where cultivar (C) was the only treatment factor (i.e. prior to the application of N and multiple M treatments) (Table 15). The five assessments conducted between winter and early spring usually provided less than acceptable (a rating of < 6) colour ratings for the *Cynodon* hybrids. 'Tifdwarf' ranked consistently the lowest performer except for in September 2007 where it was only marginally ahead of 'MS-Supreme' and 'TifEagle'. This is likely to do with the genetics and morphology of the turfgrass. 'Tifdwarf' is defined as having a basic purple plant colour in the summertime and is easily distinguishable when comparing cultivars growing side-by-side. However, when temperatures drop (late autumn and winter) 'Tifdwarf' takes on a purplish cast that may prove objectionable to some (Burton, 1966). MiniVerde™ produced higher colour ratings of the *Cynodon* hybrids and only twice fell short of being considered acceptable. The ratings for the seashore paspalums in 2007 produced and maintained a better colour than the *Cynodon* hybrids. Of the data collected in 2007, no significant differences were observed during the winter period between 'Sea Isle 2000', Sea Isle Supreme™ and Velvetene™. It was not until warmer temperatures came about in September that 'Sea Isle 2000' produced a significantly higher reading than the other two cultivars.

Table 15. Subjective colour [0 (= no green colour) to 9 (= dark green colour); 6 = acceptable colour] ratings undertaken between 5 June and 29 October 2007 of the *Cynodon* hybrid and seashore paspalum cultivars prior to treatments being applied.

Cultivars	Turf Colour Ratings				
	05-Jun-07	06-Jul-07	02-Aug-07	05-Sep-07	29-Oct-07
<i>Cynodon hybrid:</i>					
MiniVerde	7.6	5.7	4.5	5.5	6.3
MS-Supreme	6.4	4.9	3.5	4.5	5.6
Novotek	6.4	5.1	3.6	5.2	5.6
Tifdwarf	4.9	3.7	3.2	4.7	5.4
TifEagle	6.8	4.8	3.7	4.6	5.6
Tifgreen	6.1	4.8	4.6	4.8	5.9
LSD (<i>P</i> =0.05)	0.7	0.4	0.5	0.4	0.7
<i>Paspalum:</i>					
Sea Isle 2000	7.5	5.3	6.5	6.3	7.7
Sea Isle Supreme	7.5	5.5	6.5	6.0	7.1
Velvetene	7.5	5.5	6.6	5.9	6.8
LSD (<i>P</i> =0.05)	-	0.2	0.3	0.2	0.5

The following two graphs depict the colour ratings of the interactions between cultivar by mowing (C x M) levels and cultivar by nitrogen (C x N) levels. A graph has not been displayed for the C x M x N interactions due to the complexity and the inability to clearly read the large amount of data captured. Also, upon viewing the data, at no stage were there any significant differences in colour ratings of the C x M x N interactions of the *Cynodon* hybrids during any of the 22 testing dates between 16 January 2008 and 25 September 2009.

Overall, mowing heights and or rolling had little effect on colour variation. On only six occasions were there significant effects (<0.001) between C and M. Two of these occurred in the first two months following application of the mowing treatments and the later two were not until November and March 2009. Nitrogen applications had an obvious effect on turfgrass colour; the higher the nitrogen levels the higher the colour rating. From April 2008 to the end of the trial there were significant effects between C and N ranging between <0.001 and 0.039.

In May of 2009 the cultivars Novotek™ and ‘Tifgreen’ treated with N3 (4kg N/100m²/yr) recorded lower colour ratings than N2 (2kg N/100m²/yr). Novotek™ improved the following month; however the N2 treatment continued to dominate with higher colour ratings of ‘Tifgreen’ until the conclusion of the trial. The lowest colour rating was with ‘TifEagle’ being cut at 2.7 mm (M3) and fertilised at 1kg N/100m²/yr (N1) during mid-winter. The highest rating was also at the 2.7 mm cutting height with the N3 application across MiniVerde™ during late spring and ‘Tifdwarf’ during late autumn and early winter. The higher ratings of ‘Tifdwarf’ observed during the autumn and or winter of 2008 and 2009 mirrors the data collected in 2007. This also supports Burton’s (1966) claim that the cultivar takes on a darker purplish colour during the cooler period and explains why a higher visual rating is given by the scorer(s). Because of this increased purplish or darker colour during the autumn-winter period, ‘Tifdwarf’ proved to have the most consistent colour rating through the duration of the study (low of 4.5 in the winter of 2008 and a high of 7.9 in the winter of 2009).

Figure 26. Subjective colour assessments [0 (= no green colour) to 9 (= dark green colour); 6 = acceptable colour] undertaken of the *Cynodon* hybrids between 16 January 2008 and 25 September 2009. Data shown is of the Cultivar (C) x Mowing (M) interactions.

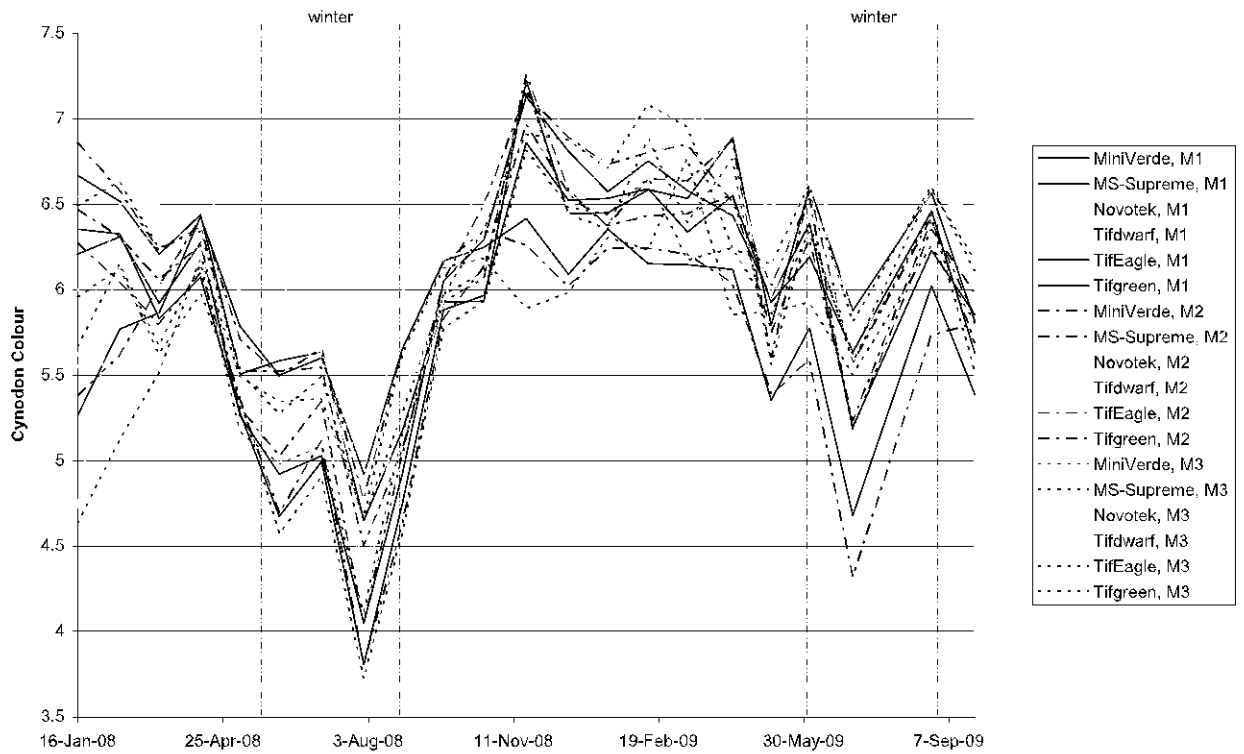
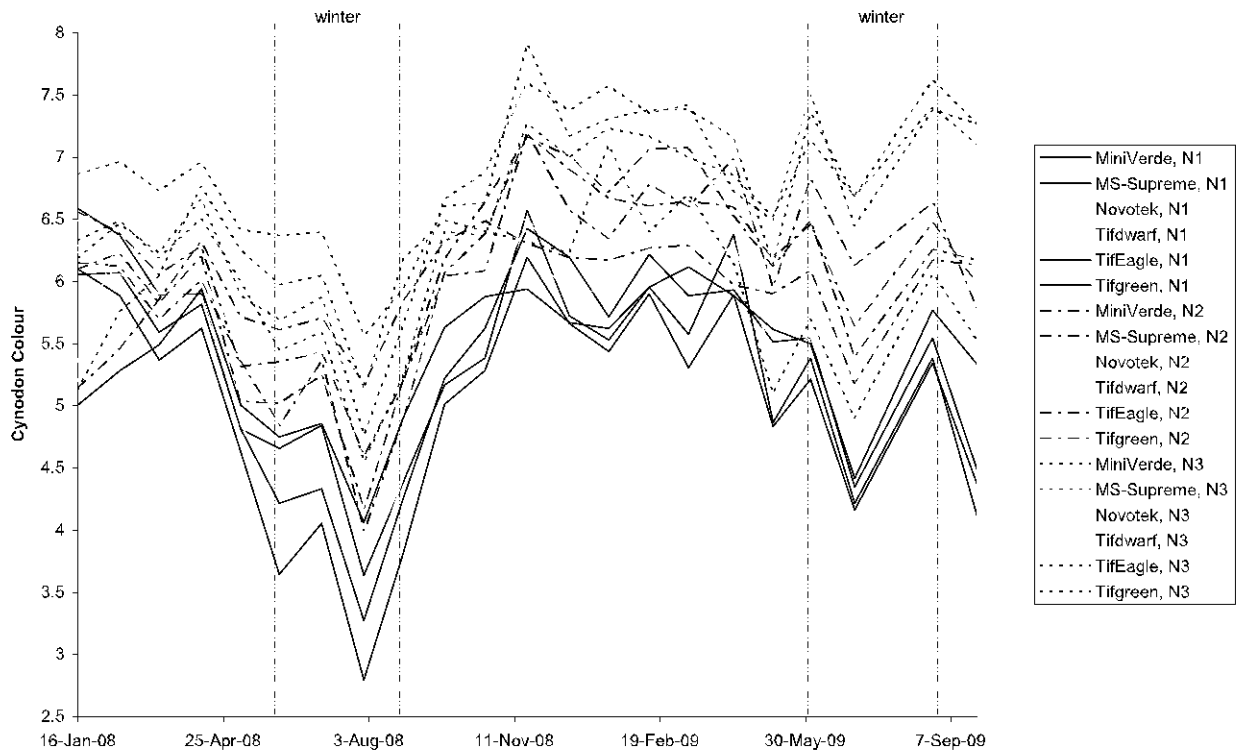


Figure 27. Subjective colour assessments [0 (= no green colour) to 9 (= dark green colour); 6 = acceptable colour] undertaken of the *Cynodon* hybrids between 16 January 2008 and 25 September 2009. Data shown is of the Cultivar (C) x Nitrogen (N) interactions.



The paspalums in general maintained a better colour through winter than the *Cynodon* hybrids. The lowest colour rating of a seashore paspalum was 4.7 in winter compared to 2.8 of the *Cynodon* hybrids at the same time.

In view of the analysed C x M data, only once was there a significant effect ($P < 0.001$). Upon closer inspection, this was of 'Sea Isle 2000' being mown at 3.5 mm (M1) which produced an average rating of 5.31, which was significantly ($P < 0.05$) lower than the comparators (Figure 28). In view of the raw data and the field notes, the lower readings given by the scorers were given because of heavy scalping.

No discernible interactions were observed following analysis of the C x N data of the seashore paspalums. However, in view of the graph (Figure 29) there are three distinct groupings which can be deceptive. These groupings relate to the nitrogen level and do not reflect a C x N treatment interaction.

'Sea Isle 2000' lost more colour than Sea Isle Supreme™ and Velvetene™ with the onset of the cold weather, but recovered faster than the other two varieties at the end of winter. Velvetene™ produced consistently the highest colour rating throughout the duration of the study.

The application of nitrogen or higher nitrogen applications in late autumn to both the *Cynodon* hybrids and seashore paspalums did not result in sustained or improved colour during the winter period. Applying nitrogen at this time (late autumn) may only extend turfgrass growth and colour by a few days, possibly even weeks depending on the temperatures experienced. Studies conducted by Goatley (1994) indicated that the application of nitrogen late during the growing season offered an improvement in 'spring greenup', but not necessarily an improvement in winter colour. Goatley (1994) recommended that potassium (K) fertilization was an appropriate and practical means of preparing a warm-season turfgrass by improving winter hardiness; while the foliar-application of iron (Fe) provided an immediate turfgrass greening effect and unlike nitrogen, it did not cause a flush of shoot growth.

Figure 28. Subjective colour assessments [0 (= no green colour) to 9 (= dark green colour); 6 = acceptable colour] undertaken of the seashore paspalums between 16 January 2008 and 25 September 2009. Data shown is for the Cultivar (C) x Mowing (M) interactions.

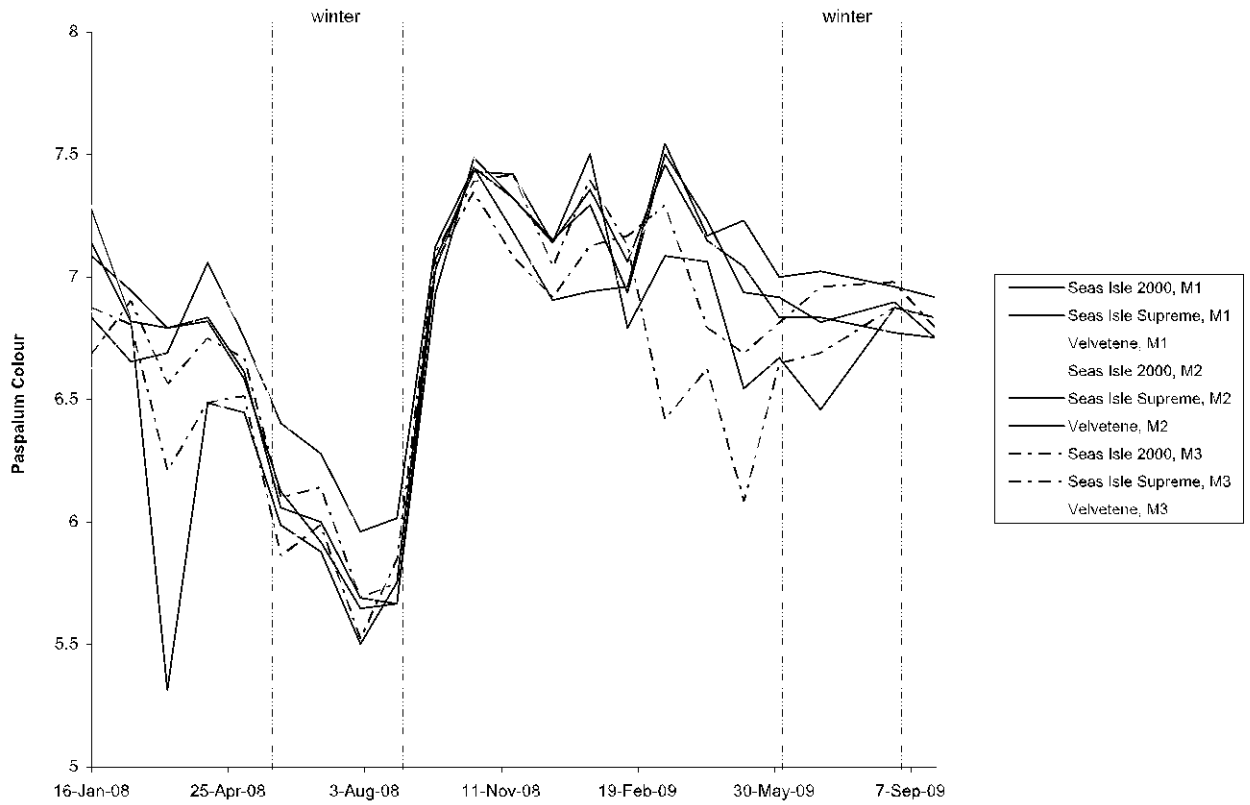
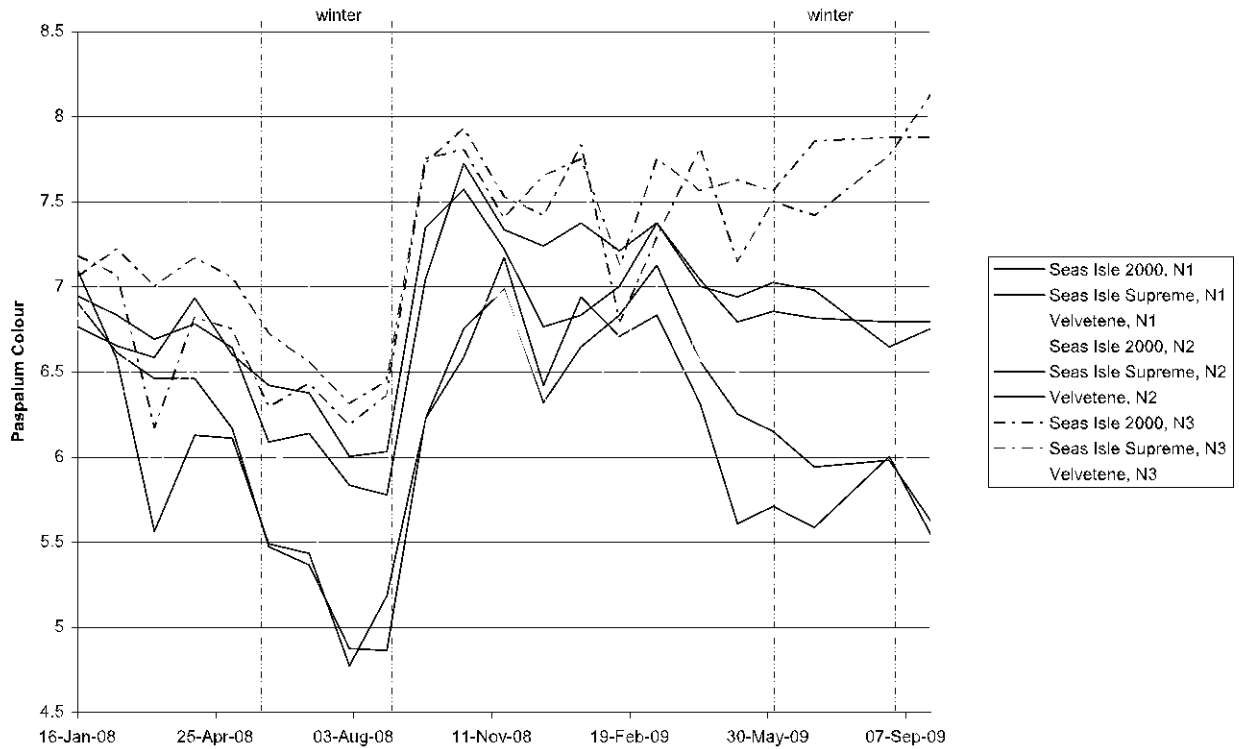


Figure 29. Subjective colour assessments [0 (= no green colour) to 9 (= dark green colour); 6 = acceptable colour] undertaken of the seashore paspalums between 16 January 2008 and 25 September 2009. Data shown is for the Cultivar (C) x Nitrogen (N) interactions.



Colour is traditionally assessed by undertaking visual subjective ratings. This is considered acceptable by Australian and international turf researchers. Although colour ratings provide quick data acquisition without the need for specialised equipment, they are a subjective measure from which human bias is difficult to remove (Karcher and Richardson, 2003). As a result, inconsistencies may exist among raters and this was observed in the data that was collected by DEEDI staff following further scrutiny by statistical analysis when ratings were considered as a second treatment factor. It was observed that one researcher gave higher ratings for colour observations of the *Cynodon* hybrids than the other two raters present. However, in view of all the collected data there were no consistent differences between raters. This is not an isolated case. Relatively poor correlations existed among experienced researchers ($r < 0.68$) when rating the same turf plots for density, colour and leaf spot was undertaken (Horst et al., 1984; Karcher and Richardson, 2003; Skogley and Sawyer, 1992). If visual colour ratings are to be undertaken it is recommended that at least two persons should undertake this task to reduce human bias.

Other techniques used to objectively measure turf colour have been used by turf researchers including the use of reflectance, chlorophyll and amino acid analysis, comparison with standard colours such charts produced by the Royal Horticultural Society (RHS Charts) and with the use of a colourimeter (Karcher and Richardson, 2003). The Field Scout TCM 500 “NDVI” Turf Colour Meter (Spectrum Technologies Inc., USA) was purchased by the DEEDI Turf Research Team in April 2009 to evaluate its performance with successfully determining turf colour. The Turf Colour Meter measures reflected light from turfgrass in the red (600nm) and near infrared (850nm – NIR) spectral bands. The difference between the two values relates to the chlorophyll concentration and plant health, providing a ‘Turf Colour Meter Rating’. The Turf Colour Meter was trialled on 11 April 2009, 8 May, 3 June, 3 July, 26 August and 25 September 2009 on the turf subplots at DEEDI Redlands. Initial results indicate that the unit provides a consistent reading and is likely to replace subjective colour ratings to remove human bias. Further analysis of the data which had been collected over the six month period is required and therefore has not been included in the final report. It will however be made available at a later date through publication in trade magazines and scientific papers.

Additional and greater detailed graphs containing mean subjective colour assessments of the *Cynodon* hybrids and seashore paspalums from testing undertaken between 16 January 2008 and 25 September 2009 can be found in Appendix 4 (available upon request from the author, 65 pages in total of summarised graphs).

ii) SUBJECTIVE QUALITY ASSESSMENTS

Introduction

Turfgrass quality was defined by Beard (1973), then later published by Beard and Beard (Beard and Beard, 2005) as the degree to which a turf conforms to an agreed standard that is a composite of uniformity, shoot density, leaf texture, growth habit, smoothness and colour (Krans and Morris, 2007). Each component has its own merit, but collectively provides the person undertaking the subjective assessment with a guide to what he or she is rating. (For descriptions of each of the six components, refer to the USA 2008 draft National Turfgrass Evaluation Program Protocols,

Standards, and Application for the Visual Field Assessment of Turfgrass (NTEP, 2008).

Greens grass can be mown and maintained periodically at very low cutting heights (e.g. 2.5 mm), but become stressed during periods of incremental weather (e.g. cloudy, hot and humid) (Bevard et al., 2005) and result in poorer turfgrass quality. Mowing heights should be raised during periods of stress. Mowing heights incurred during the DEEDI Redlands experiment were between 2.7 mm (treatment M3) and 3.5 mm (treatments M1 and M2), with rolling of the greens being undertaken weekly on one of the two 3.5 mm treatments (M2). Studies undertaken by Hartwiger et al. (2001) to determine the effect of rolling on turf quality, indicated out of rolling 0, 1, 4, or 7 times per week, once per week produced no deleterious effects to turfgrass quality while higher applications did.

As part of the detailed study, subjective quality ratings were undertaken of the *Cynodon* and *Paspalum* cultivars to determine quality differences between the cultivars throughout the various growing seasons and their response to varied management options.

Materials and Methods

Subjective quality ratings was undertaken to assess the changing characteristics of the *Cynodon* and *Paspalum* cultivars under different management regimes (mowing/rolling and nutrition). This was of importance during the change in seasons, but largely on how the turfgrass responded to different treatments (e.g. high N rates resulting in a better quality turfgrass). Ratings conducted between 5 Jun. (6 Jul., 2 Aug., 5 Sep.) and 29 Oct. 2007 were prior to the application of M x N treatments, whereas between 16 Jan. 2007 (14 Feb., 12 Mar., 10 Apr., 7 May, 3 Jun., 2 Jul., 31 Jul., 27 Aug., 24 Sep., 22 Oct., 20 Nov., 19 Dec. 2008; 15 Jan., 12 Feb., 11 Mar., 11 Apr. 8 May, 3 Jun., 3 Jul., 26 Aug.) and 25 Sep. 2009 researchers were directly able to assess the implication of the treatments that had been applied. Turfgrass quality ratings [0 (= worst) to 9 (= best); 6 = acceptable] were undertaken by one to three, usually two DEEDI research staff.

Analysis of quality data was using residual maximum likelihood of the averaged visual quality data collected by DEEDI staff. *Cynodon* and *Paspalum* were analysed separately. Treatment effects considered were cultivar (C), mowing regime (M), nitrogen level (N), and all interactions of these factors. For the *Cynodon* analyses blocking effects considered were blocks, strips within blocks, plots and substrips within strips, straps within blocks and substrips within straps. For *Paspalum* analyses blocking effects reduced to blocks, plots and substrips within blocks and substrips within plots (blocks and strips were synonymous for these analyses, as were plots and straps). In cases where the estimate of a variance component was negative this term has been omitted from the model and data reanalysed. Where appropriate, pairwise comparisons were made using the protected least significant difference procedure at $P=0.05$. All analyses were using GenStat® Release 11.1 for PC/Windows. Graphs were constructed using Microsoft® Office Excel 2003.

Results and Discussion

Prior to the commencement of the formal study (application of M and N treatments) in January 2008 the quality of both the *Cynodon* hybrids and seashore paspalum cultivars rarely fell to below acceptable. An exception to this was with 'Tifdwarf' where between June and October 2007 it never reached an acceptable standard in turfgrass quality. On four out of five occasions it was statistically lower ($P < 0.05$) than the other five cultivars, MiniVerde™, 'MS-Supreme', Novotek™, 'TifEagle' and even 'Tifgreen'. The seashore paspalums provided a better turfgrass quality compared to the *Cynodon* hybrids. Turfgrass quality observed in September 2007 decreased for both species (Table 16); however this was attributed to a reduction in mowing heights only days earlier.

Table 16. Subjective quality [0 (= worst) to 9 (= best); 6 = acceptable] ratings undertaken between 5 June and 29 October 2007 of the *Cynodon* hybrid and seashore paspalum cultivars prior to treatments being applied.

Cultivars	Turf Quality Ratings				
	05-Jun-07	06-Jul-07	02-Aug-07	05-Sep-07	29-Oct-07
<i>Cynodon</i> hybrid:					
MiniVerde	7.6	6.7	6.8	6.2	6.4
MS-Supreme	7.0	6.3	6.4	5.0	5.7
Novotek	6.6	6.0	5.8	5.6	6.1
Tifdwarf	5.0	5.1	5.4	4.6	5.0
TifEagle	6.8	5.7	6.0	5.4	6.0
Tifgreen	6.8	6.8	6.5	5.3	5.8
LSD ($P=0.05$)	0.8	0.6	0.3	0.5	0.7
<i>Paspalum</i>:					
Sea Isle 2000	7.1	5.9	6.0	5.1	6.4
Sea Isle Supreme	7.0	6.3	6.0	4.7	6.6
Velvetene	6.5	6.2	6.0	4.6	6.8
LSD ($P=0.05$)	0.3	0.4	-	0.3	1.0

There were 8 out of 22 significant ($P < 0.001$) effects observed when the C x M data of the *Cynodon* hybrids was analysed. These effects were largely seen during the winter periods. C x M ratings of the *Cynodon* hybrids were between 4.7 and 7.5 (both were the M3 treatments) from January 2008 to February 2009. After the date, there was a decline in turfgrass quality of all the *Cynodon* hybrids. MiniVerde™ and Novotek™ were the best performers and rated highly at the M2 (3.5 mm cut and roll) and M3 (2.7 mm cut not rolled) treatments. 'Tifgreen' and 'Tifdwarf' did not favour the lower cutting height (M3) between January 2008 and February 2009. The results were then reversed with the 3.5 mm cut, not rolled (M1) treatment being the worse performer of the industry standards 'Tifgreen' and 'Tifdwarf'. Not even higher nitrogen levels (treatment N3) improved the quality of 'Tifgreen' and to a similar extent 'Tifdwarf'.

There were four significant ($P < 0.001$) C x N interactions when turfgrass quality was analysed. Three of these occurred between July and September 2009 and were largely due to the higher morphological and agronomic (MA) quality of the second generation turfgrasses compared to the first generation hybrids. Quality ratings were between 4.7 and 8.0 for treatments N1 (1kg N/100m²/yr) and N3 (4kg

N/100m²/yr) respectively between January 2008 and February 2009. The quality of 'MS-Supreme' and 'TifEagle' improved with higher nitrogen applications at 2kg N/100m²/yr (N2) and 4kg N/100m²/yr (N3) which largely positioned them above the acceptable level.

From February to September 2009 the quality of the *Cynodon* hybrids decreased sharply. The reduction is likely to be a result of a preventative fungicide spray program not being adopted unlike it had been in 2007-2008. The reason for not introducing a preventative program was to assess the change in turfgrass quality but also assess which cultivars showed possible disease tolerance.

Figure 30. Subjective quality [0 (= worst) to 9 (= best); 6 = acceptable] assessments undertaken of the *Cynodon* hybrids between 16 January 2008 and 25 September 2009. Data shown is for the Cultivar (C) x Mowing (M) interactions.

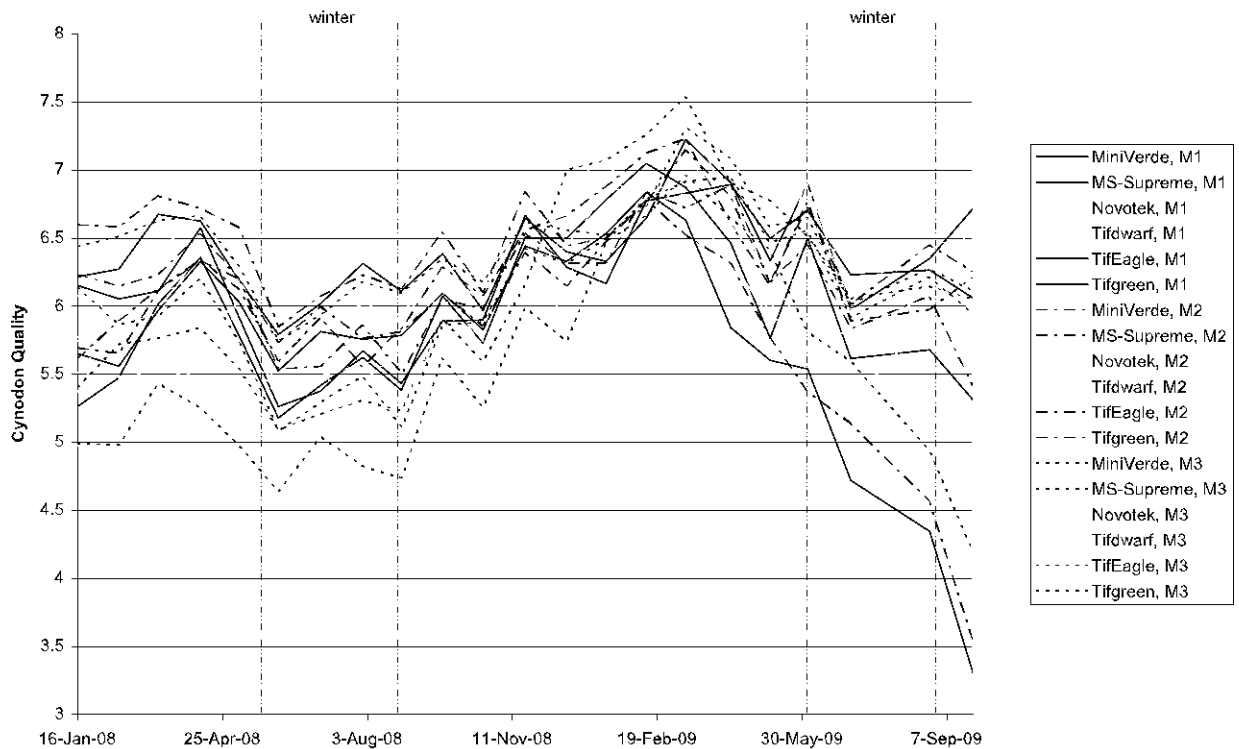
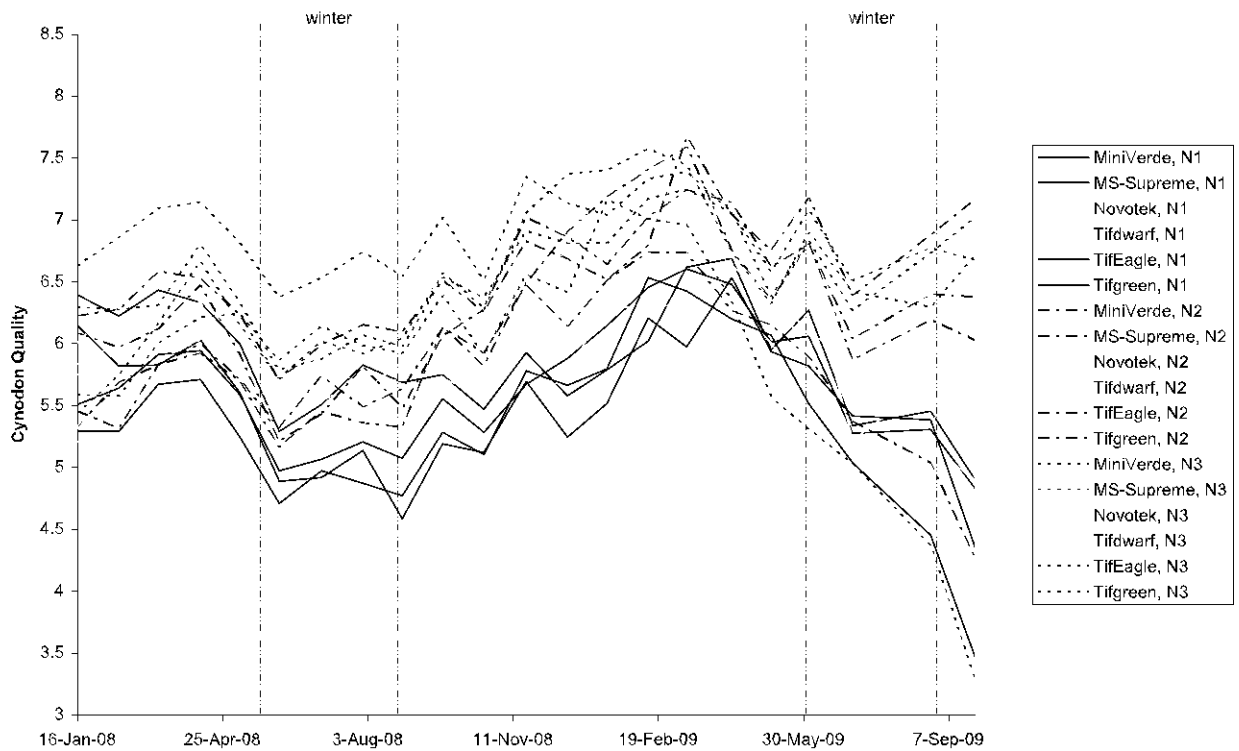


Figure 31. Subjective quality [0 (= worst) to 9 (= best); 6 = acceptable] assessments undertaken of the *Cynodon* hybrids between 16 January 2008 and 25 September 2009. Data shown is for the Cultivar (C) x Nitrogen (N) interactions.



Compared to the *Cynodon* hybrids, the seashore paspalums striped up nicely and aesthetically looked better. Colour was also a contributing factor even if it was assessed separately. Following analysis of the seashore paspalum C x M data, only once was there a significant effect ($P < 0.001$) observed and for the C x N interactions there were none of importance.

The performance based on mowing height was a mixed result. ‘SeaIsle 2000’ and Sea Isle Supreme™ did not incur high quality ratings being cut at 2.7 mm (M2), whereas the quality of Velvetene™ responded positively being cut at 2.7 mm and 3.5 mm. ‘SeaIsle2000’ was continually the worst performer in relation to turfgrass quality, the exception being during the peak of summer and at a high Nitrogen level (N3). Velvetene™ consistently ranked as the better of the three seashore paspalums tested in relation to turfgrass quality.

Like that of the *Cynodon* hybrids turfgrass quality decreased from February 2009 onwards due to a preventative fungicide program not being implemented.

Figure 32. Subjective quality [0 (= worst) to 9 (= best); 6 = acceptable] assessments undertaken of the seashore paspalums between 16 January 2008 and 25 September 2009. Data shown is for the Cultivar (C) x Mowing (M) interactions.

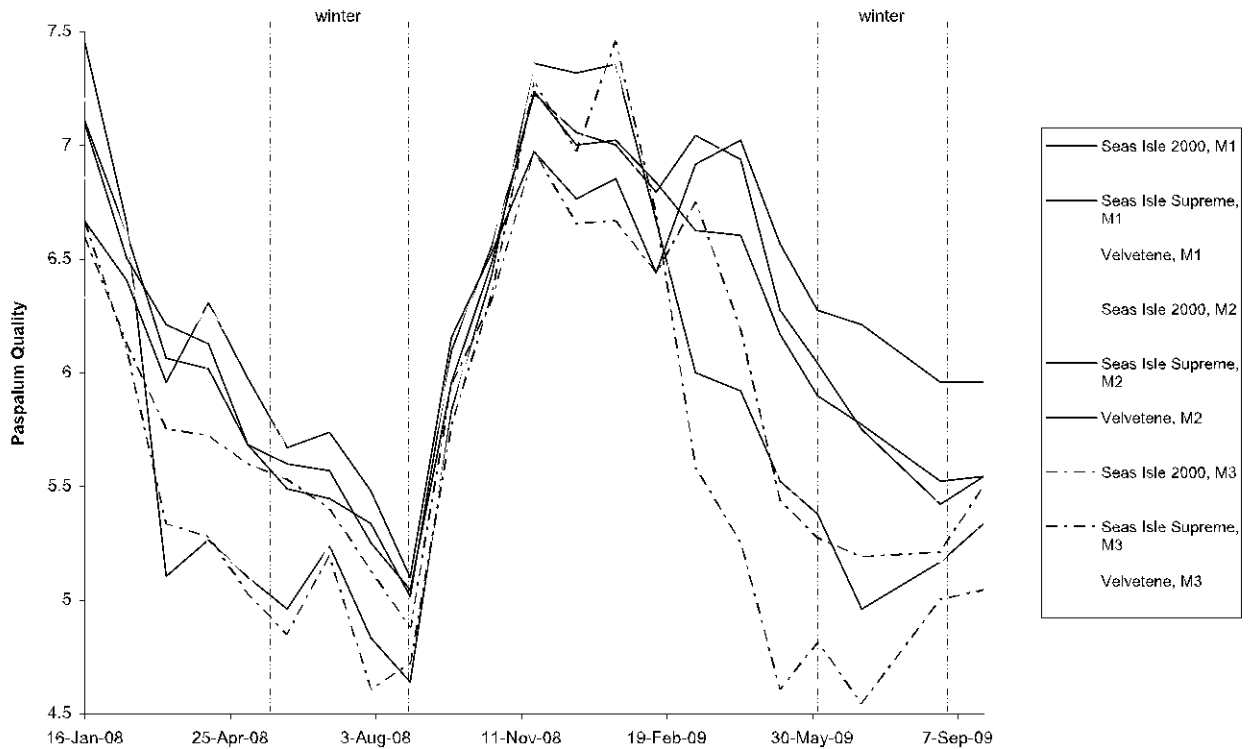
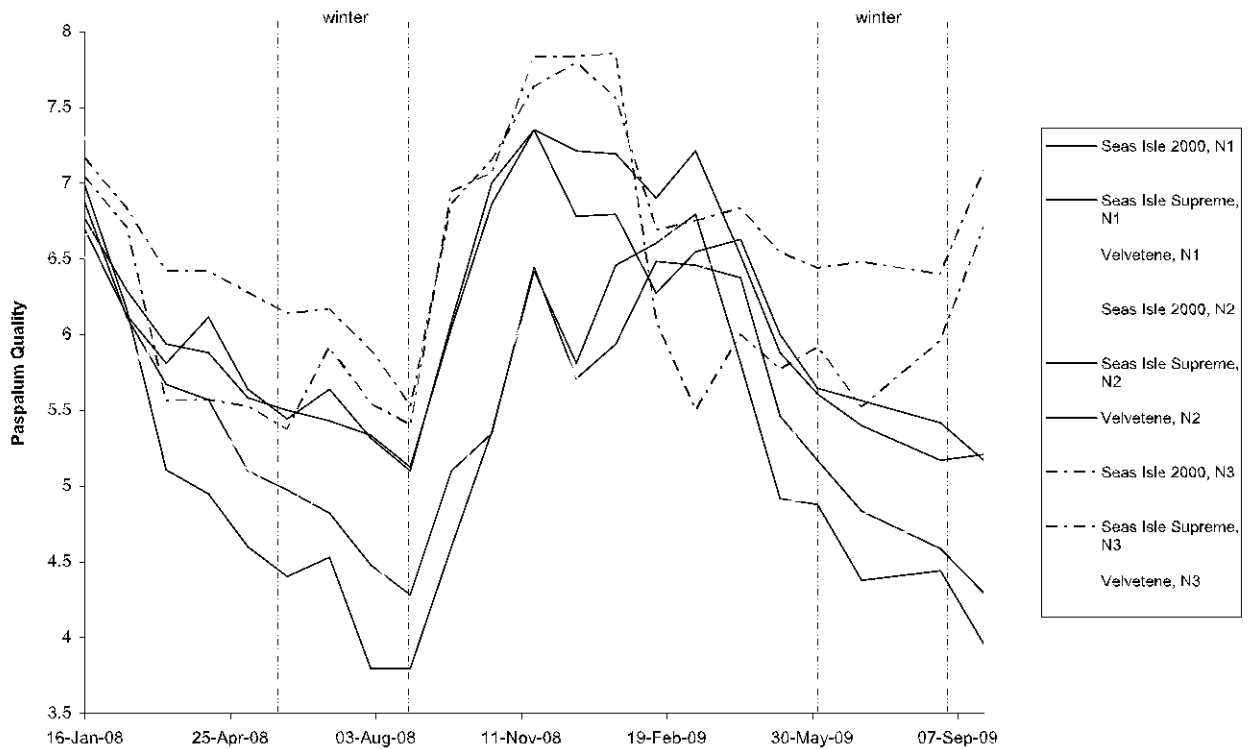


Figure 33. Subjective quality [0 (= worst) to 9 (= best); 6 = acceptable] assessments undertaken of the seashore paspalums between 16 January 2008 and 25 September 2009. Data shown is for the Cultivar (C) x Nitrogen (N) interactions.



Additional and greater detailed graphs containing mean subjective quality assessments of the *Cynodon* hybrids and seashore paspalums from testing undertaken between 16 January 2008 and 25 September 2009 can be found in Appendix 4 (available upon request from the author, 65 pages in total of summarised graphs).

iii) THATCH ASSESSMENTS

Introduction

Thatch is defined as a tightly intermingled layer of dead and living stems (stems, rhizomes and stolons) and roots that develops between the zone of green vegetation and the soil surface (Beard, 1973). The zone should not be confused or included with the 'Mat' layer, which is (if present) located directly beneath the thatch zone and is defined as an organic layer buried and/or intermixed with soil (or sand) from topdressing; It is partially decomposed thatch that has become part of the soil (Beard, 1973). A moderate amount of thatch is desirable to provide insulation, cushioning for wear tolerance, playability/player comfort (particularly elderly lawn bowlers), mulching and reduced compaction (Harivandi, 1984). However, how much or how little is debatable. Researchers have suggested anywhere between 3 mm and 8 mm for greens quality grasses to be considered to be acceptable (Beard, 1982; Daniel and Freeborg, 1979).

Factors that contribute to the build-up of thatch include high inputs of nutrient and water, turf clippings, unfavourable soil conditions (e.g. low or high pH, soil texture, poor drainage, pesticide build up etc) and grass selection (species and cultivar). A primary concern with the introduction and use of the newer *Cynodon* hybrid cultivars and the greens quality seashore paspalums is with thatch accumulation and the necessity of thatch management.

Thatch becomes a problem by causing the surface to be too soft and easily marked and or torn by footprints or turf machinery; It prevents the normal movement of water and air between the atmosphere and playing surface on top and the soil and drainage systems below because of excessive water holding capacity and corresponding oxygen depletion when wet and its potential to display hydrophobic resistance to wetting when dry (Nickson, 2007). Turf with a layer of this sort becomes difficult to maintain in normal healthy growth, being susceptible to pests and diseases and prone to damage by summer drought and winter desiccation as well as scalping when the mower sinks into the surface thatch (Shildrick, 1985). Other issues of concern include pesticide degradation, reduced root depth and mass, pest infestations, fertiliser availability, extreme temperature fluctuations, increased disease populations and an increase in detrimental sub surface feeding insects (Agnew, 1993; Nickson, 2007).

To keep thatch levels in check it is important to monitor and document thatch levels in your green to see what management practices are successfully working or require fine tuning. Subjective and quantitative assessments are two methods by which thatch can potentially be measured. Undertaking subjective ratings is fast and numerous areas of a single or multiple greens can be easily measured simply by walking over the surface of the green. However, human bias much like any form of subjective measuring can play a major role in successfully or unsuccessfully determining what thatch levels are physically present.

Taking a core from the green to measure actual thatch levels can be a little more arduous and somewhat disruptive to the golf or lawn bowls surface. However, if done correctly an uneven or soiled surface can be avoided and this is carried out time and again with golf course superintendents having to change the positioning of the hole cup, sometimes daily. Such regular movement provides ample opportunity to physically measure, document and monitor the thatch present within the green(s).

Firmness of the greens is another method to monitor thatch levels. Technological advances make the process less destructive and time efficient. Baker (1994a) suggested there were three main ways in which to measure the firmness of the putting green surface. These included: the use of the penetrometer, measuring the penetration depth of a lead golf ball that was dropped onto the putting surface and the use of a Clegg Impact Soil Tester (CIST). More recently a 'slide hammer' has been under evaluation in the USA to predict golf ball/turf bounce and roll characteristics of putting greens (Brame, 2008) while also having similar capabilities of quantifying thatch levels.

The use of a CIST is predominantly used to measure soil (or surface) hardness. Soil hardness is defined by Lush (1985) as a measurement of soil compaction or surface strength *in situ*. The higher the peak deceleration value using the CIST, the more energy being returned to the object contacting the surface, or the harder the surface (McCarty et al., 2007; Rogers et al., 1998). CIST values are influenced predominately by two factors, soil moisture and soil type. A third factor is the turfgrass (species, percentage cover etc) and its thatch. In a study undertaken by the Victorian Greenkeepers Association (2004) lawn bowls players identified hardness as a major issue especially among older players.

Materials and Methods

Subjective thatch ratings was undertaken to assess the changing characteristics of the *Cynodon* and *Paspalum* cultivars under different management regimes (mowing/rolling, nutrition, dethatching etc). Ratings conducted between 5 Jun. (6 Jul., 2 Aug., 5 Sep.) and 29 Oct. 2007 were prior to the application of M x N treatments, whereas between 16 Jan. 2007 (14 Feb., 12 Mar., 10 Apr., 7 May, 3 Jun., 2 Jul., 31 Jul., 27 Aug., 24 Sep., 22 Oct., 20 Nov., 19 Dec. 2008; 15 Jan., 12 Feb., 11 Mar., 11 Apr. 8 May, 3 Jun., 3 Jul., 26 Aug.) and 25 Sep. 2009 researchers were directly able to assess the effect of the treatments that had been applied. Turfgrass thatch ratings¹ [0 (= bare ground) to 6 (= spongy, extreme thatch); 2 = acceptable] were undertaken by one to three, usually two DEEDI research staff.

Quantitative thatch measurements were taken four times throughout the duration of the study. Assessments were undertaken of the 324 subplots on the 23 Jan., 17 Sep. 2008, 13 Jan. and 30 Sep. 2009. One sample to a depth of 350 mm and diameter of 105 mm was removed from each subplot using a Turfmaster Deluxe heavy duty golf hole cutter (Better Methods Pty Ltd, Taren Point, New South Wales) (Plate 9). The sample then had a 0.5 kg weight positioned on top of the turf to compact the vegetative material. A ruler was taken to measure the distance between the soil surface and the bottom of the weight, which was defined as quantitative thatch layer.

¹ Thatch ratings have been modified to suit greens quality grasses. For a medium- to long-textured turfgrass ratings would normally be 0 (= bare ground) to 9 (= spongy, extreme thatch); 6 = acceptable.

To determine the correlation between subjective and quantitative thatch measurements data from both sources needed to be analysed. Quantitative data were taken on four occasions from both the *Cynodon* hybrid and seashore paspalum trials during the months of January and September of 2008 and 2009 respectively. Data from subjective thatch measurements was collected on twenty-two occasions between January 2008 and September 2009. To determine if there was a correlation (the extent to which values of the two variables are proportional to each other) between the two collection methods there had to be an equal amount of data sets. Therefore subjective data corresponding to the same months was taken and analysed using statistical software to provide a correlation coefficient (r).

Analysis of subjective and quantitative thatch data was using residual maximum likelihood of the averaged data collected by DEEDI staff. *Cynodon* and *Paspalum* were analysed separately. Treatment effects considered were cultivar (C), mowing regime (M), nitrogen level (N), and all interactions of these factors. For the *Cynodon* analyses blocking effects considered were blocks, strips within blocks, plots and substrips within strips, straps within blocks and substraps within straps. For *Paspalum* analyses blocking effects reduced to blocks, plots and substrips within blocks and substraps within plots (blocks and strips were synonymous for these analyses, as were plots and straps). In cases where the estimate of a variance component was negative this term has been omitted from the model and data reanalysed. Where appropriate, pairwise comparisons were made using the protected least significant difference procedure at $P=0.05$.

Surface hardness was assessed on 13 Jul. and 3 Aug. 2007 using a 2.25 kg medium Clegg Impact Hammer (Dr Baden Clegg Pty Ltd, Wembley, Western Australia). The weighted hammer was dropped from a distance of 303 mm once to provide a Clegg Impact Value (CIV). Three readings were taken per plot and were average before statistical analysis.

All analyses were using GenStat® Release 11.1 for PC/Windows. Graphs were constructed using Microsoft® Office Excel 2003.

Results and Discussion

Subjective Thatch

Early testing of the *Cynodon* hybrids between June and October 2007 confirmed that thatch development of the “ultradwarfs” was fast from the time of planting. A heavy scarification was undertaken in February 2007. Significant differences ($P<0.05$) were observed (Table 17) between the “ultradwarfs” and the older industry standards ‘Tifgreen’ and ‘Tifdwarf’.

The seashore paspalums remained firm under the foot, compared to the couches where they (e.g. MiniVerde™) became spongy. Little cultivar variation within thatch levels was observed from outset up until 29 October 2007.

Table 17. Thatch ratings [0 (= bare ground) to 6 (= spongy, extreme thatch); 2 = acceptable] undertaken between 5 Jun. and 29 Oct. 2007 prior to the treatments being setup

Cultivars	Turf Thatch Ratings				
	05-Jun-07	06-Jul-07	02-Aug-07	05-Sep-07	29-Oct-07
<i>Cynodon hybrid:</i>					
MiniVerde	3.9	3.9	4.0	3.7	2.9
MS-Supreme	2.3	2.2	2.2	2.6	1.8
Novotek	2.4	2.1	2.1	2.3	2.1
Tifdwarf	1.0	1.1	1.1	1.7	1.4
TifEagle	3.1	2.9	2.7	2.8	1.8
Tifgreen	1.6	1.5	2.1	2.3	1.6
LSD ($P=0.05$)	0.4	0.4	0.4	0.5	0.7
<i>Paspalum:</i>					
Sea Isle 2000	1.1	1.3	1.7	1.8	1.6
Sea Isle Supreme	1.5	1.5	2.0	1.8	1.6
Velvetene	1.2	1.4	1.7	1.7	1.6
LSD ($P=0.05$)	0.1	0.2	0.1	0.1	-

Major/heavy scarification activities were undertaken in November and December 2007 to supply regional trial sites with vegetative material (sprigs) for planting. Additional dethatching practices (e.g. scarifying, groomers set at -2 mm, double cutting) were undertaken from January 2008 until the trial was completed in September 2009. These activities can be seen in Table 18.

Significant effects (<0.001 to 0.031) were observed in subjective thatch assessments of the *Cynodon* hybrids cultivars during each of the 22 testing periods from January 2008 to September 2009. Of the interaction between C x M, only 4 significant effects were observed. Raters observed slightly higher readings for the hybrids cut at 3.5 mm (M1 and M2) in comparison to being cut shorter at 2.7 mm (M3).

Higher fertility (N2 and N3) produced significant effects ($P<0.05$) from December 2008 to September 2009 when the majority of the *Cynodon* cultivars increased significant levels of thatch.

The “ultradwarfs” became spongy and produced significantly more thatch than ‘Tifgreen’ and ‘Tifdwarf’. MiniVerde™ was the most prolific, whether it was being cut at 2.7 mm or 3.5 mm, or having nitrogen being applied at 1kg N/100m²/yr (N1) or 4kg N/100m²/yr (N3). There was little to no variation in thatch reduction over winter. Thatch accumulation increased exponentially from late 2008 to late 2009 and did not show any significant reduction following dethatching practices (Table 18). This suggests that dethatching activities were neither intense nor frequent enough to make noticeable differences under foot. One exception to this was with the *Cynodon* cultivar ‘Tifgreen’ where from March 2009 it continued to decrease in subjective ratings, so too did turfgrass quality.

Figure 34. Subjective thatch [0 (= bare ground) to 6 (= spongy, extreme thatch); 2 = acceptable] assessments undertaken of the *Cynodon* hybrids between 16 January 2008 and 25 September 2009. Data shown is for the Cultivar (C) x Mowing (M) interactions.

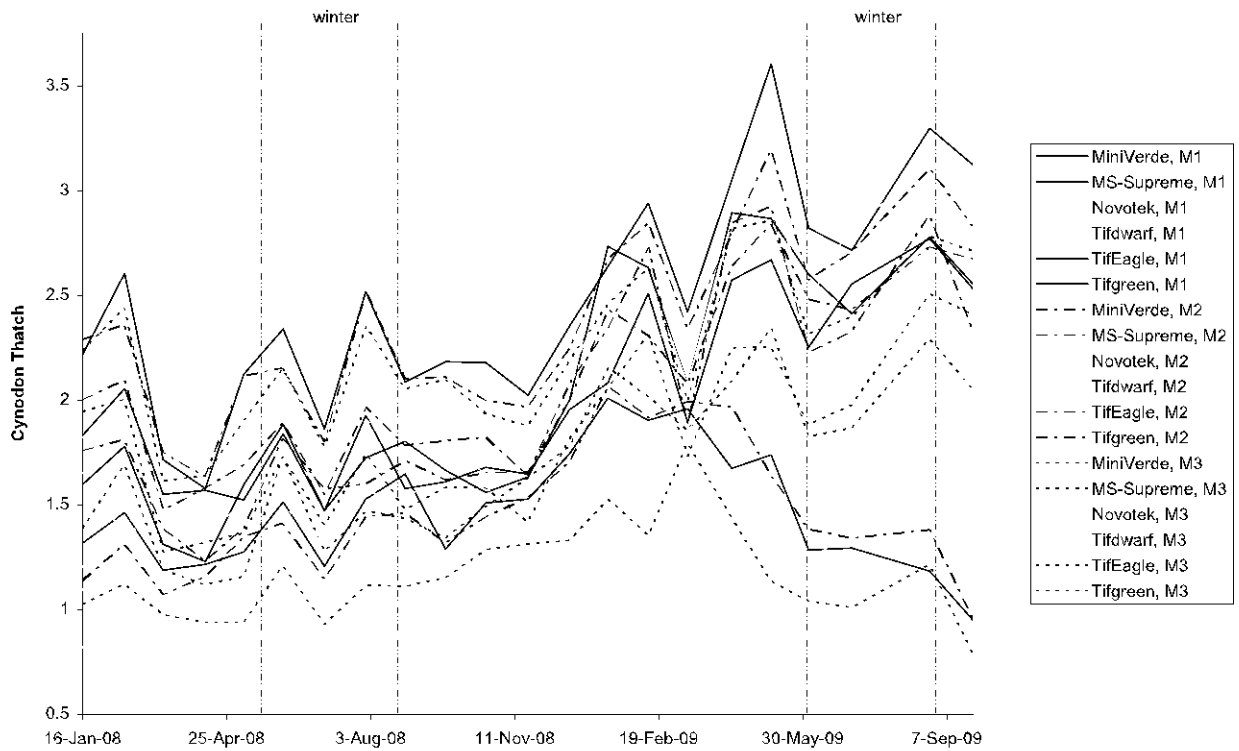
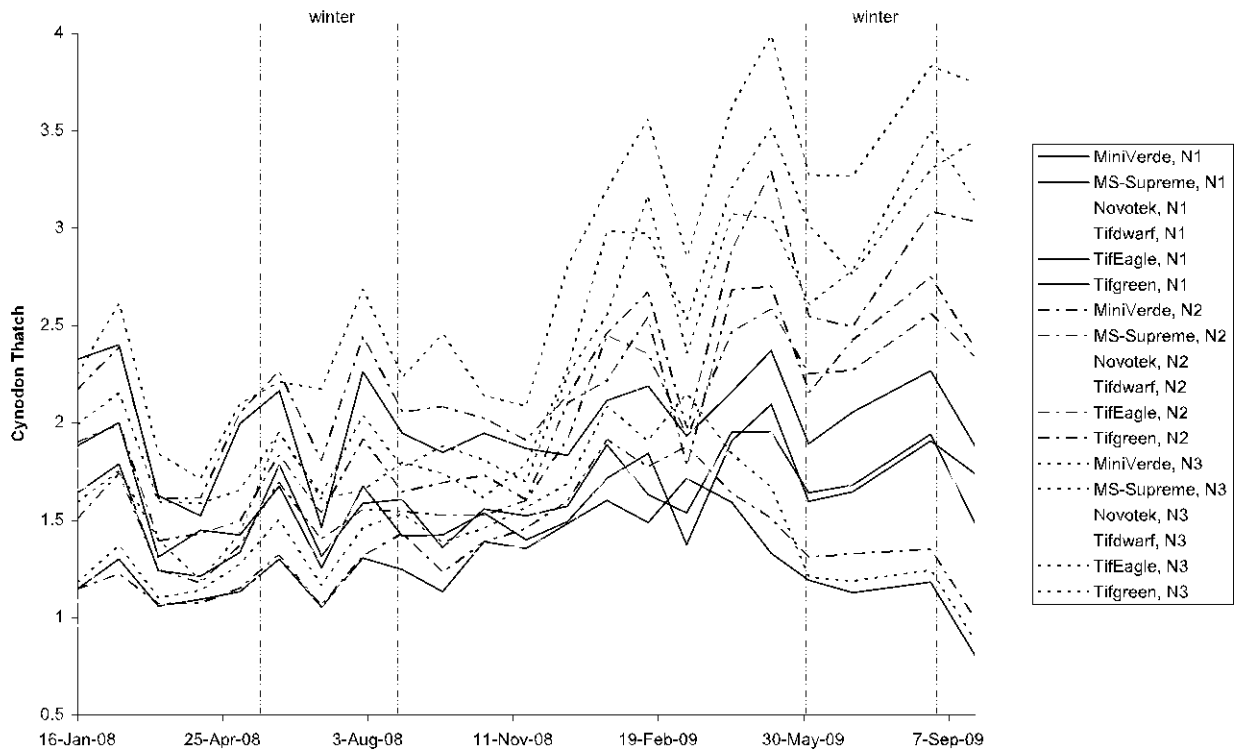


Figure 35. Subjective thatch [0 (= bare ground) to 6 (= spongy, extreme thatch); 2 = acceptable] assessments undertaken of the *Cynodon* hybrids between 16 January 2008 and 25 September 2009. Data shown is for the Cultivar (C) x Nitrogen (N) interactions.



Of the seashore paspalums there were no considerable effects of mention between either C x M and C x N, however if present, were likely to be masked by the firmness of the turf surface compared to the *Cynodon* hybrids which were on the most part, spongy. Of the three cultivars trialled, Velvetene™ had a greater branching habit (see chapter 2); however greater branching was not reflected in higher thatch accumulation. ‘Sea Isle 2000’ obtained slightly higher subjective ratings being cut at 3.5 mm compared to Velvetene™ and Sea Isle Supreme™. Nitrogen levels dominated once again like that of the *Cynodon* hybrids, with that did N3 (4kg N/100m²/yr) producing higher values.

With consideration of the subjective thatch data and dethatching program implemented to manage the seashore paspalums it is possible that scarification activities contributed to a reduction in thatch. However, thatch that was removed could have also only firmed/tightened the surface further and not necessarily addressed the problem.

Figure 36. Subjective thatch [0 (= bare ground) to 6 (= spongy, extreme thatch); 2 = acceptable] assessments undertaken of the seashore paspalums between 16 January 2008 and 25 September 2009. Data shown is for the Cultivar (C) x Mowing (M) interactions.

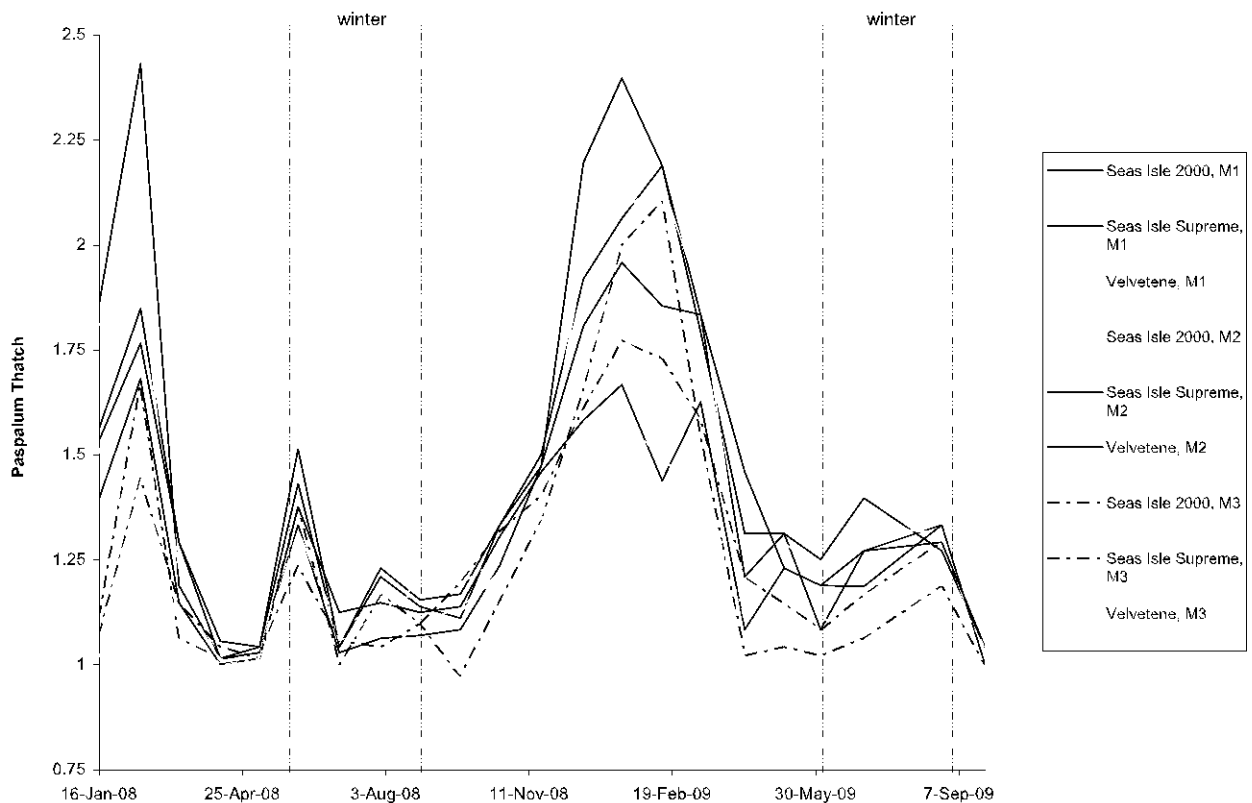
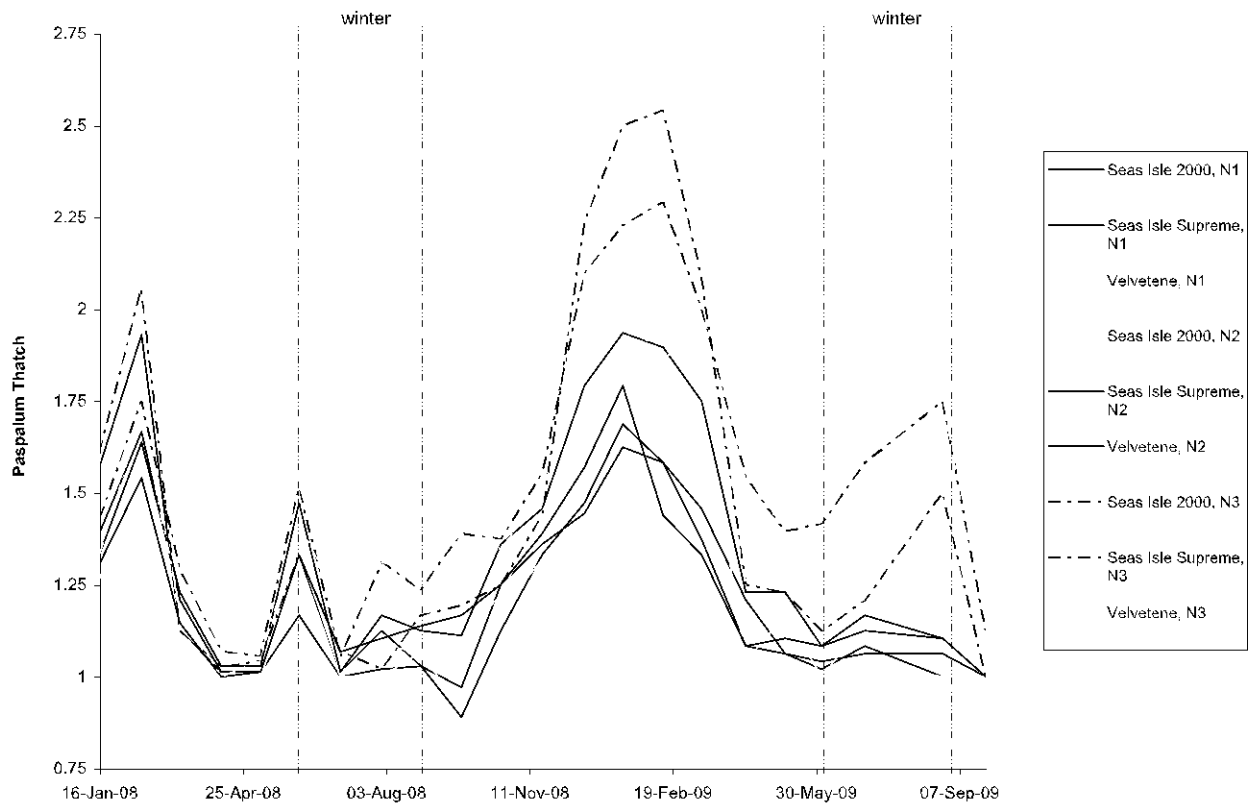


Figure 37. Subjective thatch [0 (= bare ground) to 6 (= spongy, extreme thatch); 2 = acceptable] assessments undertaken of the seashore paspalums between 16 January 2008 and 25 September 2009. Data shown is for the Cultivar (C) x Nitrogen (N) interactions.



Quantitative thatch

Recorded quantitative thatch levels of both the *Cynodon* hybrids and seashore paspalums are disturbing. From when the first physical measurements were collected in January 2008, thatch levels were already between 12 and 20 mm. These figures were already outside of the recommended values of 3 to 8 mm (Beard, 1982; Daniel and Freeborg, 1979). With the exception of 'Tifgreen' being cut at 2.7 mm (M3), at no stage did thatch levels of any of the *Cynodon* hybrids fall as low as what they were when they were first measured within the 22 month timeframe. Cultivars that were cut at 3.5 mm and rolled (treatment M2) produced slightly higher thatch levels. On the whole, there was a reduction in thatch levels from all six *Cynodon* cultivars following an intensive scarification in January 2009. The "ultradwarfs" as expected produced higher thatch levels than the first-generation greens grasses 'Tifgreen' and 'Tifdwarf' which confirms that they require a far more intensive and or frequent dethatching program to control their thatch.

Figure 38. Quantitative thatch assessments undertaken for the *Cynodon* hybrids between 23 January 2008 and 30 September 2009. Data shown is for the Cultivar (C) x Mowing (M) interactions.

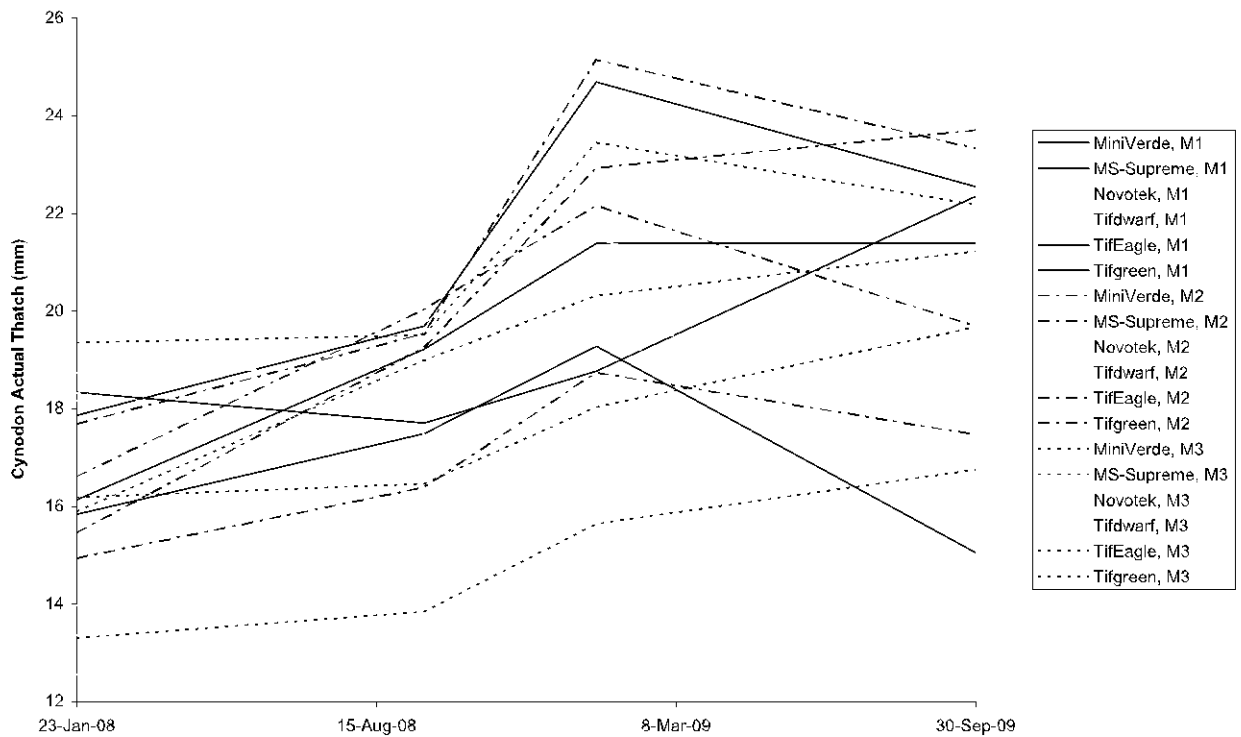
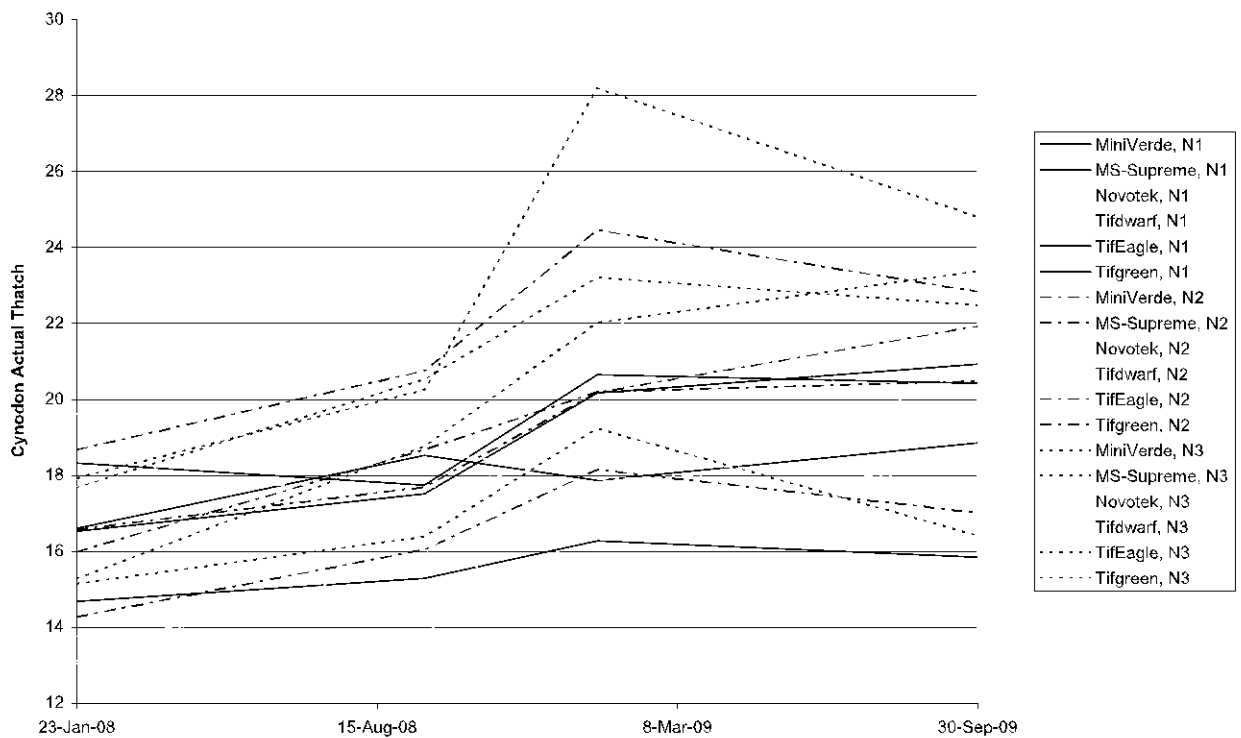
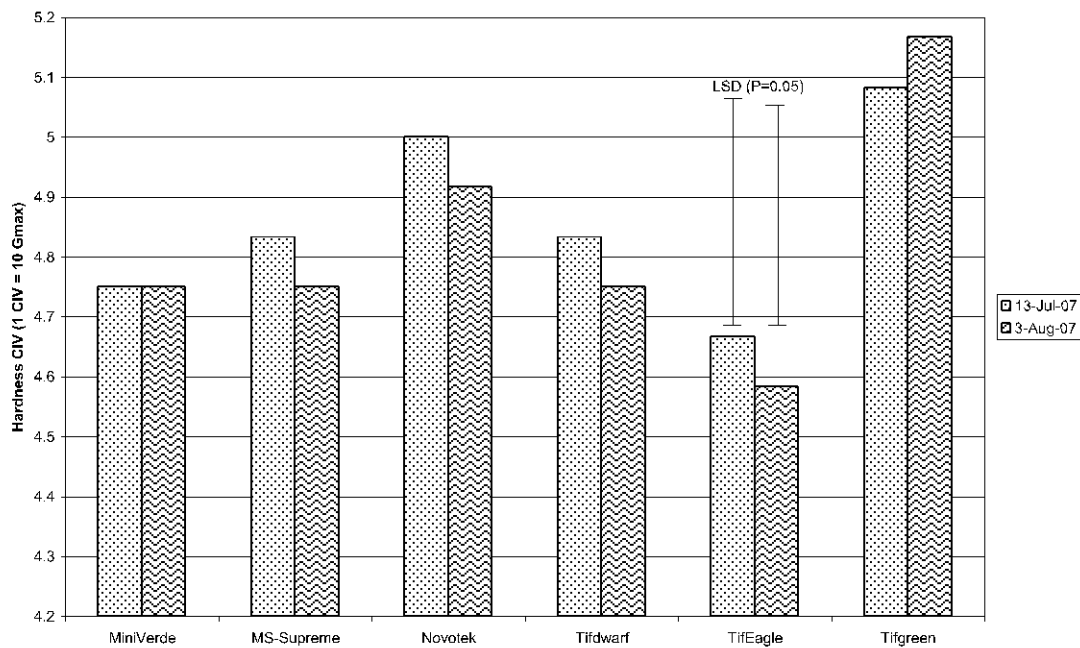


Figure 39. Quantitative thatch assessments undertaken for *Cynodon* hybrids between 23 January 2008 and 30 September 2009. Data shown is for the Cultivar (C) x Nitrogen (N) interactions.



In July and September 2007 DEEDI technical staff investigated the use of the medium 2.25 kg Clegg Impact Soil Tester (CIST) to measure firmness of the *Cynodon* greens surface (Figure 40). Following discussions with AGCSA technical staff and New Zealand Sports Turf Institute (NZSTI) staff, DEEDI scientists chose to cease using the CIST as it did not provide sufficiently accurate measurements of surface hardness relative to greens conditions. This is clearly evident when you evaluate the data collected and displayed in Figure 40, compared to Figure 38 and Figure 39.

Figure 40. Clegg Impact Soil Tester values (CIV) during testing undertaken of the *Cynodon* hybrids 13 July and 3 August 2007.



Quantitative thatch levels of the seashore paspalums were far greater than that observed within the *Cynodon* hybrids. Mowing at 3.5 mm (M1) produced higher levels of thatch compared to treatments M2 (3.5 mm cut and rolled) and M3 (2.7 mm cut). There were no significant differences ($P>0.05$) in quantitative thatch levels between cultivars, however nitrogen applications at 2kg N/100m²/yr (N2) and 4kg N/100m²/yr (N3) produced higher thatch levels.

Figure 41. Quantitative thatch assessments undertaken for seashore paspalums between 23 January 2008 and 30 September 2009. Data shown is for the Cultivar (C) x Mowing (M) interactions.

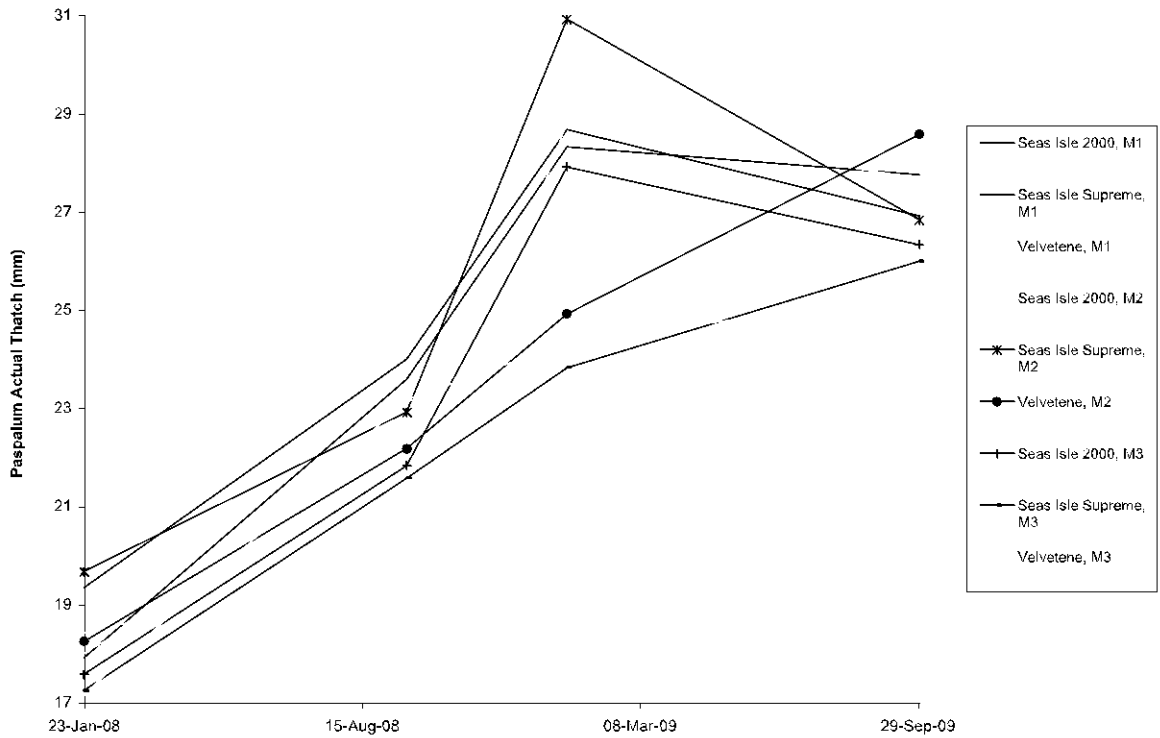


Figure 42. Quantitative thatch assessments undertaken for seashore paspalums between 23 January 2008 and 30 September 2009. Data shown is for the Cultivar (C) x Nitrogen (N) interactions.

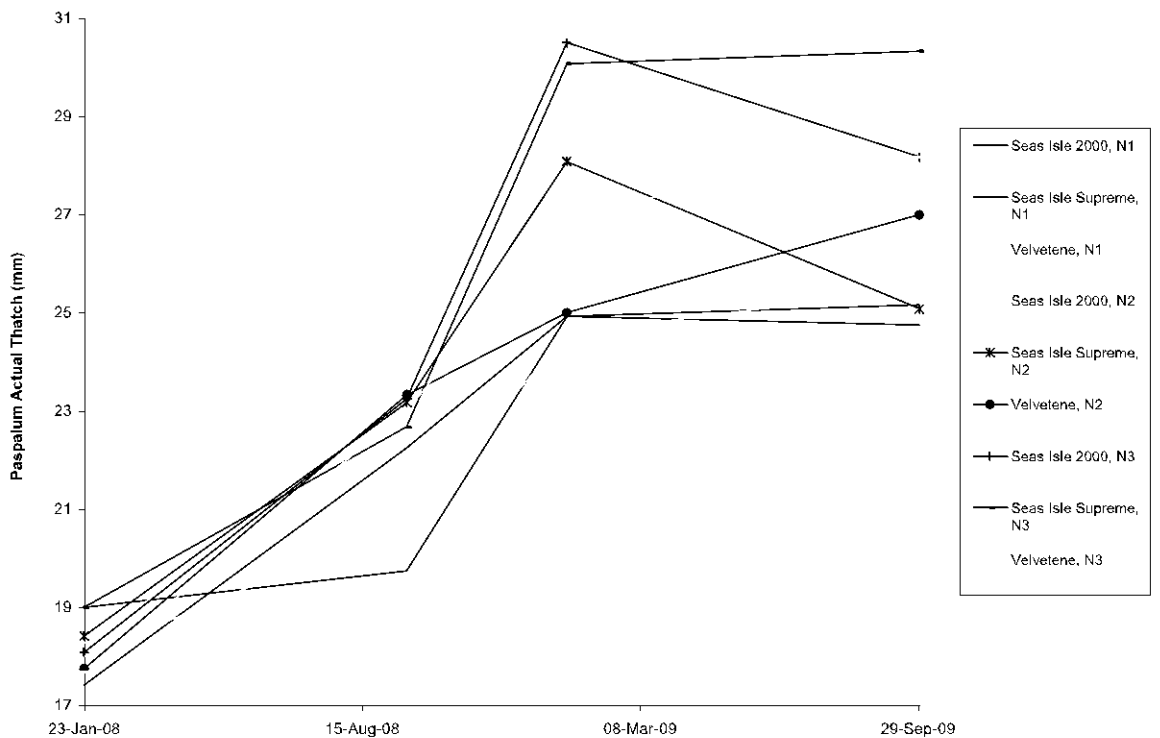


Plate 9. A section of the 324 subplots that had to be removed from the ground using a hole cup changer and then measured to determine the actual thatch depth (also the average and maximum root depths). Photo taken 17 September 2008.



A problem with adopting the quantitative approach of measuring thatch within a green is determining where the thatch layer starts and finishes. Beard (1973) clearly defines what both thatch and 'Mat' are, and where they are "commonly" located. However, in a golf course or bowls environment where a green has been *in situ* for many years and is likely to have been renovated and managed by varied turf managers, identifying these levels or zones can be difficult. Turf managers who routinely apply topdressing or undertake dusting are introducing "floating layers" and distorting (breaking down) the thatch and mat layer, which is the goal. But to identify how much thatch is in your surface, particularly in an older green, a preferred method would be to undertake organic matter content (OMC) testing. OMC testing is a method by which the percentage of organic matter of a green root zone mixture (thatch, mat and soil) can be calculated following loss of ignition or the Wakley-Black methods of testing. These tests are explained in detail in The American Society for Testing and Materials standard (ASTM F1647 – 02a) (ASTM International, 2002). OMC testing is viewed as another key tool in determining thatch/organic matter levels within your green. The information obtained from these results has the opportunity to provide turf managers with a benchmark figure and an insight into the management practices required to keep thatch levels under control.

Additional and greater detailed graphs containing mean subjective and quantitative thatch assessments of the *Cynodon* hybrids and seashore paspalums from testing undertaken between 16 January 2008 and 30 September 2009 can be found in Appendix 4 (available upon request from the author, 65 pages in total of summarised graphs).

Subjective vs. quantitative thatch

Both methods have their advantages and disadvantages. To determine if the subjective method was as accurate as physically removing and measuring samples from the green a linear correlation was made using both sets of data.

Statistical analysis of both the *Cynodon* cultivars (C), C x M (Figure 43) and C x N (Figure 44) provided very strong positive linear relationships between assessment by subjective and quantitative means. The interaction of C x M was only slightly higher ($r = 0.8473$) than C x N ($r = 0.8322$) when determining the coefficient correlation (r). However, this subtle difference is significantly magnified if the coefficient of determination (r^2 or R-squared) is calculated. The coefficient of determination is typically interpreted as the percent of variation shared between the two variables. The coefficient of determination of the C x M and C x N of the *Cynodon* hybrids were 72% and 69% respectively (notice how sharply the coefficients of determination decline when compared with their respective correlation coefficients), meaning that 28% and 31% of the variance were not shared between either subjective or quantitative means. The positive relationship of the two variables shown in the *Cynodon* hybrids indicate in this instance that subjective assessment is a suitable method from which thatch can be successfully monitored.

Figure 43. Correlation coefficient (r) of subjective and quantitative thatch assessments of the *Cynodon* hybrids cultivar (C) x mowing (M) data collected in January and September of 2008 and 2009.

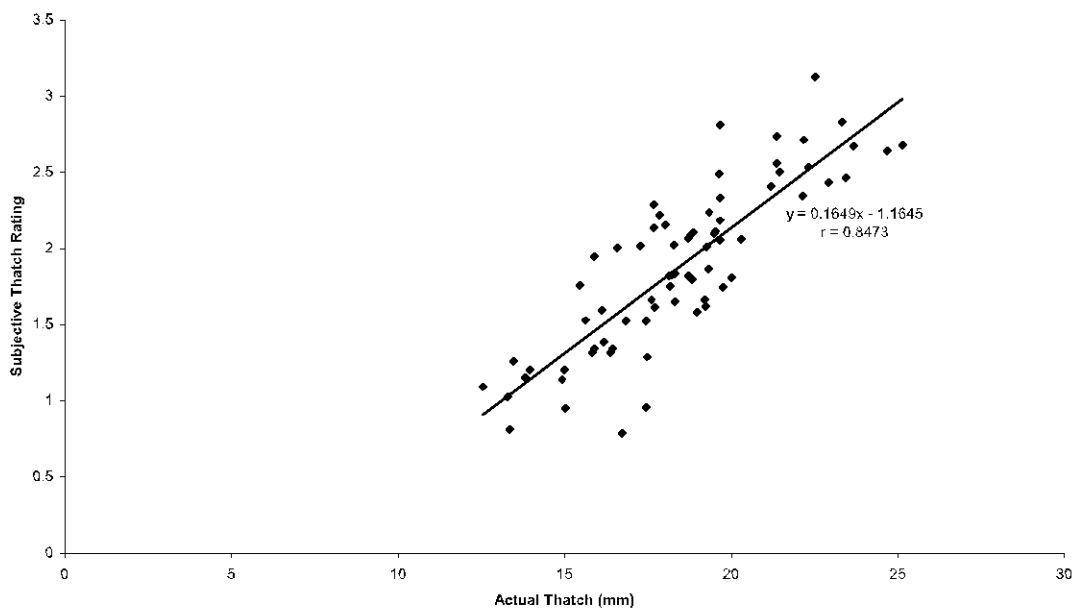
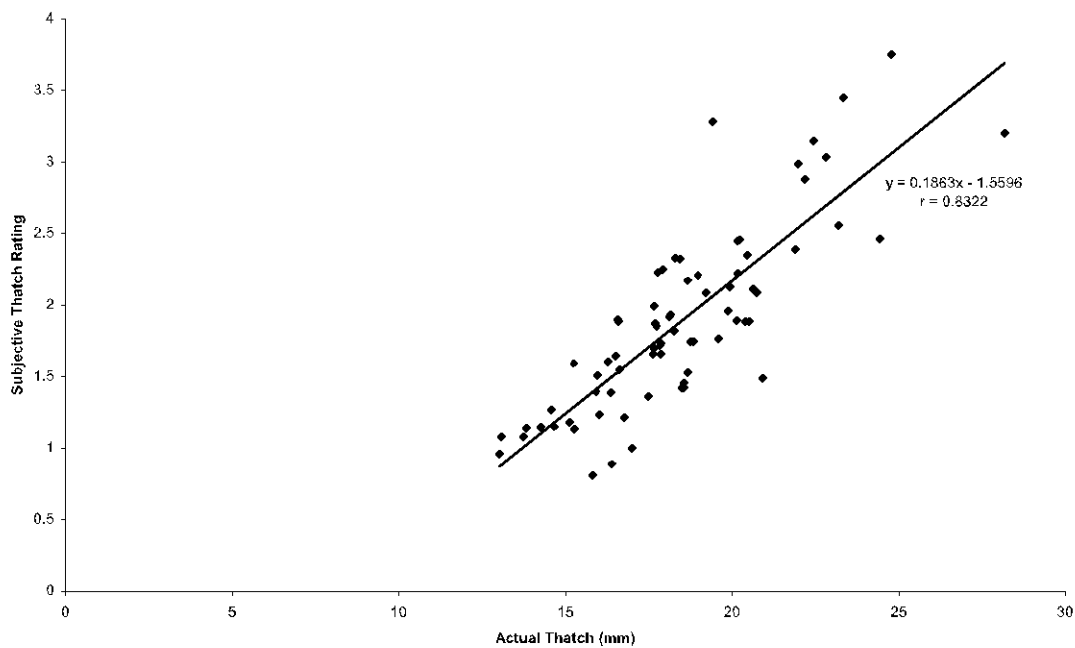


Figure 44. Correlation coefficient (r) of subjective and quantitative thatch assessments of the *Cynodon* hybrids cultivar (C) x nitrogen (N) data collected in January and September of 2008 and 2009.



Results obtained following statistical analysis of the seashore paspalums differ dramatically from the correlation coefficients seen in the *Cynodon* hybrid experiment. The coefficient correlations obtained from the C x M (Figure 45) and C x N (Figure 46) interactions following analysis showed that the linear relationship between subjective and quantitative assessments based on the 2008 and 2009 data were both positively very weak ($r = 0.2295$ and $r = 0.2865$ respectively). The coefficient of determination for both assessments were in turn extremely low, with only 5% (C x M) and 8% (C x N) of the variance in the subjective method shared with the quantitative method (or vice versa).

This weak relationship is thought to be directly linked to the failure of assessors successfully rating the *Paspalum* plots subjectively. The problem lays in the strong, dense rhizome system of the *Paspalum* plants which produces a compacted and heavily intertwined thatch and mat layer. The end result is that the *Paspalum* turfgrass remains firm under foot with an inconspicuous thatch layer, unlike the *Cynodon* hybrids, which become spongy particularly under high nitrogen rates. An increased thatch layer is unwanted, however a firmer surface is beneficial in providing faster green speeds in a species that is recognized as being slower. Due to the morphological and developmental variation between the species it is recommended to use quantitative means to efficiently measure, record, monitor and control thatch development in a seashore paspalum green.

Figure 45. Correlation coefficient (r) of subjective and quantitative thatch assessments of the seashore paspalums cultivar (C) x mowing (M) data collected in January and September of 2008 and 2009.

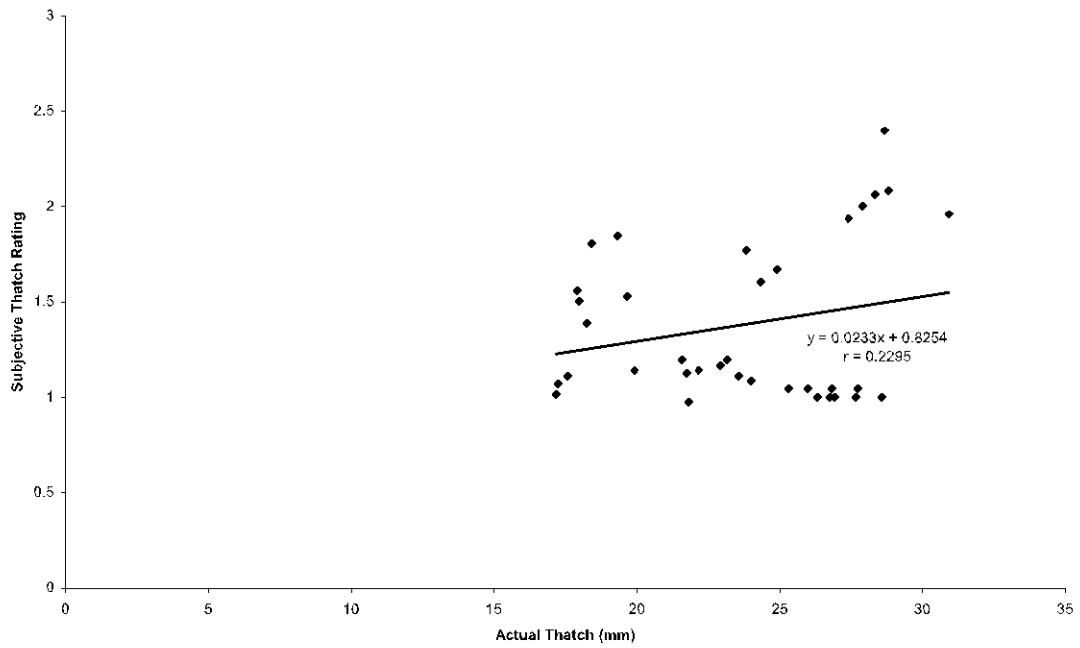
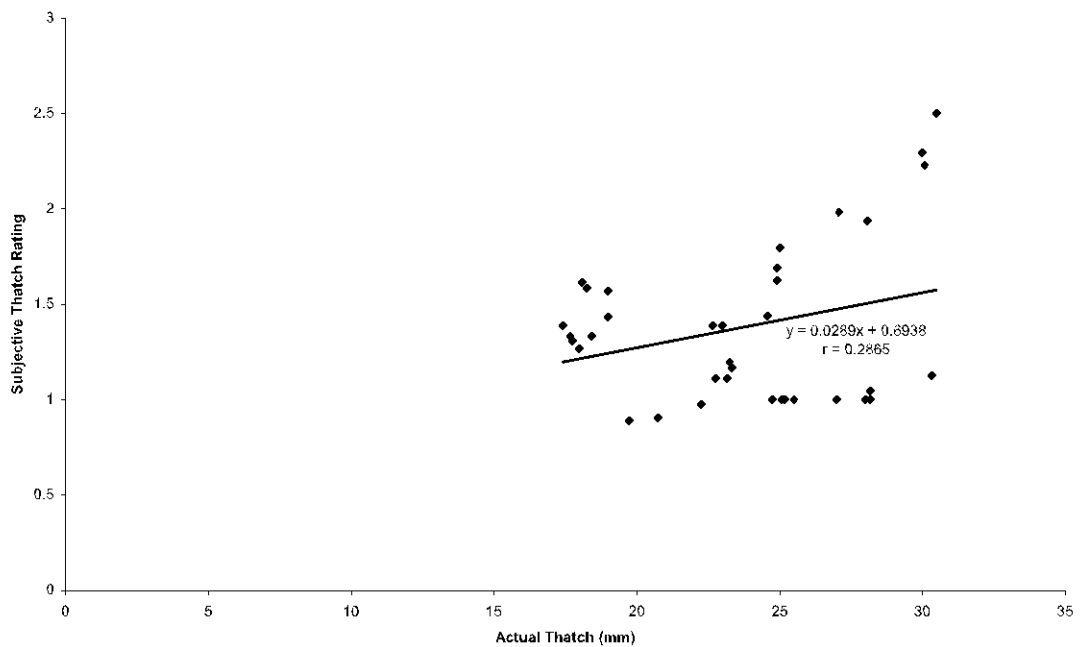


Figure 46. Correlation coefficient (r) of subjective and quantitative thatch assessments of the seashore paspalums cultivar (C) x nitrogen (N) data collected in January and September of 2008 and 2009.



iv) ROOTING DEPTHS

Introduction

For more than 40 years the United States Golf Association (USGA) recommendations for green construction have been the most widely used method of green construction throughout the USA and in other parts of the world including Australia (USGA Green Section, 2009). A standard USGA sub grade is established to a depth between 400 and 500 mm, with 300 mm provided for the root zone mixture. For the construction of the DEEDI Test Facility Green USGA specification sand and amendments were used (Figure 47). For a detailed list of sand, soil, organic, inorganic, and amendments that can be incorporated into the root zone following the 2004 revision of the USGA Recommendations for a Method of Putting Green Construction, please visit the USGA web site (<http://www.usga.org>) (USGA Green Section, 2009).

Figure 47. Cross section of DEEDI Redlands Centralised Testing green. Design and image provided by David Burrup, David Burrup Golf & Sports Turf Designs, Aus.



To obtain the optimum turfgrass surface it is essential that root development is strong. A dense healthy root system will provide the opportunity for the plant to uptake sufficient water and nutrients and overcome stresses incurred (e.g. prolonged warmer temperature, drought). To provide a healthy root system it is essential to irrigate based on depth of rooting (e.g. short daily cycles are not sufficient) and provide adequate nutrition and management practices such as aerification. These practices will allow for suitable root development and allows rhizomes and fibrous roots to explore the entire depth of the root zone medium.

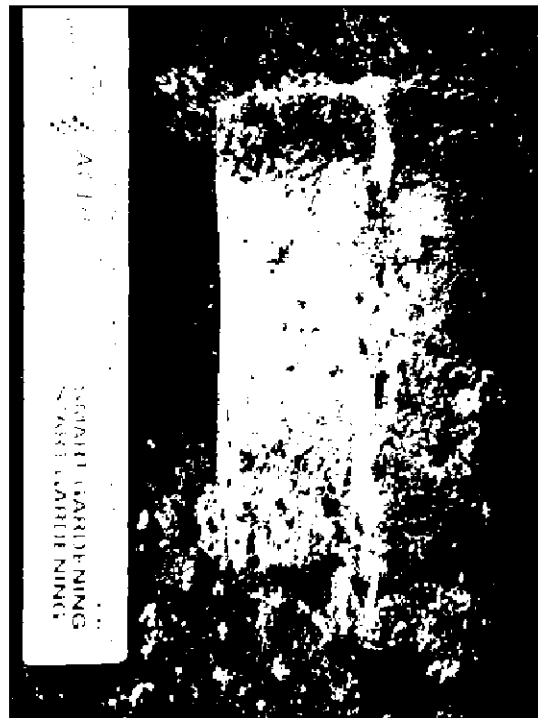
Material and Methods

Average and maximum rooting depths were measured quarterly for both the *Paspalum* and *Cynodon* cultivars. Data was collected 9 Apr., 5 Aug. 15 Oct. 2008, 14 Jan., 7 Apr., 28 Jul., and 1 Oct. 2009. One core was taken per subplot using a Turfmaster Deluxe heavy duty golf hole cutter (Better Methods Pty Ltd, Taren Point, New South Wales) and the sample was removed from the ground and positioned alongside a ruler to first obtain a maximum root depth reading; the maximum root depth was defined as the depth at which root development was greatest (which is limited to just beyond the depth of the hole changer) per core/plug (Plate 10). The core/plug was then lifted and given a gentle shake to remove any loose soil. The remaining or intact roots were then measured with a ruler to provide an average

rooting depth (data not shown). If the roots or soil did not break free from the plug, the average and maximum value would be recorded as the same value.

Analysis of maximum rooting data was using residual maximum likelihood of the averaged data collected by DEEDI staff. *Cynodon* and *Paspalum* were analysed separately. Treatment effects considered were cultivar (C), mowing regime (M), nitrogen level (N), and all interactions of these factors. For the *Cynodon* analyses blocking effects considered were blocks, strips within blocks, plots and substrips within strips, straps within blocks and substrips within straps. For *Paspalum* analyses blocking effects reduced to blocks, plots and substrips within blocks and substrips within plots (blocks and strips were synonymous for these analyses, as were plots and straps). In cases where the estimate of a variance component was negative this term has been omitted from the model and data reanalysed. Where appropriate, pair wise comparisons were made using the protected least significant difference procedure at $P=0.05$. All analyses were using GenStat® Release 11.1 for PC/Windows. Graphs were constructed using Microsoft® Office Excel 2003.

Plate 10. Measuring maximum root holding depth of a sample taken using a hole cutter on 15 October 2008. Note the cavity filled with clear white sand following coring and topdressing carried out 8 days earlier.



Results and Discussion

Once the *Cynodon* hybrids were established and treatments (M and N) imposed, root development was no shorter than to a 170 mm depth. There were no major trends in maximum rooting depth when investigating the interaction between C x M and C x N of the of the *Cynodon* hybrids. Of the C x M interactions, MiniVerde™ produced the deepest rooting system in the winter of 2008 growing to a depth of 224 mm - 225 mm (treatments M3 and M2 respectively). However in the winter of 2009 the same cultivar dropped to 171 mm and 174 mm respectively, while treatment M1 (cut at 3.5 mm) grew to a depth of 195 mm. Treatment M1 did not consistently produce the deepest rooting system, but on a whole the 3.5 mm cut (treatments M1 and M2) produced a marginally better root system. This was also evident during winter suggesting that a rise in cutting height may reduce stress levels being placed on the turfgrass during the cooler months.

High levels of nitrogen did not produce a deeper rooting system of the *Cynodon* hybrids. MiniVerde™ responded better to lower N levels, while at the other end of the scale; 'TifEagle' produced a shorter root system at higher N levels.

Figure 48. Maximum rooting depth (mm) of the *Cynodon* hybrids between 9 April 2008 and 1 October 2009. Data shown is for the Cultivar (C) x Mowing (M) interactions of the maximum rooting depths only (average depths not shown).

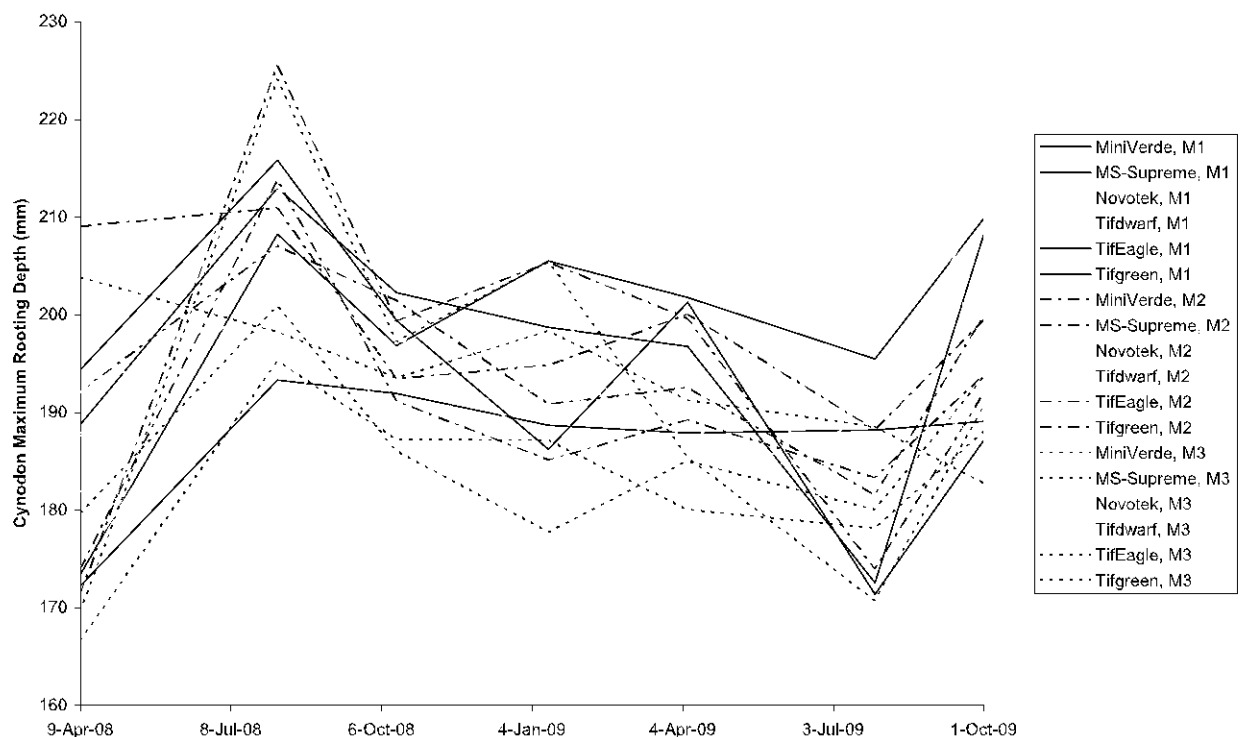
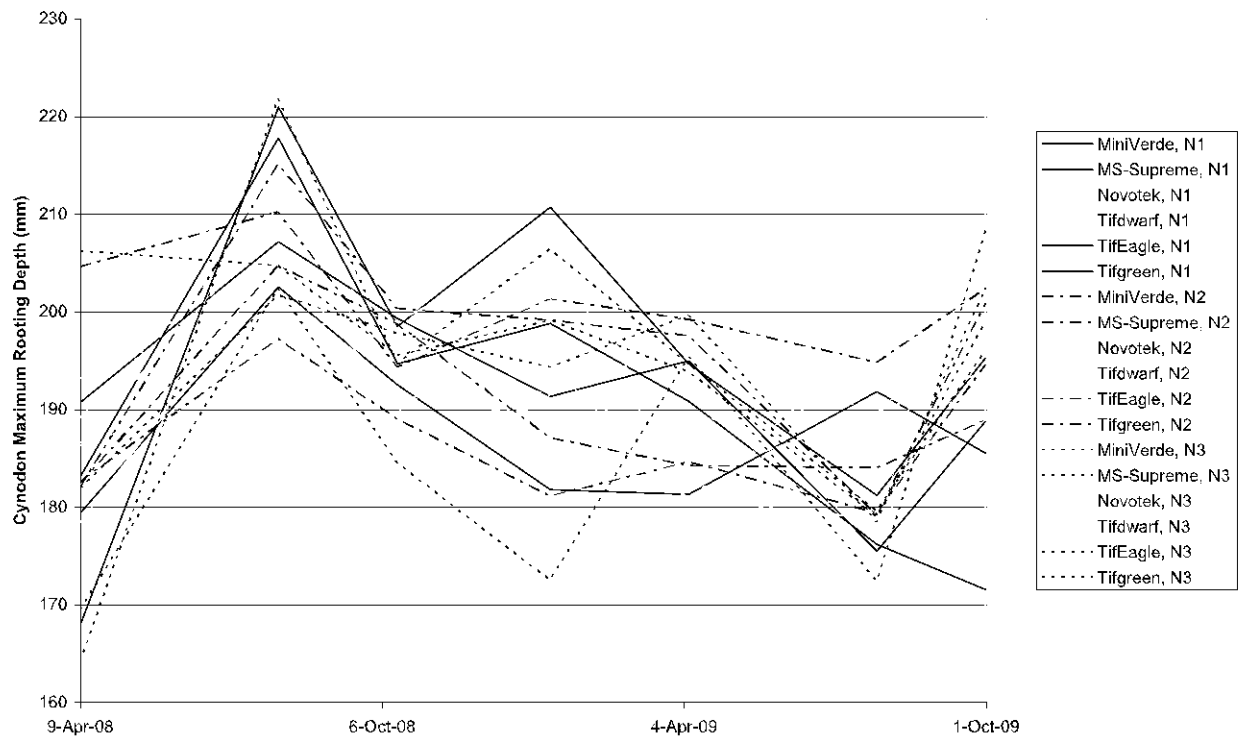


Figure 49. Maximum rooting depth (mm) of the *Cynodon* hybrids between 9 April 2008 and 1 October 2009. Data shown is for the Cultivar (C) x Nitrogen (N) interactions of the maximum rooting depths only (average depths not shown).



Root development for the seashore paspalums was very similar to that of the *Cynodon* hybrids. Following establishment and application of M and N treatments, root development did not fall below a depth of 165 mm. Like that of the *Cynodon* hybrids there were no significant interactions between C x M and C x N treatments. ‘Sea Isle 2000’ produced a deeper root system in the winter of 2008 measuring 203 mm to 207 mm being cut at 3.5 mm (M1). Root development of the seashore paspalums dropped noticeably during summer 2009. During this period Velvetene™ was the better performer of the three cultivars being mown at 3.5 mm (M1) with a lower nitrogen rate (N1).

Figure 50. Maximum rooting depth (mm) of the seashore paspalums between 9 April 2008 and 1 October 2009. Data shown is for the Cultivar (C) x Mowing (M) interactions of the maximum rooting depths only (average depths not shown).

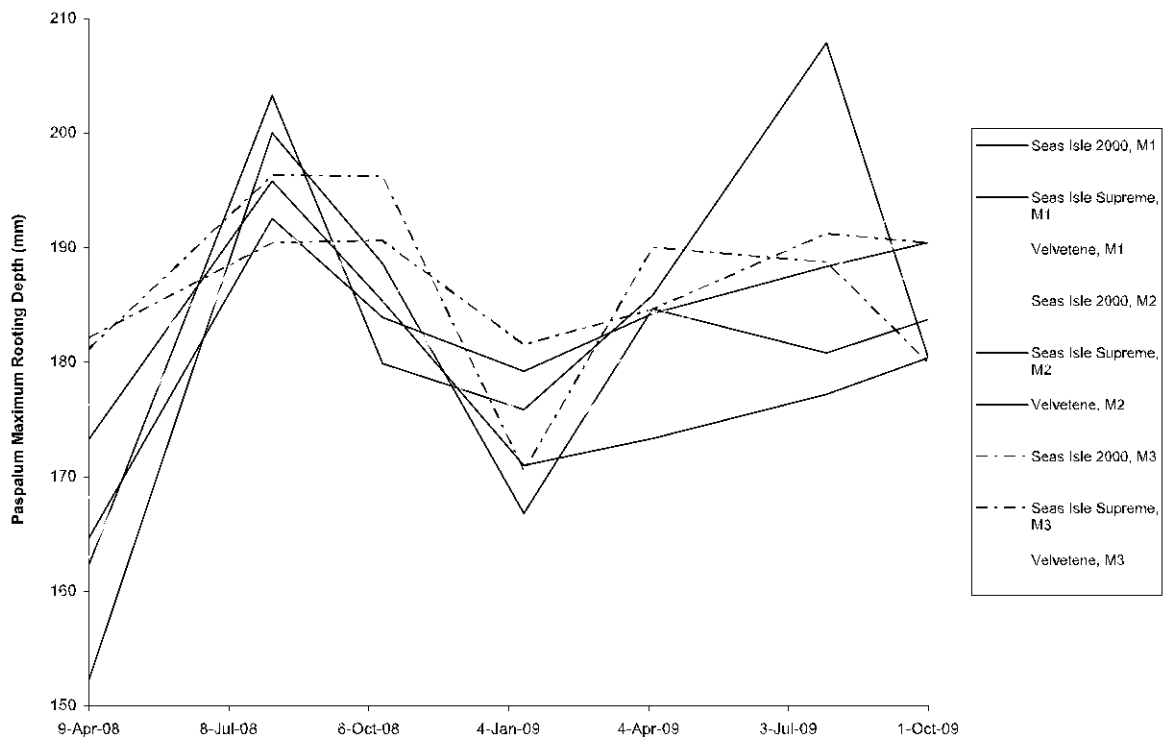
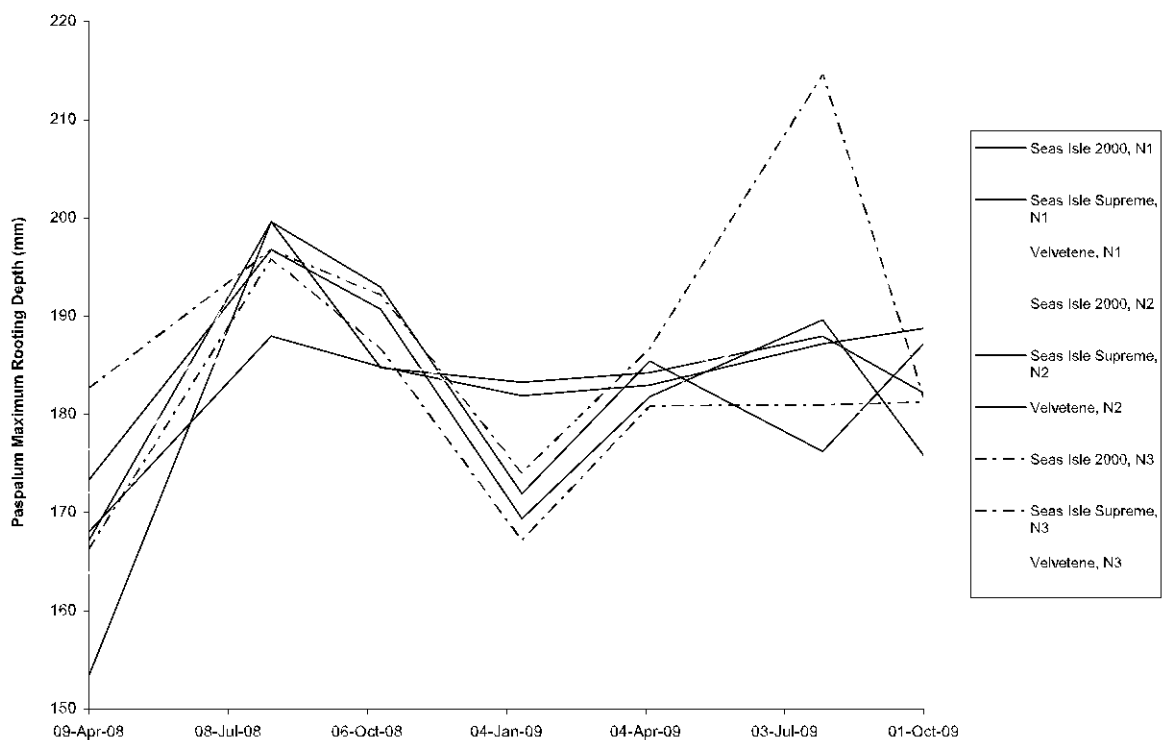


Figure 51. Maximum rooting depth (mm) of the seashore paspalums between 9 April 2008 and 1 October 2009. Data shown is for the Cultivar (C) x Nitrogen (N) interactions of the maximum rooting depths only (average depths not shown).



Additional and greater detailed graphs containing mean maximum rooting data of the *Cynodon* hybrids and seashore paspalums from testing undertaken between 9 April 2008 and 1 October 2009 can be found in Appendix 4 (available upon request from the author, 65 pages in total of summarised graphs).

v) BALL ROLL TESTING

Introduction

Over the years there has been much debate about green speed and the significance of testing and managing your greens to accommodate or suit the conditions or committee requests. Nevertheless, it is important to recognise the significance green speed plays in the game of lawn bowls and golf.

Green speed for lawn bowls and golf are measured by two separate methods. The most common method of measuring green speed for lawn bowls is by measuring the number of seconds taken by a bowl from the time of its delivery to the moment it comes to rest 24.43 m from the mat line (Board, 1995). In Australia (and many other nations), the speed of a green is regularly 15-19 seconds (Australia, 2009). In golf, there are two means by which green speed can be analysed or measured. They are, using a method given the acronym S-P-E-E-D, or by using a stimpmeter (Geary, 2009). S-P-E-E-D, was promoted in the mid-1950s by American agronomist Paul Vermeulen used to analyse green speed under the following performance standards (Vermeulen, 1995):

- Status of the turf
- Principal resources
- Environmental conditions
- Expertise of the golfers, and
- Design

The most common or adopted method to measure green speed and the playability of a putting green on a golf course is with the use of a stimpmeter (Salaiz et al., 1995). The stimpmeter named after its inventor Edward S. Stimpson, is a 0.9 m (36-inch) extruded aluminium (or timber) bar with a grooved runway on one side set at 145 degrees. A notch positioned in the runway, 76 cm (30 inches) from the surface, is used to support a golf ball until one end of the stimpmeter is lifted to an angle of roughly 20 degrees (Vermeulen, 1995). A customized version of this device is called the modified stimpmeter (Gaussoin, 1995). This particular unit is a shorter, modified version of the full length stimpmeter used primarily for research purposes on surfaces restricted by size.

Uniformity was a major objective in the creation of the stimpmeter (Nikolai, 2005) and its use is seen as the best way for golf clubs to achieve similar green speed on all 18 holes for play. It is also intended to be used to measure the uniformity of individual greens, in other words to measure the speed of intended pin locations on contoured greens to see if they vary greatly from the rest of the green (Geary, 2009).

Comparison of green speed between seashore paspalum and *Cynodon* hybrids are in general, considerably slower. Duncan and Carrow (2005) reported that some golfers in the USA complained about the playability and speed of seashore paspalum greens, but the same type of complaints were heard when greens were changed from

Bentgrass (*Agrostis* spp.) to “ultradwarf” couches, or from the *Cynodon* hybrid cultivars ‘Tifdwarf’ to ‘TifEagle’. With the acquisition of a new green (species or cultivar difference) ultimately existing members will require time to adjust. Duncan and Carrow (2005) state that tournament-quality greens using seashore paspalum are possible regardless of the specific cultivar, following adjustments in turfgrass management practices.

In a series of turf management studies undertaken by Throssell (1981) to determine what factors influenced green speed of Bentgrass, the following resulted: cutting height had the single largest impact on speed; increased nitrogen decreased ball speed; daily and multiple daily mowing increased speeds; balls rolled with the direction of the last cut resulted in faster speeds; following imposed drought, speed decreased; aeration and deep vertical cutting also decreased green speeds.

Studies undertaken by Hartwiger et al. (2001) to determine the effect of rolling on soil bulk density, putting green speed, turf quality, root mass and thatch mass, indicated that rolling the green 0, 1, 4, or 7 times per week, once per week offered the best results with increased green speed with no deleterious effects to the turfgrass.

In fertility studies as referenced by (Baker, 1994b), increasing nitrogen content generally decreased green speed and the hardness of putting surfaces. However, research undertaken by Kopec et al. (2005) on ball roll distance of ‘Sea Isle 2000’ indicated that mowing height affected ball roll distance, whereas nitrogen rates did not.

Material and Methods

Ball roll distance was assessed for the *Cynodon* hybrids and seashore paspalums on eleven occasions throughout the duration of the DEEDI study (13 Feb., 11 Apr., 4 Jun., 6 Aug., 24 Oct., 17 Dec. 2008, and 11 Feb., 29 Apr., 1 Jul., 2 Sep. and 2 Oct. 2009). Three tools were used to obtain golf ball roll distance relevant to soil moisture, temperature and time. A modified stimpmeter which is 0.64 m long is lifted to an angle of roughly 20 degrees and releases a golf ball positioned 46 cm from the surface (Gaussoin, 1995). One measurement in both directions of the length of the plot was taken in each subplot. At the same time soil moisture was measured using a MPM-160B (12 bit resolution) moisture Theta Probe, (ICT International Pty Ltd, Armidale, New South Wales) and surface temperature using a Raynger®ST™ non-contact digital thermometer (Raytek Co., Santa Cruz, CA) was taken, three times and twice respectively per subplot (Plate 11). Time was an important factor when taking measurements from 324 subplots and how this related to changes in soil moisture and surface temperature. Ball roll measurements took on average seven hours to complete per testing date.

Initially, analysis of ball roll distance data was carried out using residual maximum likelihood of the averaged data collected by DEEDI staff. The problem with using this analysis method was that a large proportion of the ball roll distances exceeded the length of the plot (2 m) even when using a modified stimpmeter. As such, the ball roll distance and subsequent data had to be limited to a maximum of 2 m. Following statistical analysis, the data was skewed because it was unable to distinguish between the readings which provided a greater distance. As such, the data shown is of the raw data collected where ball roll distance was equal to or greater than

2 m. Further analysis and modification of the data set will be required to provide a more comprehensive conclusion. Findings will be made available at a later date through trade magazines and scientific publications.

Graphs were constructed using Microsoft® Office Excel 2003.

Plate 11. Use of (left to right) a modified stimpmeter (0.64 m long), soil moisture probe and non-contact digital thermometer to measure golf ball roll distance.



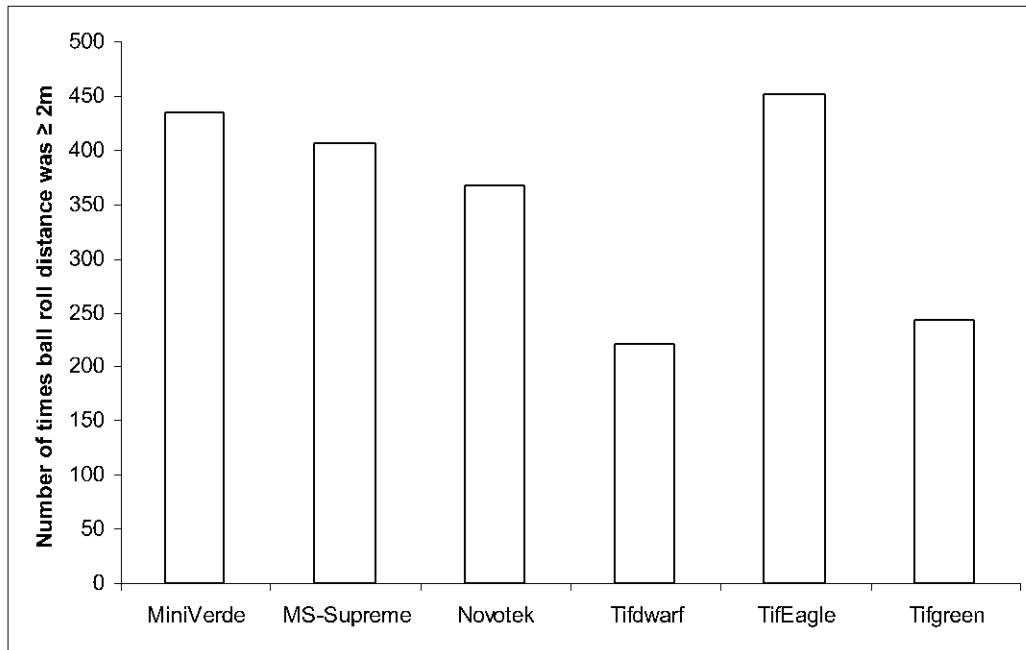
Results and Discussion

The *Cynodon* hybrids were considerably faster than the seashore paspalums during testing undertaken between 13 February 2008 and 2 October 2009. There are primarily two reasons for this (i) the waxy leaves of the seashore paspalums and (ii) the higher level of moisture present in the *Paspalum* compared to the *Cynodon* hybrids (Figure 59). On average the seashore paspalums held 5% more moisture within the top 60 mm soil profile including the thatch layer. Studies by Canaway and Baker (1992) identified that soil moisture decreased ball speed, with the effect being greater for the smaller golf ball compared to the relatively massive bowl; a 1.5% reduction in green speed due to wetness was observed for bowls, whereas the reduction was 6% for golf.

Analysis of the data obtained over the 11 testing dates showed that ball roll distance was ≥ 2 m of the *Cynodon* hybrid couches 44.7% (or 2123 of 4752 rolls) of the time and only 5% (or 155 of 2376 rolls) of the time for the seashore paspalums under trial conditions.

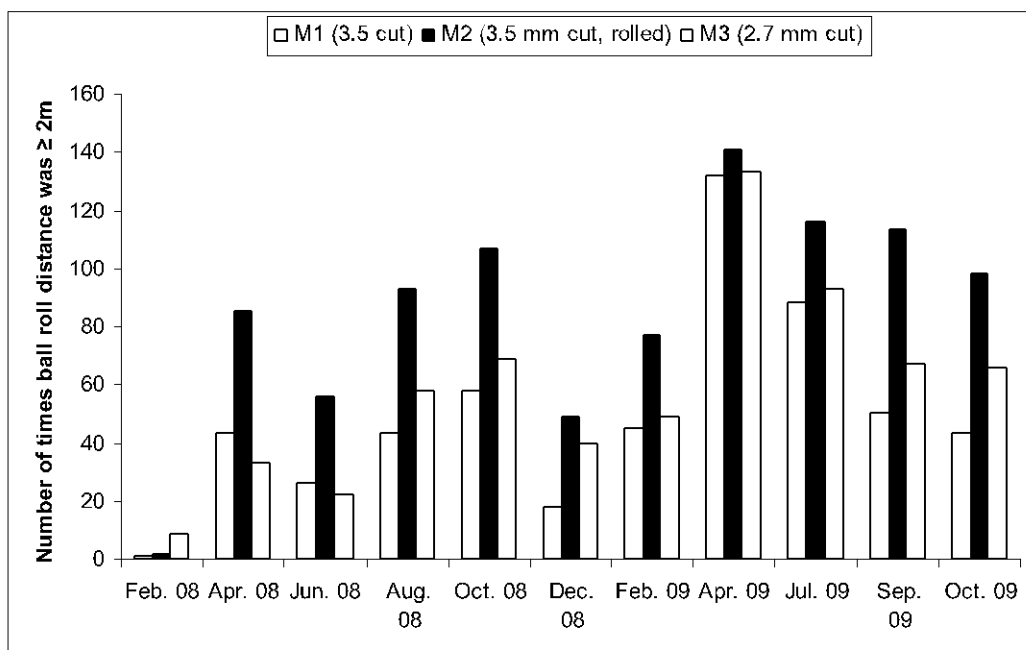
Of the *Cynodon* hybrids ‘TifEagle’ resulted in slightly faster greens than MiniVerde™, ‘MS-Supreme’ and Novotek™ (Figure 52). There was considerable difference between the second-generation “ultradwarfs” and the first-generation ‘Tifgreen’ and ‘Tifdwarf’ cultivars. Interestingly, ‘Tifgreen’ recorded a marginally higher number of times that the ball roll distance ≥ 2 m compared to ‘Tifdwarf’.

Figure 52. The number of times ball roll distance ≥ 2 m (length of individual subplots) for the *Cynodon* hybrids during testing undertaken between 13 February 2008 and 2 October 2009



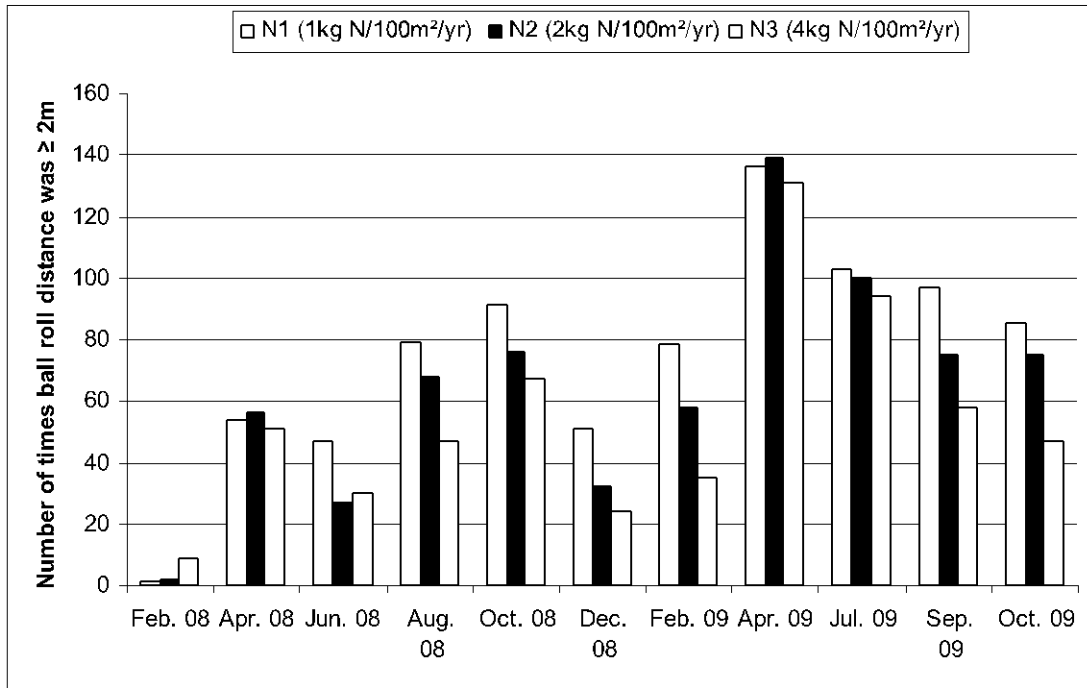
When comparing ball roll distance (≥ 2 m) of the *Cynodon* hybrids and mowing treatments, treatment M2 (3.5 mm cut and rolled) was consistently the best performer for greater distance (Figure 53). On only one occasion (13 February 2008) did treatment M3 (2.7 mm cut) surpass the 3.5 mm cutting heights (treatments M1 and M2). The *Cynodon* hybrids being cut at 2.7 mm (not rolled) performed faster than 3.5 mm cut, not rolled (M1), on all but two occasions (April and June 2008).

Figure 53. The number of times ball roll distance ≥ 2 m (length of individual subplots) for the *Cynodon* hybrids under different mowing treatments (M1, M2 and M3) during testing carried out between 13 February 2008 and 2 October 2009



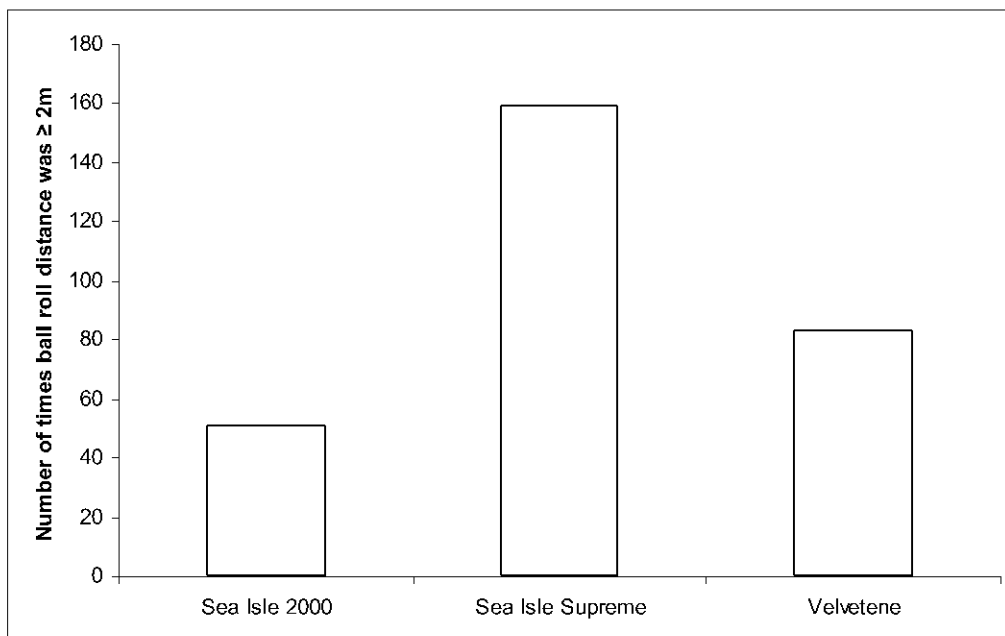
Apart from between February and April 2008 the lower fertility program (N1 – 1kg N/100m²/yr) produced marginally higher ball roll distances \geq 2m (Figure 54).

Figure 54. The number of times ball roll distance \geq 2 m (length of individual subplots) for the Cynodon hybrids under different nitrogen treatments (N1, N2 and N3) during testing carried out between 13 February 2008 and 2 October 2009



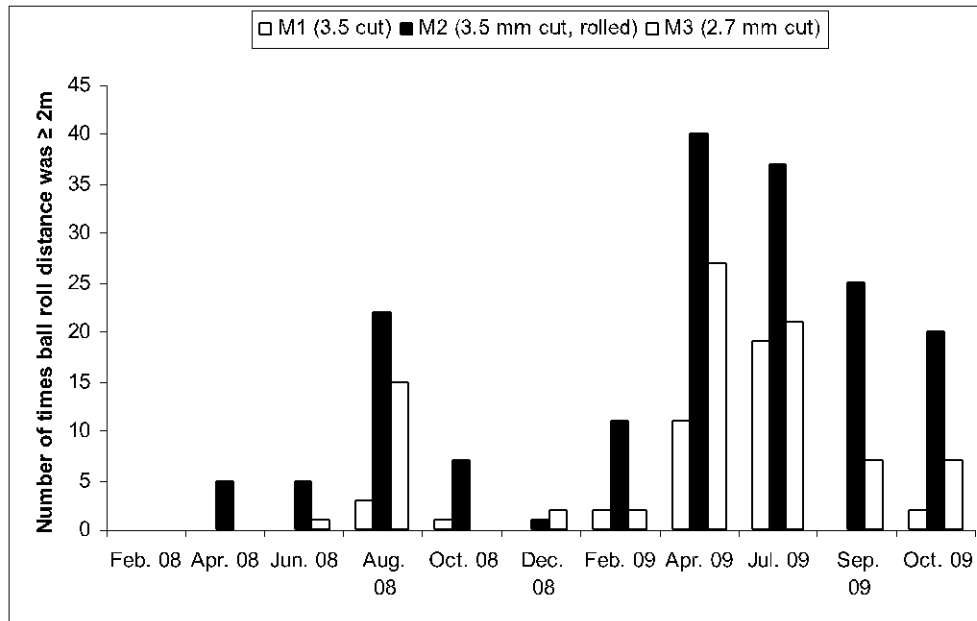
Of the seashore paspalums, Sea Isle SupremeTM produced significantly greater ball roll distances \geq 2m compared to VelveteneTM and ‘Sea Isle 2000’ following testing undertaken between 13 February 2008 and 2 October 2009 (Figure 55).

Figure 55. The number of times ball roll distance \geq 2 m (length of individual subplots) for the seashore paspalums during testing undertaken between 13 February 2008 and 2 October 2009



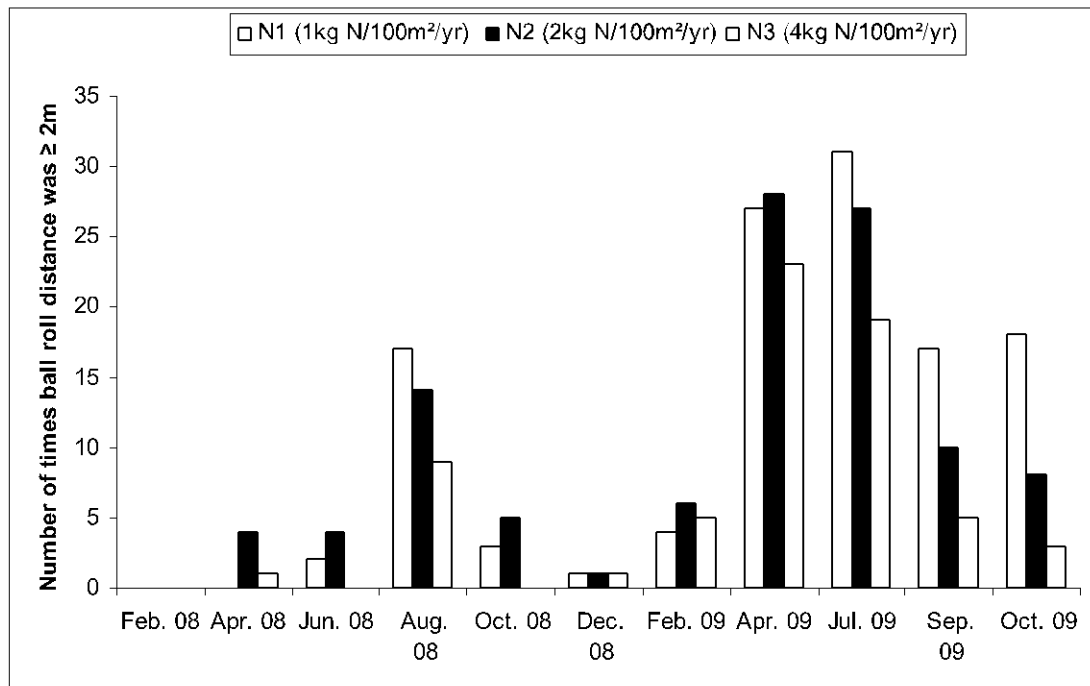
In comparing mowing and or rolling practices of the seashore paspalums, mowing at 3.5 mm with rolling produced a higher number of distances $\geq 2\text{m}$ (Figure 56). Forty-five percent of the time neither of the paspalum cultivars being cut at 3.5 mm incurred a roll distance greater than 2 m (i.e. five out of eleven testing dates).

Figure 56. The number of times ball roll distance $\geq 2\text{ m}$ (length of individual subplots) for the seashore paspalums under different mowing treatments (M1, M2 and M3) during testing carried out between 13 February 2008 and 2 October 2009



There was an inconsistency in the data collected between nitrogen levels and greater ball roll distance of the seashore paspalums. Either 1kg N/100m²/yr (N1) or 2kg N/100m²/yr (N2) produced marginally better distances than the higher levels of nitrogen (i.e. N3 - 3kg N/100m²/yr).

Figure 57. The number of times ball roll distance ≥ 2 m (length of individual subplots) for the seashore paspalums under different nitrogen treatments (N1, N2 and N3) during testing carried out between 13 February 2008 and 2 October 2009



The length of each subplot measured 2 m in distance. This was the maximum ball roll distance obtainable (excluding the edge effect) when using the modified stimpmeter. To determine the number of times ball roll was greater than 2 m over the 11 testing dates for each species a statistical analysis was conducted and then a correlation coefficient (r) was obtained to compare the two. During each testing date a total of 432 and 216 balls were rolled (2 per subplot \times 324 subplots = 648 rolls) for the *Cynodon* hybrids and seashore paspalums (C \times M \times N) plots respectively. Over 11 testing dates 44.7% (or 2123 of 4752 rolls) and 6.5% (or 155 of 2376 rolls) exceeded the 2 m plot length of the *Cynodon* hybrids and seashore paspalums respectively. When comparing the two species, a correlation coefficient of 0.8580 is provided indicating a strong positive linear relationship between the species and ball roll speed equal to or greater than 2m. This equates to a correlation coefficient of 73.6%, meaning that only 26.4% of the variance was not shared between either two species.

Figure 58. Correlation coefficient (r) of ball roll distance $\geq 2\text{m}$ for the seashore paspalums (C x M x N) and Cynodon hybrids (C x M x N) measured between 13 February 2008 and 2 October 2009

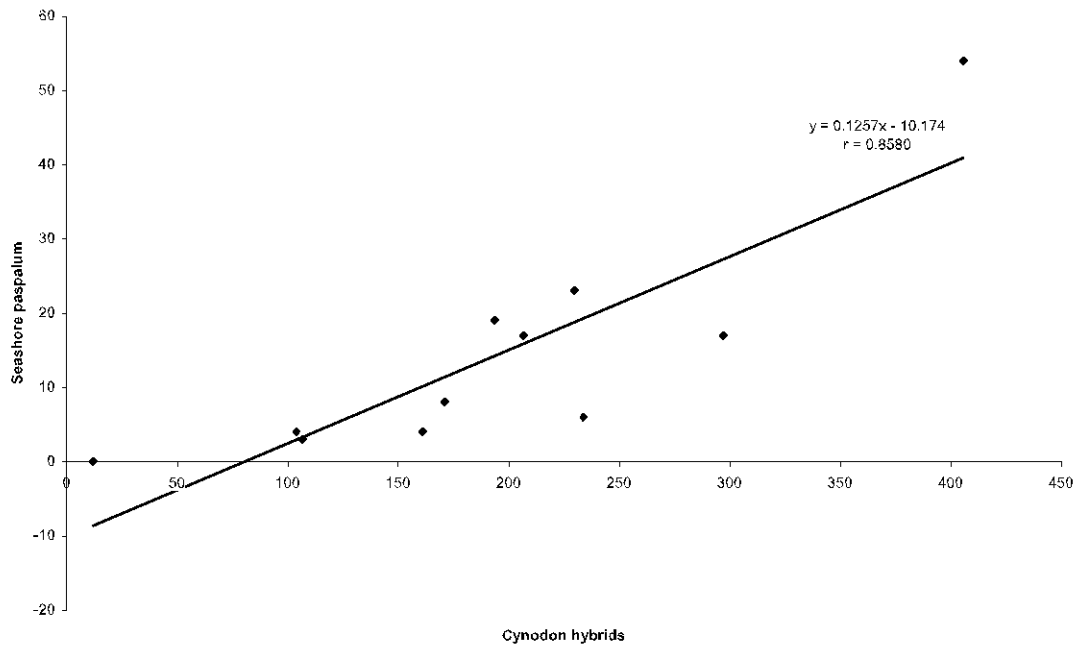
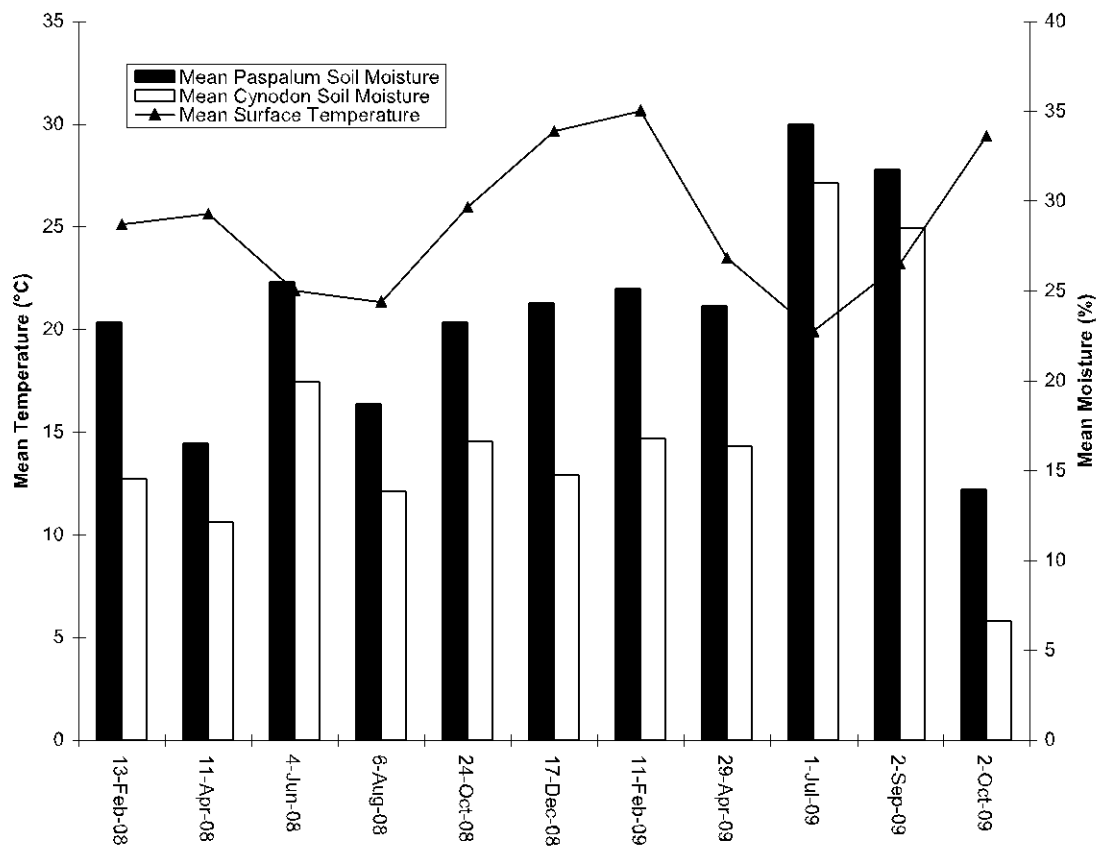


Figure 59. Mean soil moisture (%) and surface temperature ($^{\circ}\text{C}$) for the seashore paspalums and Cynodon hybrids when ball roll distance was conducted between February 2008 and October 2009.



The morphological and developmental attributes of both the *Cynodon* and *Paspalum* species are extremely different and as such, respond differently to alternate management practices. Green speed should not be considered a threat; it should be used as a management tool to obtain uniformity across green(s). Tailoring management activities to meet the needs of each specific cultivar will provide the turf the superintendent or greenkeeper, the club and the clubs members with a rewarding playing surface. Maximising green speed for speed sake alone should not be achieved at the expense of sacrificing acceptable turfgrass quality (Throssell, 1981).

vi) TURFGRASS MANAGEMENT

The following contains a list of summarised turfgrass management activities that was undertaken by DEEDI technical staff under the guidance of Jon Penberthy, Turf Experimentalist and qualified greenkeeper.

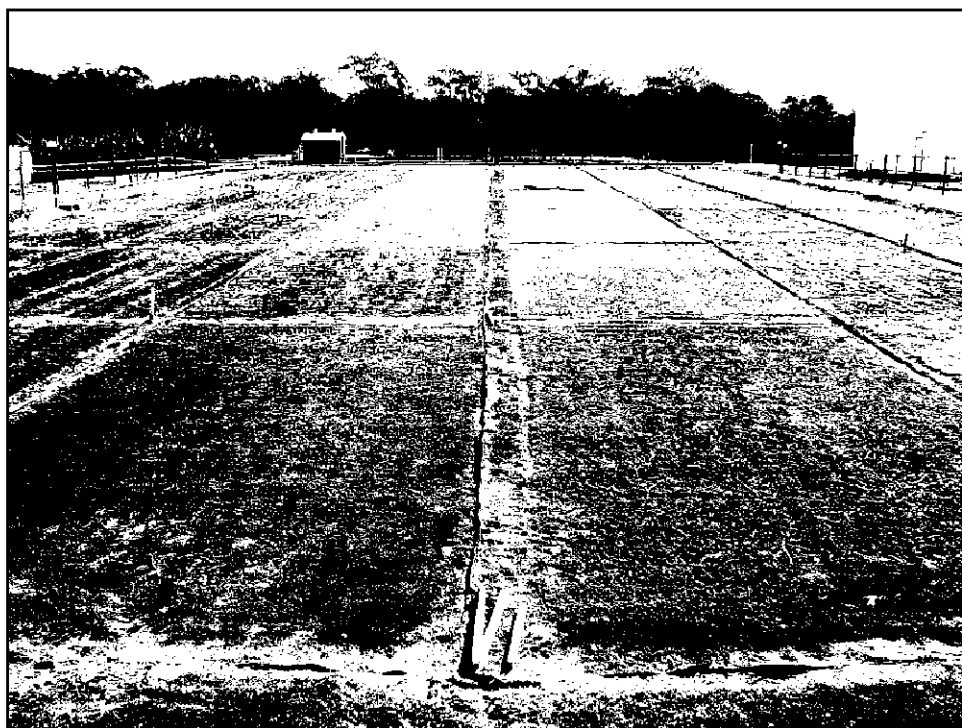
Planting and Grow In

Planting of vegetative material (rooted nodal cuttings/plugs) was undertaken at c. 15 cm spacing which commenced on 21 December 2006 and was completed by 3 January 2006. Because of the planting method and spacing between plugs, grow-in was far slower than would normally be seen on a golf or bowls green. In spring of 2006, the last of the poorly grown patches were established in and two applications of sand topdressing were carried out to remove minor depressions and improve the overall surface level of the plots.

Mowing commenced of the seashore paspalums cultivars 21 March 2006 (77 days post planting) and the *Cynodon* hybrids 20 April 2006 (107 days post planting) using a rotary push mower set on the lowest level. Rolling of the plots were undertaken to consolidate and smoothen the surface prior to the mowing of the *Paspalum* plots with a cylinder mower for the first time set at 8 mm which commenced on the 26 April 2006. The result was devastating with each cultivar effected by severe scalping, 'Sea Isle 2000' in particular (Plate 12). The *Cynodon* hybrids were not cut at the same intensity until 5 May 2006. At this time the plots were mown three times per week (Monday, Wednesday, Friday) which continued for the duration of the study. From 1 November 2006 all *Cynodon* and *Paspalum* plots were mown at 6 mm, then 5 mm on 16 March 2007, then 4.7 mm on 24 April, double cut at 4.5 mm 4 May and finally 3.5 mm was achieved on all plots 28 May 2007.

The establishment and maintenance plan provided by the AGCSA (Appendix 1) was followed and modified accordingly (e.g. additional fertiliser applications to speed establishment process) following discussion with AGCSA technical staff.

Plate 12. Severe scalping of the seashore paspalums after being cut with a cylinder mower for the first time at 8 mm two days earlier (photo taken 28 April 2006).



Four Week 'Routine' Program

As part of the formal experiment testing mowing treatments and nitrogen treatments a 'routine' 4 week rotating cycle of events was undertaken. For additional notes on each management activity please refer to their respective headings which follow.

Week 1: Consisted of applying the (liquid) fertiliser treatments (N1, N2 and N3) to the formal greens test area. This involved spraying both the *Cynodon* and *Paspalum* experiments with a rate that equates to 1 kg per 100 m² of actual nitrogen (N) per year when applied 12 times. This application also provides 0.5 kg of phosphorous (P) and 4 Kg of potassium (K) per 100m² per year (also liquid). To apply additional nitrogen to produce the N2 and N3 treatments, a 2m wide (the length of each subplot) pedestrian Green Sprayer Boom (Austates Pest Equipment Pty Ltd, Acacia Ridge, Aus.) was used. Nitrogen rates of 2kg/100m²/year (treatment N2) and 4 kg/100 m²/year (treatment N3) were applied to the assigned subplots. Liquid fertiliser was supplied by Globe Australia, Coopers Plains, Queensland.

Week 2: Subjective turfgrass quality, colour and thatch ratings were undertaken in each of the 324 subplots by DEEDI staff.

Week 3: Greens were dethatched, groomed or scarified. If coring was to be undertaken, this also occurred during this week.

Week 4: Involved topdressing or light dusting. If time allowed this practice was scheduled to coincide with week three of the 'routine' management practices to allow greater time for turfgrass recovery prior to the next fertilising application undertaken in week 1 and field assessments (ratings) in week 2.

Dethatching

The *Cynodon* hybrid plots were adversely affected in the reduction of cutting heights as was the seashore paspalums on 1 November 2006. As such the *Cynodon* hybrids required further light scarification to remove additional thatch. To assist with the height reduction and the removal of “porpoising” (i.e. where stolons emerge and grow over the mown turf) among the seashore paspalum cultivars grooming equipment (John Deere, Yatala, Queensland) was fitted to the John Deere walk behind greens mower. Porpoising was not observed in the *Cynodon* hybrids, only in the seashore paspalums and of the latter taxa ‘Sea Isle 2000’ showed considerably less porpoising than Sea Isle Supreme™ or Velvetene™ (Plate 13).

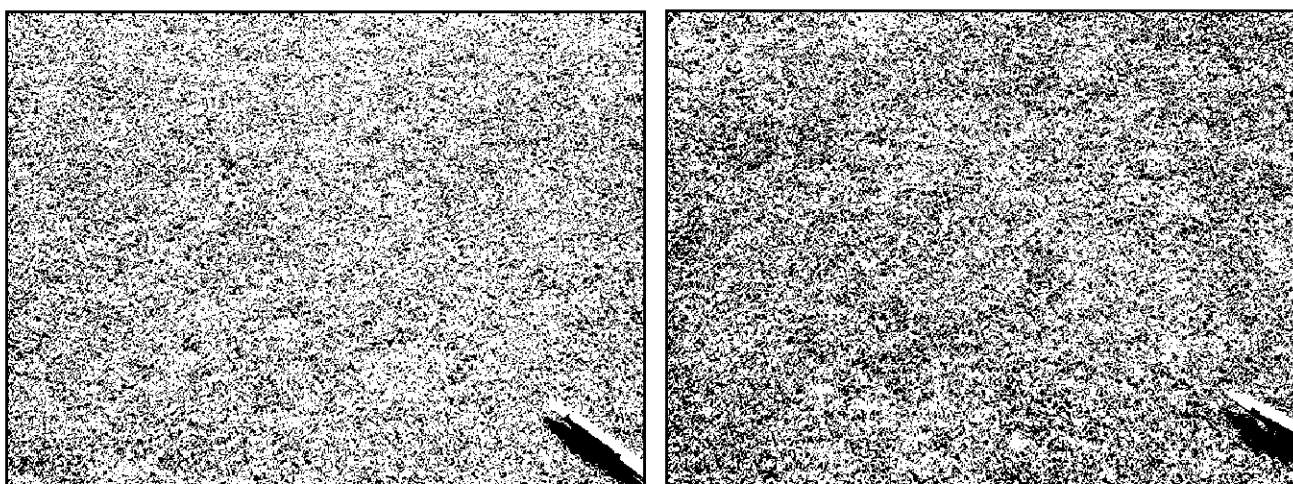
Major/heavy scarification activities were undertaken in November and December 2007 to supply regional trial sites with vegetative material (sprigs) for planting. Additional dethatching practices (e.g. scarifying, groomers set at -2 mm, double cutting) were undertaken from January 2008 until the trial was completed in September 2009 Table 18.

Table 18. Dethatching activities undertaken from November 2006 to October 2009 at the DEEDI greens test facility

Light scarification ¹	Heavy scarification ²	Groomers set at -2 mm	Greens double cut
November 2006	January 2007	February 2008	January 2009
May 2007	January 2008	March 2008	February 2009 x 2
	January 2009	February 2009	
	October 2009	August 2009	

Notes: ¹ Scott Bonnar dethatcher was used; ²Graden scarifier was used

Plate 13. Porpoising variation of the seashore paspalum cultivars (left to right) ‘Sea Isle 2000’ and Sea Isle Supreme™.



Mowing and Rolling

Following grow in of the *Cynodon* hybrid and seashore paspalum turf plots, two walk-behind greens mowers were used to enable two cutting heights at 2.7 mm (John Deere 22" cut cylinder mower, John Deere, Yatala, Qld) and 3.5 mm (Jacobsen 26" cut cylinder mower, Power Turf Australia, Yatala, Qld) to be maintained without having to adjust a single mower on each mowing occasion to achieve this. The combination of the two mowers and the turf roller (RS48-11C Roll 'n' Spike Golf Greens Roller, Tru-Turf, Ernest, Queensland) were used to impose the three mowing-rolling treatments (M1: 3.5 mm cut and no roll; M2: 3.5 mm cut and rolled; M3: 2.7 mm cut and no roll). The desired mowing heights to match the treatments were finally achieved by the 26 October 2007, at which time rolling using the turf roller was undertaken.

Fertiliser

Granular trace elements were applied quarterly to coincide with the 'routine' fertiliser applications. A renovation fertiliser was also applied when major activities took place every spring. Fertiliser was supplied by Globe Australia, Coopers Plains, Queensland.

Topdressing

Because of the adverse reaction (scalping) with the seashore paspalums following the reduction of mowing height to 5 mm on 1 November 2006 the plots were dusted with sand to encourage regrowth in the scalped patches (Plate 14 and Plate 15). If time allowed light topdressing or dusting was scheduled to coincide with week three of the 'routine' management plan to allow greater time for turfgrass to recovery prior to the next fertiliser application and field assessment (ratings).

Plate 14. *Paspalum vaginatum* 'Sea Isle 2000' showing scalping damage following gradual height reduction from 6 mm to 5 mm (photo taken 4 April 2007).



Plate 15. *Paspalum vaginatum* 'Sea Isle Supreme' without scalping damage following gradual height reduction from 6 mm to 5 mm (photo taken 4 April 2007).



Renovations

In the spring of each year, a major renovation took place involving heavy scarifying, coring, application of a renovation fertiliser with fungicide (except in 2008-2009) and a heavy topdressing. Greens were also spiked using the slicer on the Tru-Turf Roller (RS48-11C Roll) during the year as deemed necessary. Additionally once a year a solid or hollow tine aerator was used to relieve compaction and aerate the soil. The particulars were as follows:

- Use of the Wiedenmann Terra Spike (Q Turf Machinery, Capalaba, Queensland) deep tine aerator with 12 mm hollow tines giving an 8 mm hole, 50 mm x 50 mm spacing, at a depth of 150 mm with 3 to 5 degrees heave (kick)
- Use of the Wiedenmann Terra Spike deep tine aerator with 12 mm hollow tines, 50 mm x 50 mm spacing, at a depth of 100 mm. No heave (kick)

Encroachment/Quality Control

The borders between plots (c. 10 cm) were maintained by spraying regularly with glufosinate (Finale[®]) to stop lateral growth by systemic means, rather than kill growth by contact herbicide such as glyphosate (Roundup[®]) which was initially used. The former pesticide is applied weekly as a precautionary measure using a Kombi line marking machine (Toro Australia Pty Ltd) to give a more regular plot outline and limit contamination between plots.

Soil Testing

Soil tests to determine soil pH (water), electrical conductivity (salinity), phosphorous (Oslen), potassium, percentage calcium base saturation, percentage magnesium base saturation, percentage sodium base saturation and the calcium-magnesium ratio were sampled on 29 November 2005, 17 February 2006, 1 September 2007 and 15 September 2008. Tests were undertaken by the AGCSA Tech laboratory.

Plate 16. Tru-Turf roller (left) and Jacobsen mower (right) used to apply particular mowing treatments on the research plots at DEEDI. The John Deere mower was also used (a photo was not acquired on handover).

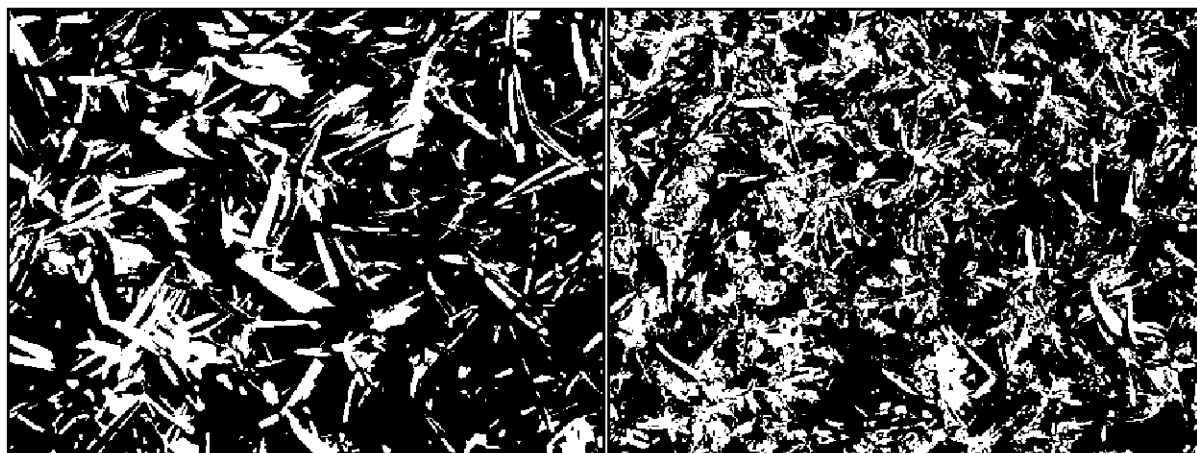


OBSERVATIONS AND DISCUSSION

Morphology (growth, development, sward characteristics)

- Of the *Cynodon* hybrids MiniVerde™ was the greenest and most rapid growing. It recovered from injury quickly and produced a nice even sward.
- ‘TifEagle’ and ‘MS Supreme’ produced less thatch than MiniVerde™ but were vigorous and produced a good surface.
- ‘MS-Supreme’ seems to be a good consistent performer in this climate, whereas Novotek™ is not performing as well as further north (e.g. Cairns tropics). ‘Champion Dwarf’ is performing better as time progresses, much like FloraDwarf™ which was very slow to establish and has a shorter root system than the other *Cynodon* hybrids. Both ‘Champion Dwarf’ and ‘FloraDwarf™ form very tight swards. ‘Tifgreen’ had reasonable colour in comparison to the other hybrids.
- The seashore paspalums were generally greener and maintained their colour for a longer period into the winter. They striped up well with mowing and provided an attractive sward that was firm under foot. Green speeds using a Stimpmeter were slower than for the *Cynodon* varieties (i.e. as much as couch is slower than Bentgrass). The higher nitrogen treatments were a deep green colour and cut down to 2.7 mm looked good.
- Dew does not form on the leaves of the seashore paspalums because of their waxy coating.
- The paspalums need to be managed differently than the couches to get the best out of their performance

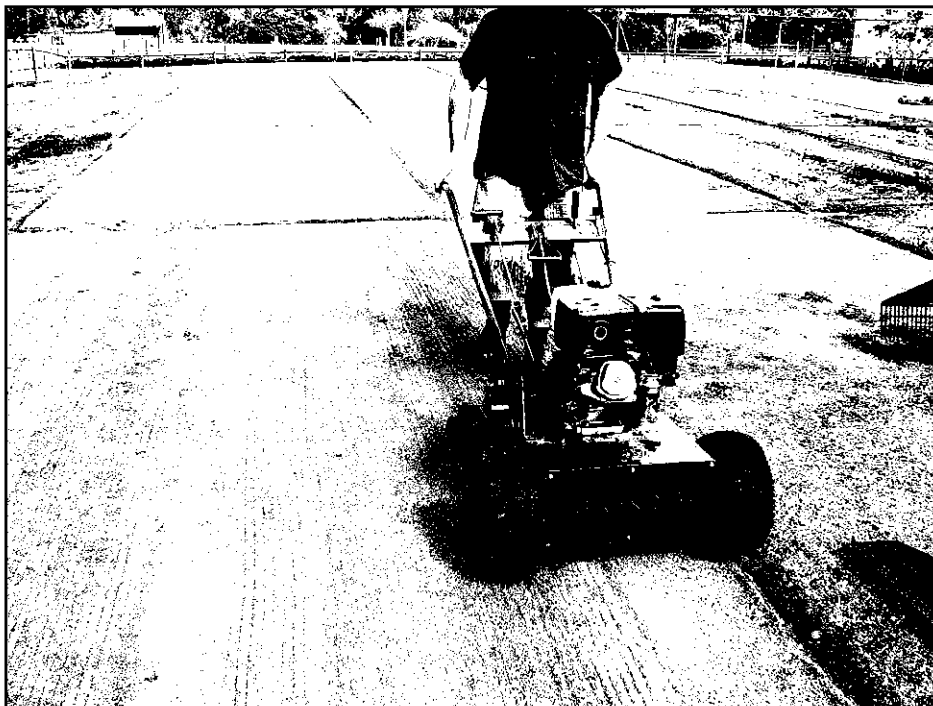
Plate 17. Water formation present on the *Cynodon* hybrids (right) compared to the seashore paspalums (left) following a heavy dew 9 June 2009. Minimum morning air temperature was 7°C.



Thatch and Dethatching

- Thatch management is still an issue with the newer *Cynodon* hybrid and greens quality seashore paspalum cultivars even from taking a heavy handed approach. Greater reduction techniques and input is required to control thatch accumulation from a very early stage in the grow-in of the greens.
- Of the *Cynodon* hybrids, MiniVerde™ accumulated thatch most rapidly followed by the ‘MS-Supreme’. ‘Tifdwarf’ appeared to be the least thatchy due to its sparse habit. Each of the different *Cynodon* cultivars require close monitoring in the field to suggest an ideal management regime for each particular site (genotype by environment effect).
- The paspalums all felt less thatchy under foot compared to the *Cynodon* cultivars, though they did develop a significant depth of thatch when soil plugs were examined. All of the *Paspalum* cultivars do not recover well from scarifying if done heavily.
- Nickson (2007) suggests the following options for thatch control: cultural practices (e.g. maintain optimum pH, no less than 4.5), mechanical removal (e.g. attachment of groomers), frequent topdressing, improvement of aeration (e.g. hollow tining, while at the same time removing thatch), and vertical mowing. Studies undertaken by Nickson (2007) indicated that the most effective form of thatch control in *Cynodon* hybrids was the application of small quantities of sand topdressing, approximately 1kg/m² at a frequency of every two to three weeks, depending on growth rates at the time of year.
- A faster rate of thatch accumulation requires adherence to good core aeration, sand topdressing, and routine light surface dethatching or grooming to dilute thatch and organic matter; thatch management should be initiated at the time of grow-in to prevent falling behind on these programs (Bevard et al., 2005).

Figure 60. Commencement of heavy scarification of the *Cynodon* hybrid plots on 5 January 2009



Mowing and Rolling

- The *Cynodon* hybrid cultivars responded best to the higher cutting height, whereas the paspalums performed best at the lower cutting height. MiniVerde™ was the better performer at the lower cutting height. If a lower height (e.g. 2.7 mm) was chosen for the *Cynodon* hybrids it would be best to have the greens cut daily for best results.
- The paspalums are very susceptible to scalping and if scalped are slow to recover to form a decent surface (aesthetically and playability). Therefore regular cutting of all species at the appropriate height is a critical management requirement. The *Paspalum* varieties were good at the lower height but recovery was slow from any scalping or damage that was incurred. Regular and repeated mowing produced a good surface.
- Greens grasses can be maintained periodically at very low cutting heights, but become stressed during periods of incremental weather (e.g. cloudy, hot and humid). Mowing heights should be raised during periods of stress. Greens become more susceptible to secondary pathogens during stressful periods under excessively low mowing heights, especially when “hungry” (Bevard et al., 2005).

Fertiliser

- A general observation of the grasses in the test facility is that both the *Cynodon* hybrid and the paspalums require a relatively high (e.g. 2 - 4 kg/100 m²/year) level of nitrogen to achieve optimum turf quality and turf density. However, higher fertility will induce greater thatch levels. MiniVerde™ was the greatest thatch producer. Use of a growth regulator may assist.
- Generally the higher nitrogen rate produced the better quality turf surfaces than the lesser treatments though it was shown that during the colder months the difference was not as pronounced. The lesson from this was that higher nitrogen was beneficial up to the point of the turf going into dormancy when its effect became negligible.

Topdressing

- Substantial savings can be made when comparing topdressing requirements of the first- and second-generation greens grasses. Less (amount and frequency) is required of the second-generation grasses while producing a denser, smoother playing surface.
- The seashore paspalums take up the sand in topdressing quickly as does MiniVerde™, ‘MS-Supreme’, Novotek™, ‘TifEagle’ and ‘Tifgreen’. ‘Tifdwarf’, FloraDwarf™ and ‘Champion Dwarf’ cultivars have the sand remain on the surface longer than the former cultivars listed and are harder to get the sand rubbed into the playing surface.
- Regular dusting of the seashore paspalum was preferable to mechanical thatch removal due to recovery being an issue.

Dormancy

‘Tifdwarf’ of the *Cynodon* hybrids seemed to hold off dormancy longer than the other couches. However, this was due to the purplish colour observed on the leaf and stolon growth during the onset of cooler temperatures.

Dormancy also occurred on all the seashore paspalum cultivars. However, the level of dormancy and reduction in colour was far greater in the *Cynodon* hybrids.

Pesticide Tolerance

All the *Cynodon* cultivars tolerated broadleaf selective herbicide up to a point. DSMA was applied with no ill effect other than some discolouration for a short period after application. The Paspalum cultivars were not tolerant of DSMA.

Fungicides were applied as disease had appeared and a preventative program was adopted in 2007-2008 for the control of Spring Dead Spot (*Leptosphaeria namari*). This was not continued into 2009 for observational purposes and the incidence of Spring Dead Spot including other “Patch Disease” was noticeably evident.

Throughout various stages of the trial a number of pesticides have been applied to the *Cynodon* hybrids and or the seashore paspalums, of which included:

PESTICIDE*	COMMENT*
Herbicide	
Ronstar®	Applied post planting and during initial grow in – no adverse effect
Fluroxypyr	Some discolouration at 5ml/L when applied in January. 3ml/L showed no adverse effect when applied in April, September and December
Metsulfuron-methyl	Applied in January – no adverse effect
DSMA	Applied at lower rate in December to <i>Cynodon</i> hybrids – No adverse effect
Fungicide	
Bravo®	Applied in May – no adverse effect
Baycor™	Applied in July – no adverse effect
Tilt®	Applied in March – no adverse effect
Heritage®	Applied in August – no adverse effect
Insecticide	
Gremlin™	Applied in October – no adverse effect
Baythroid®	Applied in spring, summer and autumn – no adverse effect

***Note: Not all pesticides used at the research facility are currently registered for use on turfgrass. Always read and follow the label instructions. Fluroxypyr and metsulfuron-methyl are to be registered for turfgrass use as a generic pesticide in 2010 by the Australian Pesticides and Veterinary Medicines Authority (APVMA) following earlier studies undertaken at DEEDI Redlands Research Station.**

vii) PESTS AND DISEASE

All eight of the *Cynodon* cultivars trialled within the formal and informal experiments suffered from “Patch Diseases”, most notably Spring Dead Spot (*Leptosphaeria namari*) and some level of Brown Patch (*Rhizoctonia* sp.). The faster growing cultivars i.e. MiniVerde™ and ‘MS- Supreme’ were fast to recover from disease or scaring compared to ‘Tifgreen’ and worse, ‘Tifdwarf’ which was the hardest hit by disease and slowest to recover

The *Paspalum* cultivars all had issues with Dollar Spot (*Sclerotinia homeocarpa*) in the winter of 2008 though Velvet™ was the least affected by the disease. Brown Patch was also present on all *Paspalum* cultivars at various stages throughout the trial.

A turf manager should learn to identify diseases and the weather conditions that favour their development. They should continually observe for early symptoms of disease and use appropriate control measures. If practical (financially etc.) adopt a preventative fungicide program to negate where possible attack of disease.

Observations undertaken in late October 2008 demonstrated quite clearly that at higher fertility the turf density was higher, the presentation as a surface was improved and most importantly there was substantially less disease (Plates 18 and 19).

Plate 18. High incidence of disease present in the low level fertility (N1 - 1kg N/100m²/yr) plot of Sea Isle Supreme™ 28 October 2008.

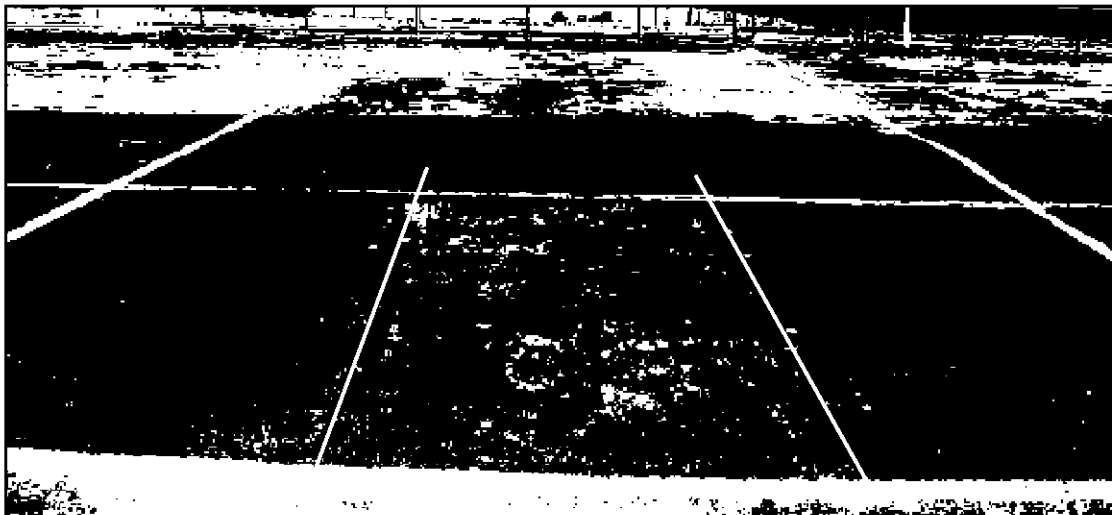
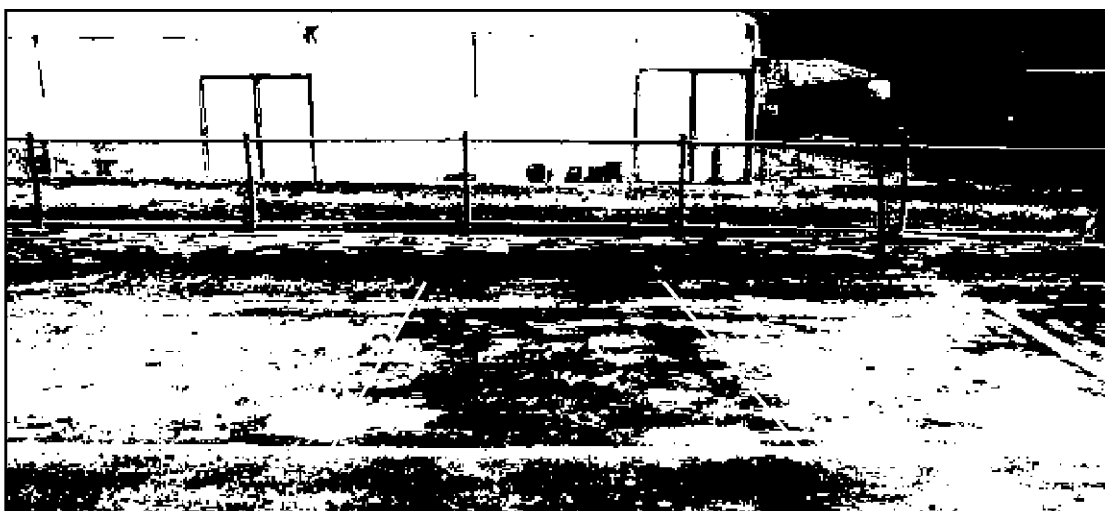


Plate 19. Very little incidence of disease present in the high level fertility (N3 - 4kg N/100m²/yr) plot of MiniVerde™ 28 October 2008.



Insecticides were applied as needed to control mites (*Eriophyes* sp.) which were possibly bermudagrass mites (*Eriophyes cynodonsensis*), ants [*Monomorium minimum* (Buckley)], mole cricket [*Gryllotalpa australis* (Erichson)], lawn armyworm [*Spodoptera mauritia* (Boisduval)] and African black beetle larvae [*Heteronychus arator* (Fabricius)]. A preventative program was not adopted which provided us with an opportunity to observe and record any differences seen within the susceptibility of the cultivars trialed.

Repeat application of miticides were sprayed in an attempt to control two-spotted mites in October of 2006, but no further applications were applied throughout the duration of the trial. This does not mean that the mites were not present, or were not causing underlying problems to turfgrass quality and playability.

On 21 September 2009 an inspection and visual rating was undertaken of mite damage of the *Cynodon* hybrid cultivars growing in the unreplicated turf demonstration plots (measuring 3 x 2.5 m) at DEEDI Redlands Research Station. General observations were made and the plots were given a rating from no 'effect present' to 'severely affected' (Table 19). Results indicated from the unreplicated plots that there were some cultivars that showed signs of possible mite resistance or tolerance, while others had varied levels of infestation.

Table 19. Ratings of mite (*Eriophyes* sp.) damage of the *Cynodon* hybrids being grown at DEEDI Redlands Research Station.

Cultivar	Damage Rating (infestation)
'Champion Dwarf'	Medium
FloraDwarf™	Severe
MiniVerde™	Medium
'MS-Supreme'	Light
Novotek™	Light
'TifEagle'	No effect present
'Tifdwarf'	No effect present
'Tifgreen'	No effect present

Further research is warranted in this area to determine what species of mites are causing problems, but also whether certain cultivars are resistant to the effects of mites. A digital photograph was taken of a medium- to coarse textured *Cynodon* hybrid cultivar on 6 January 2010 showing the damage commonly seen following an infestation of mites. Mites possess the ability to inhibit the lateral development of the turf plant by feeding on plant tissue following the puncturing of the surface cells with their fangs or stylets. The damage can often be seen following a close inspection of the turf (Plate 20). However, the arachnids which are between 0.2 and 0.5 mm in size are commonly very hard to find and accurately identify. The result if not detected poses a threat to new leaf and stolon tissue that become severely distorted effecting lateral growth and turf vigour.

Figure 61. Line drawing of four-legged mites (Eriophyoidea or Tetrapodili) sourced from (Hoy, 2008).

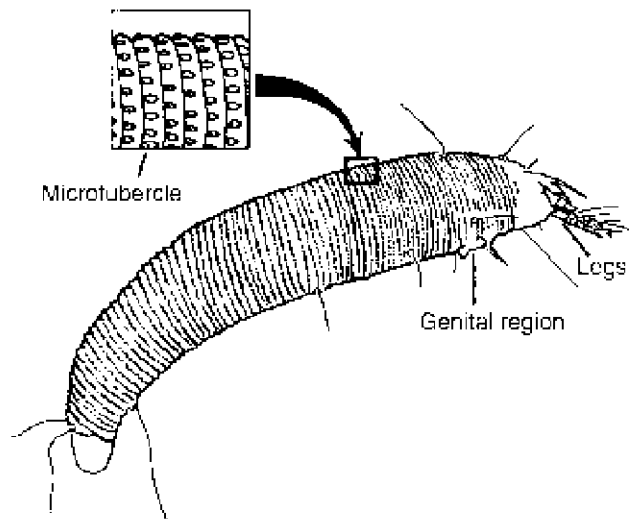
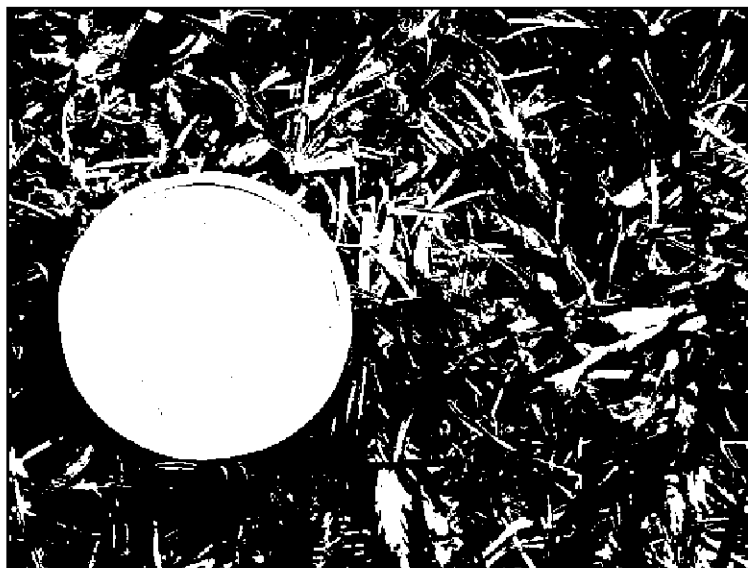


Plate 20. A two dollar coin positioned adjacent to damage commonly seen following an infestation of mites on green couch. The stunting or distortion of stolons etc. is commonly referred to the “witches broom effect”.



Incidence and identification of patch diseases in *Cynodon* hybrid cultivars

Despite a preventative fungicide programme through the 2006/07 year, two distinctly different patch diseases became evident in late winter 2007 in plots of the various hybrid *Cynodon* cultivars on the research green at Redlands. Samples of these two diseases were sent to Dr Percy Wong (University of Sydney, NSW) for identification.

The first of these showed classic symptoms of Spring Dead Spot, with dead grass across the whole patch (Plate 21a). The presence of *Leptosphaeria* sp., the causal organism of Spring Dead Spot, was confirmed by Dr Wong in the two submitted samples from 'Tifgreen' and 'MS-Supreme'. He also found Brown Patch (*Rhizoctonia solani*) present in the sample from 'MS-Supreme'.

The second patch disease showed up as a ring of dead grass around recovering green grass in the centre (Plate 21b). Dr Wong isolated *Gaeumannomyces incrustans* (not considered a pathogen in the US) from samples of 'TifEagle', together with a non-sporulating black fungus which has also been isolated from diseased 'TifEagle' at Cobbitty near Sydney, New South Wales. Further tests are warranted to determine whether or not they are pathogenic to *Cynodon* hybrid cultivars.

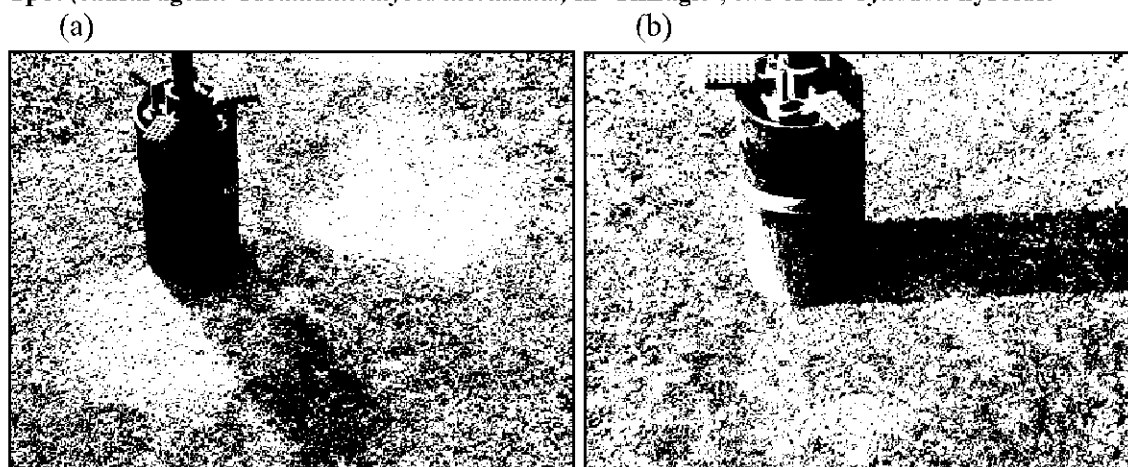
Counts of the number of diseased spots in each plot were made on 31 August 2007. All cultivars were affected to a greater or lesser degree by both diseases (Table 20). The incidence of Spring Dead Spot was greatest in 'Tifgreen' and least in 'Tifdwarf', while the incidence of Ring-Spot was most prevalent in Novotek™ and 'TifEagle'. This shows that preventative programmes for winter patch diseases are necessary with all of the new hybrid *Cynodon* cultivars, particularly in areas likely to experience cold winters. At DEEDI Redlands, these two patch diseases were not evident under warmer winter conditions in 2006.

Table 20. Incidence of patch diseases (number of diseased spots per 6 m x 3 m plot) in *Cynodon* hybrid cultivars at the DEEDI facility 31 August 2007.

Cultivar	Spring Dead Spot	Ring-Spot
MiniVerde™	5.0	4.0
MS-Supreme	7.0	6.3
Novotek™	3.5	12.3
Tifdwarf	1.0	4.8
TifEagle	7.5	12.8
Tifgreen	12.3	7.8
LSD ($P=0.05$)	7.6	5.7

Two half-size (3 m x 3 m) observation plots of 'Champion Dwarf' at the end of the Redlands Greens Test Facility were also badly affected by both patch diseases (averages of 16 and 18 diseased spots per plot for Spring Dead Spot and Ring-Spot, respectively). Interestingly, however, in two similar observation plots of FloraDwarf™, there were no spots present of either disease.

Plate 21. (a) Spring Dead Spot (causal agent: *Leptosphaeria* sp.) in ‘MS-Supreme’ and (b) Ring-Spot (causal agent: *Gaeumannomyces incrustans*) in ‘TifEagle’, two of the *Cynodon* hybrids.



Disease ratings (0= no disease present, 1= minor disease presence, and 2 high disease presence) were carried out on 5 September 2007 of both the *Cynodon* hybrid and seashore paspalums to observe how they recovered from Spring Dead Spot and Ring-Spot testing conducted on 31 August 2007 (Table 21). There were no significant differences between assessments undertaken of the *Cynodon* hybrids on 5 September 2007. However, the incidence of disease is varied to that assessed in August with the exception of ‘Tifgreen’ which remained high. ‘TifEagle’ which was moderate to high in August recovered significantly and to a lesser extent so did ‘MS-Supreme’. Of the paspalums, there was a significant difference between the incidences of disease or possible resistance and SeaDwarf™ and Sea Isle Supreme™ which was infested with Spring Dead Spot and Ring-Spot the most.

In the two half-size observation plots of ‘Champion Dwarf’ and FloraDwarf™ the results were consistent with the initial ratings undertaken five days earlier; no disease was visually observed in either of the two FloraDwarf™ plots, while the ‘Champion Dwarf’ plots rated a high presence of disease.

Table 21. Disease recovery rating of earlier Spring Dead Spot (causal agent: *Leptosphaeria* sp.) and Ring Spot (causal agent: *Gaeumannomyces incrustans*) in the *Cynodon* hybrids and seashore paspalums at DEEDI Redlands on 5 September 2007.

Cultivar	Rating	Cultivar	Rating
MiniVerde™	1.0	Sea Isle 2000	0.8
MS-Supreme	1.5	Sea Isle Supreme	2.0
Novotek™	1.0	SeaDwarf™	1.5
Tifdwarf	1.0		
TifEagle	0.8		
Tifgreen	1.3		
LSD ($P=0.05$)	0.9	LSD ($P=0.05$)	0.9

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CHAPTER 5

REGIONAL TRIAL SITES

INTRODUCTION

The following observations on the *Cynodon dactylon* x *C. transvaalensis* (*Cynodon* hybrid) and the *Paspalum vaginatum* (seashore paspalum) have been compiled from the regional site assessments. The information reflects the site specific observations and do not necessarily reflect the performance of each species and cultivar at different sites around Australia. The information provides an overview of the field performance of the grasses under typical golf course maintenance conditions, however, the data suggests that there can be variation depending on the site and climatic conditions.

These observations should be used as a guide for selecting potential cultivars for on-site evaluation.

MATERIALS AND METHODS

The regional trials were established at several locations to assess a range of *Cynodon* hybrid and seashore paspalum cultivars for their adaptation to various climates and maintenance regimes (Table 22).

The trial sites are at the following locations;

- Glenelg Golf Club, Novar Gardens, SA (Daryl Sellar)
- Chisholm TAFE, Mornington Peninsula, VIC (Bruce Macphee)
- Bermagui Golf Club, Bermagui, NSW (David Thomson)
- Coolangatta Tweed Golf Club, Tweed Heads South, NSW (Peter Lonergan)
- Indooroopilly Golf Club, Indooroopilly, QLD (Charlie Gifford)
- Horton Park Golf Club, Maroochydore, QLD (Pat Pauli)
- Twin Waters Golf Club, Twin Waters, QLD (Gary Topp)

The trials consisted of several *Cynodon* hybrid and seashore paspalum cultivars (Table 23). The grasses were selected by the individual golf course superintendent based on what may perform in that climatic zone, personal interest and recommendations from the AGCSA technical staff and DEEDI scientists. A trial area was established at each site and subjected to the establishment and maintenance practices employed at that golf course.

Table 22. Regional site conditions

Site	Soil type	Planting date	Comments
Twin Waters GC	Medium sand	Mar 04	<ul style="list-style-type: none"> ▪ Single replicates ▪ Irrigated with effluent water (high salinity/sodicity) ▪ Mowing height 3 – 4 mm
Horton Park GC	Medium sand	Nov 07	<ul style="list-style-type: none"> ▪ Six replicates ▪ Irrigated with storm water (low salinity) ▪ Mowing height 3 – 4 mm
Indooroopilly GC	Medium-fine sand	May 08	<ul style="list-style-type: none"> ▪ Two replicates ▪ Irrigated with effluent water (high salinity) ▪ Mowing height 5 mm
Coolangatta-Tweed GC	Medium sand	Jan 08	<ul style="list-style-type: none"> ▪ Single replicates ▪ Irrigated with effluent water (high salinity) ▪ Mowing height 3.5 mm
Bermagui GC	Fine sand	Dec 07	<ul style="list-style-type: none"> ▪ Two replicates ▪ Affected by high water table and high soil sodicity (1000 – 1500 mg/kg) ▪ Mowing height initially at 10 mm and lowered to 4 mm
Glenclg GC	Medium sand	Jun 07	<ul style="list-style-type: none"> ▪ Single replicates ▪ Irrigated with high salinity bore water ▪ Mowing height 3 mm
Chisholm, TAFE	Medium sand	Oct 07	<ul style="list-style-type: none"> ▪ Two replicates ▪ Irrigated with low salinity bore water ▪ Mowing height 4 - 5 mm

The establishment method was similar for each and the following is an indicative establishment program;

- Vegetative material in the form of scarified turf (sprigs) was used to establish the plots.
- The sprigs were incorporated into the surface with a rake and then packed down to ensure there was good soil/plant contact.
- An application of turf starter fertiliser (N:P:K 18:10:10) was applied at a rate of about 2kg per 100m² and Urea (N:P:K 38:0:0) at a rate of 1kg per 100m² prior to the planting of grasses.
- Fertiliser applications continued monthly with an N:P:K (22:4.7:7.6) fertiliser at about 2kg per 100m².
- Irrigation was applied as required during the grow-in period to ensure the soil was kept moist and sprigs were not allowed to dry out.

Table 23. *Cynodon* hybrid and seashore paspalum cultivars established at the regional trial sites

Trial site location	<i>Cynodon dactylon</i> x <i>C. transvaalensis</i> (<i>Cynodon</i> hybrid)								<i>Paspalum vaginatum</i> (seashore paspalum)			
	Champion Dwarf	MiniVerde™	FloraDwarf™	TifEagle	Tifdwarf	Tifgreen	Novotek™	MS-Supreme	Sea Islc 2000	Velvetene™	Sea Isle Supreme™	Sea Dwarf™
Bermagui GC	X	X		X	X	X		X	X	X		X
Chisholm TAFE		X		X				X	X	X		
Coolangatta Tweed GC		X		X	X	X		X	X	X		
Glenelg GC	X	X	X	X	X			X	X		X	X
Horton Park GC	X	X		X	X	X		X	X	X		
Indooroopilly GC		X	X				X	X		X	X	
Twin Waters GC		X	X	X	X	X	X	X				

The golf course superintendents were requested to rate the grasses and to make observations on the following characteristics;

1. Characteristics as a putting surface
2. Disease susceptibility
3. Potential to recover from disease
4. Thatch accumulation and control
5. Mowing height
6. Recovery from damage
7. Topdressing requirements
8. Nutritional requirements
9. Wear tolerance
10. Herbicide tolerance
11. Weed, pest and disease problems
12. Sward characteristics (e.g. open low form, allows light in, potential for weed invasion)

RESULTS

Establishment of the *Cynodon* hybrids

Chisholm TAFE, Rosebud Campus

The trial was planted in late October 2007 and irrigation was applied three times daily during the grow-in period to ensure the soil was kept moist and sprigs were not allowed to dry out. It was up to five weeks before there were any real signs of growth from either the *Cynodon* or *Paspalum* varieties. This slow establishment period was as a result of the fineness of planting material consisting of scarifyings with very few intact rhizomes or stolons.

At 14 weeks after planting, coverage across all plots was at 60-70% with the Paspalums being slightly more advanced. By March most plots had achieved full cover and were maintained at 5.0 mm, being cut twice per week.

Horton Park Golf Club

The warm season grasses used in this trial were planted in November 2007. Tifgreen, Sea Isle 2000 and Velvetene™ established the quickest, with Champion Dwarf being the slowest but still covered in reasonable time. Champion Dwarf looked to be the most prostrate with Tifgreen having the tallest growth habit.

Bermagui Country Club

The plots were stolonised in December 2007. The TifEagle and MS-Supreme established within 4 weeks after planting, with MiniVerde™ being a little slower. Of the paspalums, the Sea Isle 2000 was the fastest to establish and the SeaDwarf™ the slowest.

Glenclg Golf Club

Establishment was very slow from the time of planting due to the late planting in June 2007. As a result, the speed of establishment was extremely slow, with a full coverage barely achieved by the end of summer 2008. MS-Supreme was quickest to establish initially, despite the shade influence. Tifdwarf was very slow and by late summer still had a poor coverage.

Coolangatta Tweed Golf Club

The trial site was established in January 2008. The fastest cultivar to establish was TifEagle.

Indooroopilly Golf Club

The trial site was stolonised during the first week of May 2008. Sea Isle Supreme™ was the first to establish but was likely to be due to having a higher quality of sprig material compared to the other cultivars.

Twin Waters Golf Club

The trial site was stolonised with vegetative material sourced from DEEDI in March 2004. The first cultivars to establish were Tifdwarf and Sea Isle 2000 of the *Cynodon* hybrids and *Paspalum* cultivars respectively. MiniVerde™ was the slowest to establish.

Sward characteristics of the *Cynodon* hybrids

The hybrid couchgrasses can be characterised as follows;

- Very high turfgrass density for all of hybrid couchgrasses except for Tifgreen which has an open habit
- All of the couchgrasses, except for Tifgreen form a very tight surface
- Stolons and leaves are very low growing and prostrate for all the cultivars except for Tifgreen. Tifgreen has a broader leaf that is more upright and erect and stolon growth is more vigorous
- Champion Dwarf potentially has the most prostrate growth habit with Tifgreen having the tallest growth habit
- Tifgreen has the most open growth habit and lowest turf density
- Tifdwarf still provides a low growing turf of high density but has a slightly lower density compared to TifEagle and Champion Dwarf
- All cultivars except Tifgreen produce a dense, tight and even putting surface.

Disease of the *Cynodon* hybrids

All of the regional sites reported the occurrence of disease in the hybrid couchgrasses with the main incidence of disease occurring during the dormancy period. The main diseases reported were “patch diseases” which includes both *Gaumannomyces* and *Rhizoctonia* species. There was differences in the severity of the disease between cultivars, however, the severity of the disease was not consistent between cultivars and is more a location effect. MS-Supreme is potentially the least affected by disease.

The following observations were made;

- Victoria:
 - All cultivars were equally affected by “patch disease”.
 - In the winter of 2009 the couchgrasses were severely affected by Spring Dead Spot (*Leptosphaeria namari*) to the point where there was a 90 – 95% loss of turf cover and density.
 - During the 2009/10 summer recovery was very slow and the surface is still considered to be poor and unacceptable.
- South Australia:
 - All cultivars were equally affected by “patch disease”.
 - All cultivars were highly susceptible to disease in the winter of 2009 despite the application of fungicides.
 - Recovery from disease has been very slow.
- Queensland:
 - Most cultivars were affected by disease in some form.
 - Horton Park GC:
 - In the winter of 2008 MiniVerde™ and TifEagle were the worst affected by “patch disease”.
 - In the winter of 2009 all cultivars were affected by “patch disease”. However, all cultivars exhibited good recovery except for Tifgreen.

- Indooroopilly GC – All cultivars affected by *Drechslera* sp. leaf disease.
- Coolangatta-Tweed GC – All cultivars affected by “patch disease” with TifEagle being the least affected.
- Dollar Spot reported in MiniVerde™ in the summer of 2009-2010.
- New South Wales
 - MiniVerde™ most affected by disease.

In terms of managing the occurrence of disease the incidence of disease is less where there is a higher fertility rate (about 3 kgN/100m²/year) and the use of preventative fungicides. Thatch control is also likely to influence the occurrence and severity of disease i.e. good thatch control will result in less disease.

There are some indications that as some cultivars become more mature they are less severely affected by disease. TifEagle is the most obvious example of where this has occurred.

In the northern climates all cultivars, with possibly the exception of Tifgreen, appear to recover from disease relatively quickly with the onset of warm weather and increasing day length. This is providing that the level of fertility is adequate.

In the southern states of Victoria and South Australia the incidence of disease is more severe and the rate of recovery is considerably slower.

Thatch development and thatch control of the *Cynodon* hybrids

All of the new *Cynodon* hybrid cultivars tend to produce a large amount of thatch with MiniVerde™ potentially the greatest thatch producer, particularly compared to Tifdwarf and Tifgreen. The maintenance of the new hybrid couchgrasses will require a program of regular dethatching/grooming as well as regular light dustings of sand.

It was noted that the tendency towards high thatch accumulation resulted in greater formation of dry patch.

At Horton Park Golf Club there was a regular program of verticutting and sanding during the 2009-2010 growing season. With verticutting at 1 – 3 mm combined with sand dusting the effects of thatch were negated. Because of the tight surface it is difficult to get the sand to penetrate the turf sward and sand is often picked up during verticutting.

A general thatch control and dusting program would be as follows;

Thatch

- Thatch prevention should begin 3 to 4 weeks after planting a new “ultradwarf” couchgrass, with an emphasis on prevention rather than control.
- Biomass of ultradwarf couchgrass greens must be managed differently from that of Tifdwarf.
- Injuries from aggressive vertical mowing shock ultradwarf cultivars, slowing growth and possibly increasing the chance for “couchgrass decline” disease.

Topdressing

- Topdressing material should be fine enough (e.g. 0.25 mm - 0.75 mm in diameter) to filter into the turf canopy.
- Light topdressing for example, 0.03-0.043 cubic meters/100 square meters every 7 to 14 days.
- It has been noted that regular dusting can be difficult because the density of the turf is such that it is very difficult to brush the sand into the thatch layer. An alternative means of thatch control has been suggested in that the turf is groomed in two directions every week during the growing season.

Surface grooming

- The stolons of actively growing couchgrass lie flat, and the growing point escapes the mower bedknife, causing thatch and grain.
- Vertical mowing, grooming and brushing help to overcome or reduce this horizontal stolon growth.
- Brushing improves the putting quality of “ultradwarf” greens and helps reduce grain.
- Brushing raises the tips of juvenile stolons to create a smoother, more complete clipping.
- In conjunction with light topdressing, brushing keeps the raised stolons and shoots vertical to produce a more consistent putting surface.
- It is less injurious to the plant than vertical mowing or grooming.
- Brushing is performed daily during periods of active growth.

Renovations

In addition to the regular grooming and dusting the “ultradwarfs” require hollow core aerification and topdressing twice a year.

Mowing height of the *Cynodon* hybrids

All of the regional sites are maintained at a cutting height of 3.0 mm – 5.0 mm and all of the hybrid couchgrasses are producing a satisfactory surface at these cutting heights. As a general observation these grasses do not respond well to prolonged low cutting.

As a general recommendation on mowing and cutting height the following is noted;

- Cutting heights best at 3.0 mm – 4.5 mm.
- Where the couchgrass is maintained at 3.0 mm – 3.5 mm it was noted that they could be managed at a lower cutting height (e.g. for tournament preparation).
- During peak growth cut daily using walk-behind mowers with groomers.
- Regular double cutting during periods of strong growth.

Under optimal growing conditions, ultradwarf couchgrasses can tolerate mowing heights as low as 3.2 mm for extended periods and 2.5 mm for short periods. At these mowing heights, the turf maintains acceptable density, but the plant is under considerable stress.

Recovery from damage of the *Cynodon* hybrids

There has been limited observations on turf recovery from damage, however, it has been observed that recovery from disease damage is relatively quick under good growing conditions (in particular temperature). In Victoria and South Australia the recovery from disease has been very slow.

In Victoria, Tifgreen has been very slow to recover from summer drought stress and disease scars are still prominent. All other cultivars were severely affected but did recover a complete turf cover.

Dormancy of the *Cynodon* hybrids

Dormancy occurs on all cultivars at all sites. In Victoria and South Australia dormancy is very strong and “spring greenup” does not occur until at least mid-September (South Australia) to October (Victoria). In Victoria MS-Supreme and MiniVerde™ are the earliest cultivars to go into dormancy in winter.

Nutritional requirements of the *Cynodon* hybrids

As a general observation the new hybrid couchgrasses require a relatively high nitrogen input to provide the best quality surface and in particular as a guard against the incidence of disease. At this point in time the optimum rate of nitrogen is at 3 kg/100m², potassium at 4 – 5 kg/100m²/year and phosphorus to be determined through soil tests.

Pesticide tolerance of the *Cynodon* hybrids

Across all of the regional sites there has been various pesticides applied to the *Cynodon* hybrid cultivars (Table 24).

Table 24. Pesticides used on the *Cynodon* hybrid cultivars at regional trial sites

PESTICIDE	COMMENT*
Herbicide	
Dimension® (a.i. dithiopyr)	Applied late November - no adverse effect Applied in July – shortened root systems compared to untreated area. TifEagle was the most sensitive and resulted in high incidence of disease.
Spearhead® (a.i. 20 g/l clopyralid, 15 g/l diflufenican, 300 g/L MCPA)	Applied in summer - no adverse effect
Pendimethalin	Applied in July – shortened root systems in all cultivars compared to untreated area. FloraDwarf was the most sensitive and resulted in a high incidence of disease.
Propyzamide	Applied in April – no adverse effect
Monument® (a.i. trifloxysulfuron sodium)	Applied in July – no adverse effect
Endothal	Applied in July – no adverse effect
Trinoc™ (a.i. DSMA & MCPA)	Applied in July – some minor discolouration
Mecoprop/MCPA/Dicamba	Applied in August – no adverse effect
Oxadiazon	Applied after stolonising – no comments made
Paclobutrazol	Distinct burn noted
Daconate® (a.i. MSMA)	No adverse effects unless spot treatments applied (slight burn)
Fungicide	
Ipridione	Applied in late November – no adverse effect
Chlorothalonil	Applied in late November – no adverse effect
Alicette Signature® (a.i. fosetyl al)	Applied in late November – no adverse effect
Penncozeb® (a.i. mancozeb)	Applied in late November – no adverse effect
Baycor® (a.i. bitertanol)	Applied in July – no adverse effect
Insecticide	
Acelepryn® (a.i. chlorantraniliprole)	Applied summer – no adverse effect
Growth retardant	
Primo Maxx® (a.i. trinexapac)	Applied in summer – all cultivars suffered leaf burn. All except Tifgreen recovered in 2 weeks.

**Note: Not all pesticides have been trialled on all cultivars at all locations and under all climatic conditions. Always read and follow the label instructions.*

Site specific characteristics and suitability concerning the *Cynodon* hybrids

Victoria and South Australia

Hybrid couchgrasses have been used for bowling greens in Victoria and South Australia and in particular the cultivar Tifdwarf. Tifdwarf is considered to be successful, however, it is strongly dormant in winter and does not break dormancy until September (at the earliest) in SA and northern Victoria and not until October (at the earliest) in southern Victoria.

The bowls season commences in September, often when the grass is still dormant. This can result in some loss of turf density and decline in surface performance unless well managed. Patch diseases such as Spring Dead Spot is often present and severe turf damage can result. In southern Victoria with the milder summers turf recovery can be very slow.

The new hybrid couchgrasses appear to react in a similar manner to Tifdwarf and do not necessarily offer a superior alternative in South Australia and Victoria. In the Victoria trial, Tifdwarf and Tifgreen were considered to be superior to the other cultivars.

Queensland

Cynodon hybrid cultivars have been used for golf greens and bowling greens in Queensland for more than 30 years with Tifgreen (328) being predominantly used on golf greens and Tifdwarf used extensively on bowling greens. Tifdwarf has also been used to a limited extent on golf greens.

Tifgreen has not always performed well on golf greens. In recent times it has been highly susceptible to Ectotrophic Root Infecting (ERI) fungi and suffered summer decline during hot and humid weather. Tifgreen also performs very poorly in the tropical north under conditions of constant cloud cover and low light which occurs during the wet season.

The problems with Tifgreen are possibly related to the inability of Tifgreen to perform under a high intensity maintenance regime required to provide superior putting surfaces. In particular lower cutting heights during summer creates stresses that result in a higher incidence of ERI fungi and the associated damage.

All of the new hybrid couchgrasses have the potential to provide superior putting surfaces to Tifgreen. There is no specific cultivar across all sites that can be considered to be superior to all other cultivars. At each site there is a "favourite" cultivar and even over time as the grasses have matured the "favourite" has changed. As the grasses mature the main change appears to relate to susceptibility to disease.

The golf course superintendents were canvassed as to what cultivar(s) they would select if they were to make a change. The following comments were made;

- None of the grasses were that outstanding that would initiate change with TifEagle being the preferred grass. Grasses must be trialed on a green in play so that they are subjected to typical golf course wear.
- The cultivars; TifEagle, MiniVerde™, MS-Supreme and Champion Dwarf are all potential alternatives to Tifgreen. Champion Dwarf is a high maintenance grass and would need to be tried on a green in play. If a choice had to be made today TifEagle is the obvious selection because it is the only grass available.

- In South Australia the couchgrasses struggled though MS-Supreme showed the greatest potential and is worth further investigation.
- In Victoria, Tifgreen was considered to have the greatest prospect with MiniVerde™, MS-Supreme considered to be substantially inferior.
- MS-Supreme was the standout across all seasons.
- TifEagle is slightly better than MS-Supreme and both of these as far better than the rest.

Establishment of seashore paspalum

Chisholm TAFE, Rosebud Campus

The trial was planted in late October 2007 and irrigation was applied three times daily during the grow-in period to ensure the soil was kept moist and sprigs were not allowed to dry out. It was up to five weeks before there were any real signs of growth from either the *Cynodon* or *Paspalum* varieties. This slow establishment period was as a result of the fineness of planting material consisting of scarifyings with very few intact rhizomes or stolons.

At 14 weeks after planting, coverage across all plots was at 60-70% with the paspalums being slightly more advanced.

Horton Park Golf Club

The warm-season grasses used in this trial were planted in November 2007. Sea Isle 2000 and Velvetene™ established the quickest, with SeaDwarf™ being the slowest but still covered in reasonable time.

Bermagui Country Club

The plots were stolonised in December 2007. Of the Paspalums, the Sea Isle 2000 was the fastest to establish and SeaDwarf™ the slowest.

Glenelg Golf Club

Establishment was very slow from the time of planting due to the late planting in June 2007. As a result, the speed of establishment was extremely slow, with a full coverage barely achieved by the end of summer 2008.

Indooroopilly Golf Club

The trial site was stolonised during the first week of May 2008. Sea Isle Supreme™ was the first to establish but this was due to having a higher quality of sprig material compared to the other cultivars.

Twin Waters Golf Club

The trial site was stolonised with vegetative material in March 2004. Sea Isle 2000 was the quickest to establish.

Sward characteristics of seashore paspalum

All of the seashore paspalums can be characterised as follows;

- High turfgrass density
- Appear to be finer in winter than summer
- Forms a moderately tight surface
- Stolons and leaves are low growing and prostrate, however, some cultivars will produce stolons that will grow upwards and then bend back towards the surface. This is often referred to as “porpoising”.
- Velvetene™ has the more open growth habit.
- All cultivars produce a moderately dense and even putting surface.
- The putting surface is described as being “sticky” and will not necessarily provide a fast putting surface.

Disease of seashore paspalum

All of the regional sites reported the occurrence of disease in the seashore paspalums with the main incidence of disease occurring following rainfall and under cloud cover. The main disease reported was Dollar Spot with some “patch disease” (mainly *Rhizoctonia* species) and Leaf Blight (*Drechslera* and *Curvularia* spp.) recorded. *Pythium* sp., Phoma and Anthracnose (*Colletotricum* sp.) were also reported at the South Australia site.

There was little difference in the severity of the disease between cultivars.

All cultivars appear to recover from Dollar Spot relatively quickly with the onset of clear and dry weather. Disease scars can persist with the onset of dormancy.

Thatch development and thatch control of seashore paspalum

All of the seashore paspalums tend to produce a large amount of thatch and as a consequence are easily scalped during mowing. Scalping appears to be more pronounced during the winter. The seashore paspalums are slow to recover from scalping and require considerable vigilance to ensure that they are not scalped. The maintenance of the seashore paspalums will require a program of regular dethatching/grooming as well as regular light dustings of sand.

The observations from South Australia and Victoria were that the seashore paspalums tended to form more thatch than the hybrid couchgrasses.

At Horton Park GC there was a regular program of verticutting and sanding during the 2009-2010 growing season. With verticutting at 1.0 mm – 3.0 mm combined with sand dusting the effects of thatch were negated.

A general thatch control and dusting program would be similar to the ultradwarf couchgrasses as follows;

Thatch

- Thatch prevention should begin 3 to 4 weeks after planting a new seashore paspalum green, with an emphasis on prevention rather than control.

Topdressing

- Topdressing material should be fine enough (e.g. 0.25 mm - 0.75 mm in diameter) to filter into the turf canopy.
- Light topdressing for example, 0.03-0.043 cubic meters/100 square meters every 7 to 14 days.
- It has been noted that regular dusting can be difficult because the density of the turf is such that it is very difficult to brush the sand into the thatch layer.

Surface grooming

- Vertical mowing, grooming and brushing helps to improve the fineness of the leaf and the evenness of the surface. It also removes the stolons that have a tendency to “porpoise”.
- Brushing improves the putting quality of seashore paspalum greens and helps reduce grain.
- Brushing raises the tips of juvenile stolons to create a smoother, more complete clipping.
- In conjunction with light topdressing, brushing keeps the raised stolons and shoots vertical to produce a more consistent putting surface.
- It is less injurious to the plant than vertical mowing or grooming.
- Brushing is performed daily during periods of active growth.

Renovations

In addition to the regular grooming and dusting the seashore paspalums require hollow core aeration and topdressing twice a year.

Mowing height of seashore paspalum

All of the regional sites are maintained at a cutting height of 3.0 mm – 5.0 mm and all of the seashore paspalums are producing a satisfactory surface at these cutting heights. The general observation is that they respond better to the lower height of cut (i.e. 3 mm) and require the lower cutting height in order to produce an acceptable putting surface.

Recovery from damage of seashore paspalum

There has been limited observations on turf recovery from damage, however, it has been observed that recovery from disease damage is relatively quick under good growing conditions (in particular temperature). It was noted that seashore paspalum recovered quickly through aggressive stolon growth into the bare area.

Where seashore paspalum is damaged by scalping it is often slow to recover and scalping must be avoided.

Drought stress tolerance of seashore paspalum

At two of the regional sites (Victoria and Queensland) an irrigation failure placed the seashore paspalums under moisture deficit. The hybrid couchgrasses were severely affected, however, the seashore paspalums suffered considerably less from moisture deficit and were quick to recover. The seashore paspalums also appeared to be less prone to forming localised dry patch compared to the hybrid couchgrasses.

Pesticide tolerance of seashore paspalum

Across all of the regional sites there has been a number of pesticides applied to the seashore paspalum cultivars (Table 25).

Table 25. Pesticides used on the seashore paspalum cultivars at regional trial sites

PESTICIDE	COMMENT*
Herbicide	
Spearhead® (a.i. 20 g/l clopyralid, 15 g/l diflufenican, 300 g/L MCPA)	Applied in summer - no adverse effect
Mecoprop/MCPA/Dicamba	No adverse effects reported
Fungicide	
Triadimenol	No adverse effect
Chlorothalonil	Applied in late November – no adverse effect
Baycor® (a.i. bitertanol)	Applied in July – no adverse effect
Triadimenol	Applied in July – no adverse effect
Thiram	Applied in July – no adverse effect

**Note: Not all pesticides have been trialled on all cultivars at all locations and under all climatic conditions. Always read and follow the label instructions.*

Dormancy of seashore paspalum

Dormancy occurs on all cultivars at all sites, however, the seashore paspalums do not go as dormant as the hybrid couchgrasses. This is particularly the case in South Australia and Victoria. The general observation is that Velvetene™ has a greater loss of colour compared to SeaIsle 2000.

Nutritional requirements of seashore paspalum

As a general observation the seashore paspalums require a relatively high nitrogen input to provide the best quality surface and in particular as a guard against the incidence of disease. At this point in time the optimum rate of nitrogen is at 3 kg/100m²/year, potassium at 4 – 5 kg/100m²/year and phosphorus to be determined through soil tests.

Site specific characteristics and suitability concerning seashore paspalum

There has been little or no history of using seashore paspalum on putting greens in Australia.

In Victoria, the observation was made that the seashore paspalums have been surprisingly good with Velvetene™ the stand out and is worth further consideration.

At none of the remaining sites was seashore paspalum considered to be an alternative to the hybrid couchgrasses.

Seashore paspalum appears to have limited application where hybrid couchgrass can be maintained and its use is likely to be restricted to sites with high salinity water (greater than 2500 mg/L).

The golf course superintendents were canvassed as to what cultivar(s) they believe had the best qualities. The following comments were made;

- Sea Isle 2000 is the better of the two paspalums in Melbourne's climate, it has superior colour, density and texture.
- Sea Isle 2000 was quickest to establish and was slightly better than the Velvetene™ and much better than the Sea Dwarf™.

CONCLUSION

Cynodon hybrids

The regional trials have provided useful information from a practical perspective on the merits of the grasses under trial. The general opinion on the hybrid couchgrasses is that the new cultivars provide a superior surface to Tifgreen and potentially better than Tifdwarf.

The preferred cultivar varied from site to site and also varied over time at each site. That is, as the cultivars matured the merits of particular cultivars changed. An example of this is susceptibility to disease, where in year one a particular cultivar may have been severely affected by disease, in year two there was a low incidence of disease. This particular aspect emphasises the importance of undertaking on-site evaluations for at least 2 – 3 years so that the effects of maturity and long term maintenance practices can be observed.

All of the new cultivars are high thatch producers and an intensive program of dusting and dethatching will be essential where they are introduced.

All of the cultivars, including Tifdwarf and Tifgreen tended to suffer from “patch” diseases including Spring Dead Spot (*Leptosphaeria namari*), Take-All Patch (*Gaumannomyces* sp.) and Brown Patch (*Rhizoctonia* sp). In some situations the damage was extensive. The effects of disease was more prominent in the cooler southern climates where the disease severely damaged the putting surface. A critical aspect of managing these grasses is to maintain good thatch control and to have a preventative fungicide program.

In terms of fertility, the new cultivars do have a relatively high nitrogen requirement (about 3 kg/100m²/yr) in order to achieve a high quality putting surface and to assist in reducing the impacts of disease. The implications are that at this level of fertility it will stimulate thatch accumulation and again reinforces the need for a diligent thatch control strategy.

Seashore paspalum

The regional trials have provided useful information from a practical perspective on the merits of the grasses under trial. The general opinion on seashore paspalum is that it has limited application for replacing the hybrid couchgrasses.

As a putting surface seashore paspalum is a difficult grass from which to produce an acceptable green speed due to the “sticky” nature of the leaf which increases the resistance to ball roll. As with the hybrid couchgrasses all cultivars are high thatch producers and will require an intensive program of thatch management.

All cultivars are affected by the incidence of disease and in particular Dollar Spot. Dollar Spot appears to be most prominent during periods of cloudy and humid weather and often disappears when clear, sunny weather returns.

All of the second-generation seashore paspalum cultivars are high thatch producers and an intensive program of dusting and dethatching will be essential where they are introduced.

In terms of fertility, the new cultivars do have a relatively high nitrogen requirement (about 3 kg/100m²/yr) in order to achieve a high quality putting surface. The implications are that at this level of fertility it will stimulate thatch accumulation and again reinforces the need for a diligent thatch control strategy.

The seashore paspalums are susceptible to scalping and are slow to recover from such damage. Regular, low cutting is an essential aspect of maintaining these grasses.

For a golf club to selecting either a hybrid couchgrass or seashore paspalum they need to;

- Review the research data.
- Look at the trial plots.
- Inspect greens in play that have the new grasses.
- Select 2 – 3 cultivars that are considered to be the better types.
- Establish them in large (large enough to putt on) plots/nursery/practice putter. Ideally the area should be subjected to wear.
- Maintain them exactly as they would be on the golf course. This is a critical aspect. Regular mowing, fertilising etc. is essential.
- Assess them over at least 2 - 3 years.
- Make a selection and establish it in a green in play so that it is subjected to typical wear.

CHAPTER 6

TECHNOLOGY TRANSFER

During the TU05001 project we conducted a program of ongoing communication and extension activities. Our published information output to date included 6 articles in industry journals, 5 newsletters which were distributed by the Australian Golf Course Superintendents Association (AGCSA), 1 national conference presentation and conference proceedings, 3 articles published in general media, 1 major field day and numerous tours for industry of both the regional trial sites and the Redlands DEEDI centralised test facility.

To rollout the results and recommendations contained in this report two seminars have already been scheduled for 2010. The first will be a series of presentations made by Project Leader Matt Roche at the seminar Sustainable Turfgrass Management in Asia 2010 which will be held in Pattaya, Thailand (8-10 March 2010). Following will be presentations made by Matt Roche and John Neylan, General Manager of the AGCSA at the 26th Australian Turfgrass Conference which will be held on the Gold Coast, Queensland (21-25 June 2010). Material will later be released in instalments through the Australian Turfgrass Management Journal, other turfgrass and sports publications and will also be made available on the AGCSA (<http://www.agcsa.com.au>) and DEEDI (<http://www.deedi.qld.gov.au>) web sites.

SEMINARS AND INDUSTRY PRESENTATIONS

- Visit and inspection of the DEEDI greens facility by the attendees of the 22nd Australian Turfgrass Conference, 21 July 2006
- Presentation “update on warm-season turfgrass trials: evaluation of new greens grasses” at the 23rd Australian Turfgrass Conference, Cairns, 25 July 2007
- The Golf Course Superintendents Association of Queensland (GCSAQ) held their committee meeting at Redlands Research Station on 18 January 2008. This provided the group an opportunity to inspect the Redlands Greens Test Facility and get an update of the project and its findings.
- Superintendent Phil Soergaard and a delegation from Lakelands Golf Club, Merrimac, Queensland inspected the trial site on 12 June 2008
- Visit and inspection of the DEEDI greens facility by the attendees of the 13th Australian Racecourse Managers Conference on 20 August 2008
- Field Day at DEEDI Redlands Research Station, 12 May 2009

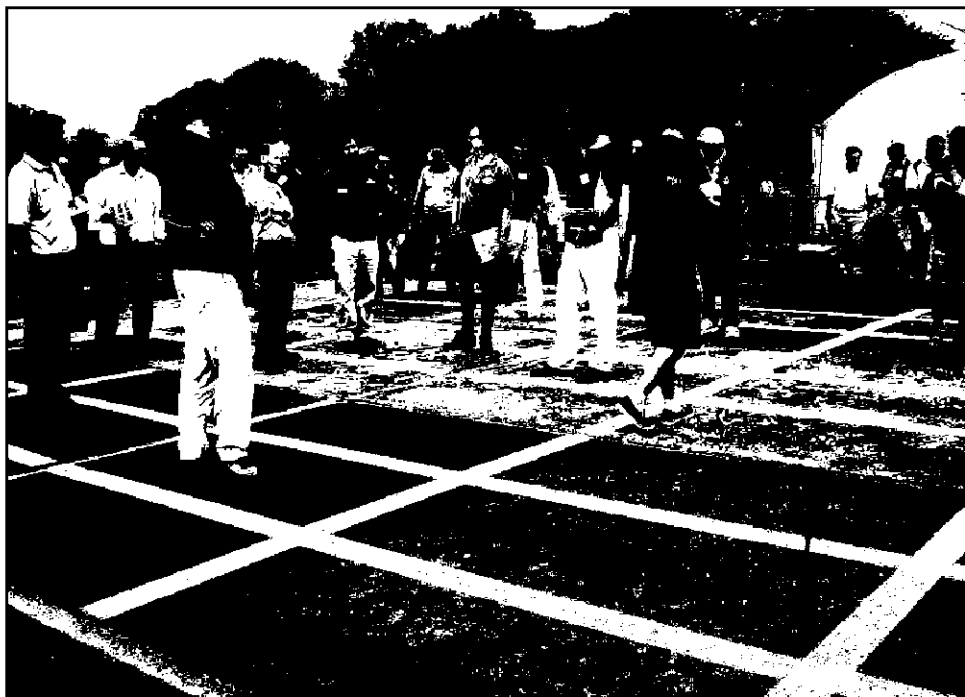
Staff of the AGCSA and DEEDI hosted a field day at Redlands Research Station, Qld on 12 May 2009 as part of the information roll-out for the TU05001 warm-season greens grass study. The aim of the field day was to showcase preliminary results obtained from all 8 trial sites (Redlands Centralised Test Centre and 7 regional test sites) and to provide evidence of how different species and even cultivars respond differently to geographic conditions and management practices. The information provided to the 48 participating superintendents and greenkeepers

provided them with an insight in how to effectively provide their members with high quality golf and bowls playing surfaces given the right inputs at an achievable cost to the club.

Presentations on the research activities and BMPs were made by:

- John Geary, Environmental Agronomist, AGCSA
 - Matt Roche, Senior Scientist, DEEDI
 - Jon Penberthy, ex. superintendent and DEEDI Technical Officer
 - Pat Pauli, Golf Course Superintendent, Horton Park Golf Club
 - Gary Topp, Twin Waters Golf Club
 - Peter Lonergan, Coolangatta and Tweed Head Golf Club
 - Charlie Gifford, Indooroopilly Golf Club.
- Visit by Steve Isaac of the Royal and Ancient in Scotland, 24 September 2009
- A visit of the DEEDI test facility was undertaken on the 14 September from Steve Isaac. Steve is golf course management director for Royal and Ancient (R&A) in Scotland. Steve was on site to provide some helpful tips during his recent visit to Australia to undertake a series of sustainability golf course management seminars within Australia organised by the AGCSA.
- A presentation was made by Jon Penberthy, DEEDI Experimentalist to attendees of Qld Turf Research Golf Day held on the 10 November 2008 and again on 16 November 2009 at Robina Woods Golf Course, Gold Coast.
 - Numerous site visits were undertaken by superintendents and greenkeepers from within the turfgrass industry at all seven regional trial sites and DEEDI test facility.

Plate 22. Attendees of the 2009 field day at DEEDI Redlands Research Station inspecting the greens test facility



PUBLICATIONS

- Roche, M.B, Penberthy, J.D., & Loch, D.S. 2007. Update on Warm-Season Turfgrass Trials: Evaluation of New Greens Grasses. 23rd Australian Turfgrass Conference, Cairns pp. 64-67.
- Neylan, J. 2008. AGCSA Tech update: Warm-season grass trials at Redlands. *Australian Turfgrass Management Journal* 10 (1) 33-34.
- Neylan, J. 2008 Warm-season and Poa annua trials update. *Australian Turfgrass Management Journal* 10 (6) 36-40.
- Neylan, J. & Peart, A. 2009 Local ecotypes perform in bentgrass salinity trials. *Australian Turfgrass Management Journal* 11 (1) 34-37.
- Neylan, J. 2009 Selection, management of new greens grasses. TurfCraft International Mar-Apr 32-35.
- Roche, M.B. 2009. Warm-Season Greens Grass Trial Field Day – May 9. *Australian Turfgrass Management* 11 (4) 66.
- Penberthy, J. 2009. Redlands warm-season greens trials wraps up. *Australian Turfgrass Management Journal* 11 (6) 44.

A series of newsletters (five in total) which contained research updates and information were distributed by the AGCSA to collaborating superintendents and financial contributors to the project. Newsletters were distributed in August and December 2006, October 2007, September 2008 and February 2009.

MEDIA

Following the field day held at Redlands Research Station on 12 May 2009, DEEDI staff posted a press release of the event which was provided by Qld State Minister for Primary Industries & Fisheries Tim Mullherin. The article was run by the Courier Mail (28/7/09 – Morley, P. In search of a perfect green p. 19), Sunshine Coast Times (30/7/09 – <http://www.mysunshinecoast.com.au/articles>) and the Australian Financial Review (31/7/09 – Jay, C. Perfect putts a step closer p. 49). The content was also published on the Qld Government web site (<http://www.cabinet.qld.gov.au/MMS/StatementSearch.aspx>) as a Ministerial Media Statement (30/7/09) and on the Pro Golf Australia (PGA) web site (<http://www.pga.org.au>) (4/8/09). As a result of these publications radio interviews followed soon after which included: ABC Radio Capricornia (live on 31/7/09), ABC radio Central (prerecorded on 31/7/09), ABC 612 drivetime (live on 31/9/09), ABC Sunshine Coast (6:50 AM live 3/8/09) and ABC Townsville (prerecorded 3/8/09). A television interview for Mackay and Bundaberg Channel 7 was also undertaken by Primary Industries & Fisheries Minister Tim Mullherin on 29 July 2009 live from the Mackay Regional Botanic Gardens. A similar story was run by Brisbane News the week commencing 3 August 2009.

Information was also published on the AGCSA (<http://www.agcsa.com.au>) and DEEDI web site informing the industry of recent activities and trial results.

CASE STUDIES

Three case studies have been documented to show activities that were undertaken at either ends of the TUO5001 project timeline. When the warm-season grass study was in its embryonic stage former DEEDI Principal Scientist Dr Don Loch was involved in discussions with Terry Anderlini from Tropical Lawns Pty Ltd about the use of Novotek™ on a bowling green in Bundaberg (case study one); In 2006 the Ipswich Golf Club wanted to resurface 11 of their 18 greens and fairways to Velvetene™ which would enable the club to use lower quality water (case study two); more recently DEEDI researchers were approached by Queensland Bowls wanting to improve their problematic green and potentially improve the playing performance of their centre of excellence which has been setup at Coorparoo Bowls Club (case study three).

Case study one: Novotek™ Finds Favour on Bundaberg Green

By Dr Don Loch, former QPIF Principal Turf Scientist

Back in 2001, Tantitha Bowls Club re-developed one of their three greens with the new Novotek™ hybrid green couch. They were supported in this venture by Bowls Queensland, who saw it as an opportunity to trial this promising (but at that time, unproven) grass on a bowls green in a real world situation. Now, nine years on, Tantitha's Novotek™ green has become very popular with Bundaberg locals, who consider it the best bowls surface to play on in the district.

The surface of the old green at Tantitha was removed and the original sandy loam profile amended by mixing in some sand before sprigging the new Novotek™ green on 17 September 2001. The sprigs took quickly and the Club was back playing again on their new green within 12 weeks of planting.

Novotek™ was developed by Terry Anderlini from Tropical Lawns in Gordonvale. During the wet season, the quality of 'Tifgreen' (328) and 'Tifdwarf' greens in tropical north Queensland deteriorates badly under the combined effects of long periods of low light caused by heavy cloud cover and wet season diseases encouraged by the high humidity. However, some patches within these affected greens remain dense, dark green and vigorous. In the mid-1990s, Terry collected 42 of these superior mutant clones from a number of local greens, and trialled them on his turf farm for several years before finally selecting a clone from the 15th green at the Novotel Palm Cove resort course to commercialise. The new cultivar was registered for Plant Breeder's Rights (PBR) in 2003 as 'TL2', but is being marketed under the name "Novotek" in recognition of its origin.

At DEEDI Redlands, we find that Novotek™ behaves very much like a dense, vigorous "Tifdwarf type" of plant, and grows more rapidly than 'Tifdwarf' under warm summer conditions. When uncut, it produces more seed heads and grows taller than the new American ultradwarf varieties such as 'TifEagle', 'Champion Dwarf', 'MS-Supreme' and FloraDwarf™; but this presents no real problems on regularly mown greens.

More importantly, at greens mowing height, Novotek™ produces slightly less thatch than other "ultradwarfs", making its management easier and less expensive. In

the tropics, Novotek's real strength lies in its abilities to grow in situations with low light, high humidity and poor air movement coupled with its resistance to wet season diseases.

At Tantitha, greenkeeper Tony Barrit finds Novotek™ easy to manage based on the same practices he uses with 'Tifdwarf' on the Club's other two greens. It is mown to the height of 10-cent piece, and fertilised with slow release fertiliser about every 8 weeks. The Novotek green is renovated each year between October and January in rotation with Tantitha's two 'Tifdwarf' greens. Following renovation, Novotek™ receives a little more grooming through to about April because it grows more rapidly under warm temperatures. On the flip side, though, Novotek™ requires less spraying to control diseases in a environment like Tantitha.

In north Queensland, Novotek™ has been used on golf greens at Mossman, Palm Cove and Port Douglas for several years, and its superior performance during the tropical wet season has now led to increasing interest from other courses and bowls greens from far north Queensland through Mt Isa to Darwin and Humptydoo. It has also proven successful under similarly challenging conditions with seasonal heat, humidity and low light in tropical Southeast Asia where it is being marketed by Gary Chatfield (Global Turf Consulting) under license from Tropical Lawns.

Plate 23. Bowlers playing on Novotek™ green at Tantitha (source: Tony Barrit)



Case study two: Velvetene™ being used from tees to greens at Ipswich Golf Club

By Jon Penberthy, DEEDI Experimentalist

In 2008, planting of the reconstructed Ipswich Golf Club, Queensland, was undertaken using the *Paspalum vaginatum* cultivar Velvetene™ (TFWA02). The Golf Club had been made an offer by a land developer to furnish the members with a newly designed and constructed Golf Course in return for land for housing associated with the new course. Effectively the Club had sold off part of the course and restructured 18 holes.

The Golf Course architect chosen for the project was Wayne Grady Golf Design and they were asked to come up with a better variety of turf for use on greens as the Superintendent, Peter Currey, was not happy with the performance of the *Cynodon* hybrid 'Tifgreen' which was quick to go into dormancy and showed considerably slow spring 'greenup'. Ipswich which is located approximately 40 km west of Brisbane is prone to very hot conditions through summer and very cold conditions through winter. Peter Currey considered the Tifgreen was not handling the extremes of weather the Golf Course was regularly experiencing. The Superintendent had tried oversowing with A4 Bentgrass (*Agrostis* sp.) which seemed to work well with good heat tolerance and recovery whilst providing a good surface. However, encroaching weeds continued to be a problem.

Other problems had developed over time with use of Tifgreen at the Ipswich Golf Club, diseases like Spring Dead Spot (*Leptosphaeria namari*), Brown Patch (*Rhizoctonia* sp.) and Ectrotropic root infecting (ETRI) fungi had become prevalent and a change was deemed necessary. Previously the greens had been a variety of Queensland Blue Couch (*Digitaria didactyla*) and regrowth of remnants of this variety and common green couch (*Cynodon dactylon*) were seen as a problem that could be solved by going to a new surface.

When the Golf Course architects became involved they were asked investigate for an alternative variety for use on the greens. They first looked at using 'Tifdwarf', but then visited Colonial Golf Club at Robina, Queensland, where several practice greens had been produced using Velvetene™. The Velvetene™ greens at the Golf Coast Club were in good condition and after looking at several other sites, including the centralised test facility at QDEEDI Redlands Research Station, they chose use Velvetene™.

The remainder of the course (fairways and tees) was a mixture of green couch varieties with 'Wintergreen' and 'CT-2' having been strip planted on several fairways and a mixture of common green and blue couch on the others. Once every two or three years fairways had been thinning out and starting to look ordinary due to several factors but lack of water being the primary reason. With the idea of having Velvetene™ as the greens grass variety it was seen as a benefit to have a monoculture of Velvetene™ over the whole course thereby doing away with the problem of couch encroachment into greens.

The decision was made to go with Velvetene™ from tee to green as the problems the club was having gaining access to suitable water were becoming greater. The Club has an allocation of water from nearby Moogerah Dam but in the past few years has only been able to access 50% of their entitlement and of that only 10% at a time. Although the club had its own catchment and storage pond the allocation from

Moogerah was required to maintain the course and it was no longer able to meet half its demand. It got to a stage where fairways were not being watered for two months at a time and greens were being hand watered to keep them alive. Velvetene™ was promoted to the club as being more drought tolerant than the turf cover they had and able to endure lower quality water whilst maintaining a surface. It was also promoted as requiring 40% less nitrogen by the suppliers.

Water quality at the site was not an issue though it had a generally low pH but quantity was a problem. Since reconstruction the Ipswich Golf Club has a greater hard surface catchment that now supplies a 40 Megalitre holding dam. They still have access to the Moogerah Dam allocation but are a lot better off than before the works took place. Although the Velvetene™ was promoted as being drought tolerant, this is yet to be proven on this site.

Problems encountered with changing to Velvetene™ have included weeds coming up through the new turf. They are using moderate applications of raw salt to control green couch with some success. The Superintendent has been using a squad of volunteers to go over the course tee to green covering any weeds with salt and reports a good degree of success with this approach. One fairway that had been heavily infested with couch is now back to 25% green couch after continued salt applications and is seen as getting under control.

The other significant problem is Dollar Spot (*Sclerotinia homeocarpa*) with some greens being more of a problem than others. Peter Currey is trying to avoid environmental damage through the use of pesticides and is looking at cultural methods to control this problem. Where there is no alternative Peter resorts to using a fungicide to control this disease but prefers to use an Integrated Pest Management (IPM) approach.

The greens following establishment and once in play were seen as being slower (ball roll speed) than the Tifgreen greens by the members. However, over time, as they have had more management carried out, the members have come to accept them. Peter Currey commented that the turf colour is outstanding (staying green longer) and that the Velvetene™ greens are now very true to putt on and the members are not complaining. He is cutting them at 3 mm, six days a week and constantly working them, by either double cutting, verticutting or dusting the greens to produce a good surface. Velvetene™ like that of other seashore paspalums have a tendency to thatch up and scalping is to be avoided at all costs as they take a long time to recover from damage. To combat scalping Peter is mowing the greens with dethatching units every two weeks and dusting them, some times using a very light dust by itself.

Fairways are being cut at 15 mm twice a week to keep on top of them. The club bought a spin spreader to be able to carry out topdressing quickly over the course to reduce thatch problems and this has been a great difference in managing Velvetene™ as opposed to couch varieties. It has taken two years for the grass to really take off and obtain full cover. The timeframe was exacerbated following extreme temperature and a dry heat during establishment which really held back growth.

The Ipswich Golf Club are playing 11 holes of the new course and 7 of the old course as part of the brief was to keep the course open for the members. Problems have been encountered here by the fact that where housing development is under way sometimes irrigation lines to the old part of the course have been cut. The surfaces should continue to get better as the course matures.

Case study three: MiniVerde™ in use at Queensland Bowls Centre of Excellence

By Matt Roche, DEEDI Acting Senior Scientist

The first bowling green to be supplied planting material of MiniVerde™ was Coorparoo Bowls Club, Coorparoo, Queensland on 14 Sep. 2009 to sprig their number two (eastern) bowling green. Following permission from John Holmes, Global Sales Manager, of Phillip Jennings Turf Farm, Sandersville, Georgia, USA, DEEDI supplied material to contract greenkeeper Darryl Bain (Professional Greens Management Pty Ltd) of the club following discussions with Queensland Bowls who wanted to upgrade one of their two greens. The purpose of this was not only to improve the problematic green, but it was also to supply a potentially improved turfgrass to what is now the centre of excellence for lawn bowls. The centre is part of Queensland Bowls high performance program being run in conjunction with the Queensland Academy of Sport, Australian Sports Commission and Bowls Australia in an effort to be acknowledged as the number one elite bowling state in Australia.

Alan Duff, DEEDI Turf Team Leader, reported on the 15 January 2009 that the growing in of the turf at Coorparoo Bowls Club was going excellent. However, its superior growth has already been identified by the Coorparoo greenkeeper. Over the Christmas period and start of the New Year the turf is growing rapidly and fast covering to produce a quality playing surface following sprigging four months earlier. Daily mowing is required of the surface and routine dethatching has already commenced. It is great to see this being undertaken in its early development state as with the growth of MiniVerde™ it is recommended that a dethatching program start almost immediately. MiniVerde™ will perform and produce a great surface; however the appropriate resources must be made available to keep it (largely the thatch) under control.

Plate 24. Growing in of MiniVerde™ at Coorparoo Bowls Club 15 January 2009.



CHAPTER 7

GENERAL PROJECT CONCLUSION AND RECOMMENDATIONS

Introduction of the newer *Cynodon* hybrids (“ultradwarfs”) and greens quality seashore paspalums will be dependent on largely one component; thatch accumulation and successful management being undertaken from a very early stage in the grow-in of the greens. Frequent light dusting or topdressing is recommended every seven to fourteen days with material fine enough to filter through the turf canopy. Some “ultradwarf” cultivars may require higher levels of sand and paspalums more so than the *Cynodon* hybrids. Groomers should be utilized where possible during the growing season (e.g. weekly) to continuously reduce thatch accumulation and prevent “porpoising” seen in the seashore paspalums. Such practices will assist in thatch reduction and result in denser, smoother and faster putting and bowls surfaces. Prevention is the key to ensuring long term success.

The following observations and recommendations on the *Cynodon* hybrids (or couchgrass) and the seashore paspalums have been compiled from the eight trial sites (7 x regional trial sites and DEEDI centralised testing facility) following routine assessments undertaken throughout the duration of the warm-season grasses trial (TU05001). The information reflects the site specific observations and do not necessarily reflect the performance of each species and cultivar at different sites around Australia. The information provides an overview of the field performance of the grasses under typical golf course maintenance conditions, however, the data suggests that there can be variation depending on the site and climatic conditions. Such evidence highlights the need to undertake genotype by environment (G x E) studies on new and old cultivars.

These observations should be used as a means of selecting potential cultivars for on-site evaluation.

CYNODON HYBRIDS

Sward Characteristics (turf density, growth characteristics etc.)

All of the eight *Cynodon* hybrids can be characterised as follows:

- Very high turfgrass density
- Forms a very tight surface
- Stolons and leaves are very low growing and prostrate
- ‘Champion Dwarf’ potentially has the most prostrate growth habit with ‘Tifgreen’ having the tallest growth habit.
- ‘Tifgreen’ has the most open growth habit and lowest turf density
- ‘Tifdwarf’ provides a low growing turf of high density but has a lower density compared to ‘TifEagle’ and Champion Dwarf
- FloraDwarf™ was slow to establish (including root development) but performed well over time

- All cultivars except ‘Tifgreen’ produce a dense, tight and even putting surface
- All cultivars display an improvement in turf colour when day length increases
- The “ultradwarfs” produced faster green speeds than ‘Tifgreen’ and ‘Tifdwarf’. However, all *Cynodon* hybrids were considerably faster than the seashore paspalums under trial conditions

Disease

All trial sites reported the occurrence of disease in the *Cynodon* hybrids with the main incidence of disease occurring during the dormancy period (autumn and winter). The main disease reported was “patch diseases” which includes both *Gaeumannomyces* and *Rhizoctonia* species. There were differences in the severity of the disease between cultivars, however, the severity of the disease was not consistent between cultivars and is largely attributed to an environment (location) effect. Of the eight *Cynodon* hybrids, ‘MS-Supreme’ is potentially the least affected by disease.

The following observations were made:

- *Victoria (VIC)*:
 - All cultivars were equally affected by “patch disease”
- *South Australia (SA)*:
 - All cultivars were equally affected by “patch disease”
- *Queensland (QLD)*:
 - Most cultivars were affected by disease in some form
 - Horton Park GC – MiniVerde™ and ‘TifEagle’ worst affected by “patch disease”
 - Indooroopilly GC – All cultivars affected by *Drechslera* sp. leaf disease
 - Coolangatta-Tweed GC – All cultivars with the exception of ‘TifEagle’ were affected by “patch disease”
 - DEEDI Redlands – All cultivars were effected by disease
 - Novotek™ a cultivar which was chosen for its disease resistance is not performing as well in South East Queensland compared to North Queensland.
- *New South Wales (NSW)*:
 - MiniVerde™, followed by ‘MS-Supreme’ was the most affected by disease
 - Bermagui GC – ‘TifEagle’ was not as badly effected by disease

In terms of managing the occurrence of disease, the incidence of disease is less where there is a higher fertility rate (about 3 kgN/100m²/year), but with higher Nitrogen comes added growth and thatch. Thatch levels must remain in check, which will also assist in lowering the occurrence and severity of disease. If finances permit, a preventative fungicide program should be implemented to negate mild to severe infestations of disease including Spring Dead Spot (*Leptosphaeria namari*), Dollar Spot (*Sclerotinia homeocarpa*), Brown Patch (*Rhizoctonia solani*), and Ring-Spot (*Gaeumannomyces incurstans*).

All cultivars appear to recover from disease relatively quickly with the onset of warmer temperatures and increasing day length, providing that the level of fertility is adequate.

Key points:

- All cultivars are susceptible to disease depending on location
- Disease control is dependent on good thatch control, adequate fertility and the use of preventative fungicides
- If finances permit, a preventative fungicide program should be implemented to negate mild to severe infestations of disease

Thatch and Thatch Control

All of the new second generation “ultradwarf” couchgrasses tend to produce a large amount of thatch with MiniVerde™ being the greatest thatch producer, particularly compared to ‘Tifdwarf’ and ‘Tifgreen’. The maintenance of the new *Cynodon* hybrids will require a program of regular dethatching/grooming as well as regular light dustings of sand.

It was noted that the tendency towards high thatch accumulation resulted in greater formation of dry patch.

A general thatch control and dusting program would be as follows:

Thatch:

- Thatch prevention should begin 3 to 4 weeks after planting a new ultradwarf couchgrass green, with an emphasis on prevention rather than control.
- Biomass of “ultradwarf” couchgrass greens must be managed differently from that of ‘Tifdwarf’.
- Injuries from aggressive vertical mowing shock “ultradwarf” cultivars, slowing growth and possibly increasing the chance for “couchgrass decline” disease.

Topdressing:

- Topdressing material should be fine enough (e.g., 0.25 mm to 0.75 mm in diameter) to filter into the turf canopy.
- Light topdressing for example, 0.03 to 0.043 cubic meters/100 square meters every 7 to 14 days.
- MiniVerde™, ‘MS-Supreme’, Novotek™, ‘TifEagle’ and ‘Tifgreen’ take up the sand in topdressing quickly. ‘Tifdwarf’, ‘Champion Dwarf’ and FloraDwarf™ have the sand remain on the surface longer than the former cultivars
- It has been noted that regular dusting can be difficult because the density of the turf is such that it is very difficult to brush the sand into the thatch layer. An alternative means of thatch control has been suggested where the turf is groomed in two directions every week during the growing season.

Surface Grooming:

- The stolons of actively growing couchgrass lie flat, and the growing point escapes the mower bedknife, causing thatch and grain.
- Vertical mowing, grooming and brushing helps to overcome or reduce this horizontal stolon growth.
- Brushing improves the putting quality of “ultradwarf” greens and helps reduce grain.

- Brushing raises the tips of juvenile stolons to create a smoother, more complete clipping.
- In conjunction with light topdressing, brushing keeps the raised stolons and shoots vertical to produce a more consistent putting surface.
- It is less harmful to the plant than vertical mowing or grooming.
- Daily brushing should take place during periods of active growth.

Renovations:

- In addition to the regular grooming and dusting the “ultradwarfs” require hollow core aeration and topdressing twice a year. Solid tining should be used more frequently.

Mowing Height and Rolling

All of the regional sites were maintained at a cutting height of 3.0 mm to 5.0 mm and all of the *Cynodon* hybrids produced a satisfactory surface at these cutting heights. As a general observation these grasses do not respond well to prolonged low cutting.

As a general recommendation on mowing, cutting height and rolling the following is noted:

- Cutting heights best at 3.0 mm to 4.5 mm
- During peak growth cut daily using walk-behind mowers with groomers
- Regular double cutting during periods of strong growth
- Rolling of the greens should be carried out once per week and should be undertaken within 48 hours of when the clubs formal competition is held. This will achieve optimum green speed.

At the DEEDI Redlands test facility two mowing heights were imposed, 3.5 mm and 2.7 mm. The results indicated the *Cynodon* cultivars accepted the lower cutting height (i.e. 2.7 mm) and produced a good surface and was second fastest to being cut (at 3.5 mm) and rolled. However, greens being maintained at this height would have to be cut daily for best results.

Under optimal growing conditions, “ultradwarf” couchgrasses can tolerate mowing heights as low as 3.2 mm for extended periods and 2.5 mm for short periods. At these mowing heights, the turf maintains acceptable density, but the plant is under considerable stress.

Recovery from Damage

MiniVerde™ was vigorous and recovered well following vertical mowing. ‘Tifdwarf’ was slow to recover from disease scars and showed these for considerable time during the winter months. In general, turf recovery from disease on the other *Cynodon* hybrids was relatively quick under good growing conditions (in particular temperature).

In the state of Victoria at Chisholm TAFE, ‘Tifgreen’ was very slow to recover from summer drought stress and disease scars remained prominent for an extended period. All other cultivars were severely affected but did recover to form a complete turf cover.

Nutritional Requirements

As a general observation the new second generation *Cynodon* hybrids require a relatively high nitrogen input to provide the best quality surface and in particularly to minimise the incidence of disease. At this point in time the optimum rate of nitrogen is at 3 kg/100m²/year.

Dormancy

Dormancy occurs on all cultivars at all sites. In Victoria and South Australia dormancy is very strong and “spring greenup” does not occur until at least mid-September (South Australia) to October (Victoria). In Victoria ‘MS-Supreme’ and MiniVerde™ are the earliest cultivars to go into dormancy in winter.

‘Tifdwarf’ was observed as having greater winter dormancy based on colour. This is due to the purplish colour observed on the leaves and stolon growth which is incurred during the onset of cooler temperatures.

In studies conducted by DEEDI staff results showed that the critical threshold levels for active growth by first- and second-generation *Cynodon* hybrid cultivars occurs at air temperatures of about 9 - 10°C or at soil temperatures (10cm below ground) of 15 - 16°C. Below these levels, very little or no growth takes place and either freezing or chilling stress can occur. At temperatures above the threshold levels, active growth will inevitably increase, but a cut off will follow with temperatures being too extreme causing heat stress to the turf.

Pesticide Tolerance

Across all of the trial sites there has been various pesticides applied, of which can be seen in Table 26.

Table 26. Pesticides applied to *Cynodon* hybrids cultivars at regional and or the DEEDI centralised test facility.

PESTICIDE*	COMMENT*
Herbicide	
Ronstar®	Applied post planting and during initial grow in (Feb., Jun., Aug.) – no adverse effect
Dimension™	Applied late Nov. - no adverse effect Applied in July – shortened root systems compared to untreated area. TifEagle was the most sensitive and resulted in high incidence of disease.
Spearhead™	Applied in summer - no adverse effect
Pendimethalin	Applied in July – shortened root systems in all cultivars compared to untreated area. FloraDwarf™ was the most sensitive and resulted in a high incidence of disease.
Fluroxypyr	Some discolouration at 5ml/L when applied in January. 3ml/L showed no adverse effect when applied in April, September and December
Metsulfuron-methyl	Applied in January – no adverse effect
Propyzamide	Applied in April – no adverse effect

PESTICIDE*	COMMENT*
Monument™	Applied in July – no adverse effect
Endothal	Applied in July – no adverse effect
Trinoc™	Applied in July – some minor discolouration
Mecoprop/MCPA/Dicamba	Applied in August – no adverse effect
DSMA	Applied in December at a lower rate – no adverse effect
Fungicide	
Ipridione	Applied in late Nov. – no adverse effect
Chlorothalonil	Applied in late Nov. – no adverse effect
Signature™	Applied in late Nov. – no adverse effect
Tilt®	Applied in March – no adverse effect
Penncozeb™	Applied in late Nov. – no adverse effect
Baycor™	Applied in July – no adverse effect
Insecticide	
Acelepryn™	Applied summer – no adverse effect
Gremlin™	Applied in October – no adverse effect
Baythroid®	Applied in spring, summer and autumn – no adverse effect
Bravo®	Applied in May – no adverse effect
Heritage®	Applied in August – no adverse effect
Growth retardant	
Primo™	Applied in summer – all cultivars suffered leaf burn. All except ‘Tifgreen’ recovered in 2 weeks. ‘Tifgreen’ recovered in 3 weeks.

**Note: Not all pesticides have been trialled on all cultivars at all locations and under all climatic conditions. Always read and follow the label instructions. Fluroxypyr and metsulfuron-methyl are to be registered for turfgrass use as a generic pesticide in 2010 by the Australian Pesticides and Veterinary Medicines Authority (APVMA) following earlier studies undertaken at DEEDI Redlands Research Station.*

SEASHORE PASPALUM

Sward Characteristics (turf density, growth characteristics etc.)

All of the seashore paspalums can be characterised as follows:

- High turfgrass density
- Seashore paspalums appear finer in winter than summer
- Forms a moderately tight surface and is harder under foot
- Stolons and leaves are low growing and prostrate, however, some cultivars will produce stolons that will grow upwards and then bend back towards the surface. This is often referred to as “porpoising”.
- Velvetene™ has the more open growth habit.

- All cultivars produce a moderately dense and even putting surface particular when cut lower.
- Sea Isle Supreme™ was consistently faster (green speed) than Velvetene™ and Sea Isle 2000. However, in comparison to the *Cynodon* hybrids they were considerably slower under trial conditions. The paspalums recorded approximately 5% higher soil moisture readings than the *Cynodon* hybrids
- The putting surface is described as being “sticky” and will not necessarily provide an ideal putting surface.
- Dew does not form on the leaves of the seashore paspalums because of this waxy leaf coating (which make it “sticky”). This is a potential advantage in terms of disease management and playability at certain times of the year
- The seashore paspalums stripe up well compared to the *Cynodon* hybrids.

Disease

All trial sites reported the occurrence of disease in the seashore paspalums with the main incidence of disease occurring following rainfall and under cloud cover. The main disease reported was Dollar Spot (*Sclerotinia homoeocarpa*) with some “patch disease” (mainly *Rhizoctonia* sp.) and Leaf Spot (*Drechslera* and *Curvularia* spp.) recorded. A higher fertility rate (about 3 kgN/100m²/year) has shown to limit the occurrence and severity of disease. However, like that of the *Cynodon* hybrids, with added nitrogen comes supplementary thatch development.

There was little difference in the severity of the disease between cultivars. All cultivars appear to recover from Dollar Spot relatively quickly with the onset of clear and dry weather. Disease scars can persist with the onset of dormancy.

Thatch and Thatch Control

All of the seashore paspalums tend to produce a large amount of thatch and as a consequence are easily scalped during mowing. Scalping appears to be more pronounced during the winter. The seashore paspalums are slow to recover from scalping and require considerable vigilance to ensure that they are not scalped. Extra care should be taken during the winter when the paspalums are more prone to scalping.

Topdressing:

- A general thatch control and dusting program would be similar to the “ultradwarf” couchgrasses. However, paspalums take up more sand than the majority of the couches

Surface Grooming:

- The maintenance of the seashore paspalums will require a program of regular light dethatching/grooming as well as regular light dustings of sand.
- The paspalums did not respond well to heavy vertical mowing

Renovations:

- In addition to the regular grooming and dusting the seashore paspalums require hollow core aeration and topdressing twice a year.

Mowing Height and Rolling

All of the regional sites are maintained at a cutting height of 3.0 mm to 5.0 mm and all of the seashore paspalums are producing a satisfactory surface at these cutting heights. The general observation is that they respond better to the lower height of cut (i.e. 3 mm) and require the lower cutting height in order to produce an acceptable putting surface.

At the DEEDI Redlands test facility two mowing heights were imposed, 3.5 mm and 2.7 mm. The results indicated that the paspalum varieties produced a good quality surface at both heights, but was marginally better at the higher cut. If a lower cutting height (e.g. 2.7 mm – 3.0 mm) was desired, regular and repeated mowings are necessary to reduce scalping and produce a smooth surface.

Rolling of the greens should be carried out once per week and should be undertaken within 48 hours of when the clubs formal competition is held. Greens being cut higher (e.g. 3.5 mm) and rolled produced a faster surface than not being rolled or cut at 2.7 mm.

Recovery from Damage

Turf recovery following disease is relatively quick under good growing conditions (in particular temperature). Paspalums are slow to recover from scalping and requires constant vigilance of thatch development which hightens the opportunity for scalping to occur.

Drought Stress Tolerance

At two of the regional sites located in Victoria (Chisholm TAFE) and Queensland (Horton Park) an irrigation failure placed the seashore paspalums under moisture deficit. Whereas the hybrid couchgrasses were severely affected, the seashore paspalums suffered considerably less from moisture deficit and were quick to recover. This is likely to be a result of the dense rhizome and thatch layer present in comparsion to the *Cynodon* hybrids.

Nutritional Requirements

As a general observation the seashore paspalums requirere a relatively high nitrogen input to provide the best quality surface and in particular as a guard against the incidence of disease. At this point in time the optimum rate of nitrogen is at 3 kg/100m².

Dormancy

Dormancy occurs on all cultivars at all sites. However, the level of dromancy and reduction in colour was far greater in the *Cynodon* hybrids. In Victoria 'Sea Isle 2000' produced a darker colour in the winter.

Pesticide Tolerance

Across all of the trial sites there has been various pesticides applied, of which can be seen listed in Table 27.

Table 27. Pesticides applied to seashore paspalum cultivars at regional and or the DEEDI centralised test facility.

PESTICIDE*	COMMENT*
Herbicide	
Ronstar®	Applied post planting and during initial grow in (Feb., Jun., Aug.) – no adverse effect
Spearhead™	Applied in summer - no adverse effect
Fluroxypyr	Applied in Jan., Apr., Sep., and Dec. – no adverse effect
Metsulfuron-methyl	Applied in January – no adverse effect
DSMA	Applied in December – prone to leaf burn or loss of turf at low rates
Fungicide	
Triadimenol	No adverse effect
Chlorothalonil	Applied in late November – no adverse effect
Baycor™	Applied in July – no adverse effect
Bravo®	Applied in May – no adverse effect
Tilt®	Applied in March – no adverse effect
Heritage®	Applied in August – no adverse effect
Insecticide	
Gremlin™	Applied in October – no adverse effect
Baythroid®	Applied in spring, summer and autumn – no adverse effect

**Note: Not all pesticides have been trialled on all cultivars at all locations and under all climatic conditions. Always read and follow the label instructions. Fluroxypyr and metsulfuron-methyl are to be registered for turfgrass use as a generic pesticide in 2010 by the Australian Pesticides and Veterinary Medicines Authority (APVMA) following earlier studies undertaken at DEEDI Redlands Research Station.*

APPENDIX 1

REDLANDS GREENS TESTS FACILITY – ESTABLISHMENT AND MAINTENANCE PLAN



Tech

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REDLANDS GREENS TEST FACILITY – GROW-IN AND MAINTENANCE PLAN

Pre-planting

The following shall be evenly applied to the above surfaces and carefully raked into the surface of the seed bed using a bunker rake machine:

- Pelleted poultry manure @ 150 kg/100m²
- Starter fertiliser (NPK 8:10:10) @ 5 kg/100m²
- Slow Release Nitrogen @ 2.5kg/100m²
- Agricultural Lime @10kg/100m²
- Dolomite @15kg/100m²
- Trace element mix containing at least Zinc, Copper, Manganese and Boron and applied at manufacturer's recommendation.

All amendments are to be lightly tilled into the top 50 mm prior to stolonizing (**can apply to the surface after planting**).

Turfgrass establishment (“grow-in”)

There are several key aspects of the “grow-in” period to ensure that there is successful turfgrass establishment and these are;

Watering

Following planting, the newly planted stolons must be kept damp (but not saturated) at all times, especially during the heat of the day. Frequent light watering (5 minute irrigation cycles) may be needed to achieve acceptable results.

Once the grass has struck and is showing obvious signs of growth (producing new leaves and runners) water can be progressively reduced until it is only necessary once every second day (or less, depending on the season) when the grass is running vigorously.

Fertiliser Program for Green

The following fertiliser program is indicative during the growing-in period, that is, up until playability has been achieved. Wherever necessary, to sustain vigorous growth and coverage, additional fertiliser applications should be made.

Greens should be fertilised every 7 days with an NPK (8:10:10) fertiliser or similar at a rate of **2.5 kg/100m²** until full cover is achieved. It is essential that the juvenile turf is not allowed to suffer a nutrient deficiency during establishment.

During the "grow-in" period it will be necessary to take soil samples to test for nutrients so as to ensure that the appropriate nutrient balance is achieved. Analysis must include; pH, salinity, cations (Ca, Mg, Na and K) and phosphorus.

Herbicides, Insecticides, Fungicides

Weed growth must be controlled quickly and weeding must be done before seed heads set and develop. Weeding can either be done by hand or by the use of selective herbicides.

The recommended rates and method of application should be strictly adhered to and ideally should be trialed prior to broad scale use.

The invasion by damaging insects leads to growth stunting and poor cover. Typical insect pests are;

Mites: Two types of mites occur

- Spider mites will cause silver streaks on the leaves and a dry look to the grass.
- Stunt mites will cause a bunchy multi-branched growth at the tip and will greatly slow grass cover.

Tipfly: Maggot activity in the grass tips will kill the terminal shoot and this will then stop the runners extending. Adult flies are small.

Specific treatments are best prescribed when problems occur. All insecticides used for treatment are very poisonous and care not to expose workers to danger must be exercised.

All operators applying pesticides must have the appropriate training and certificate for the application of pesticides.

It is impossible to pre-empt what diseases may occur. Therefore, specific fungicide treatments must be determined once a disease has been identified.

It is the responsibility of the contractor to keep all grass in a healthy state at all times up to handover.

Mowing

It is important that the green is mown regularly and at the appropriate height, as an aid to establishment. As a general guide the green should be mown eventually at 3 – 3.5 mm.

To assist in establishment commence mowing **as soon as possible** at about 6 mm to "top" the grass. Mowing should commence when there is about 50 – 75% ground cover. As the grass fills in and the surface gets smoother gradually lower the cutting height to about 4 - 4.5 mm. Once top dressed and level, the cutting height can be reduced to the maintenance height of about 3 mm.

Topdressing the Green

The sand used in construction shall be used as the topdressing medium. The first topdressing can be relatively heavy and applied when there is about 50 – 75% cover. This is then followed by 2 – 3 light dressings to produce a level surface that is not scalped when mown. The light dressings will be about 0.1 – 0.3 cubic metres/100m² and once worked into the thatch there should be very little left on the surface.

Dethatching/scarifying

During the grow-in and topdressing stage it may be necessary to dethatch to thin out the thick areas and to assist in getting the topdressing sand into the turf.

On-going Maintenance

Fertiliser program

Work on applying;

- Nitrogen at 1.5 – 2.5 kgN/100m²/year (maybe higher in the first year)*.
- Potassium at 3 – 4 kgN/100m²/year*.
- Phosphorus as per soil test.
- Micronutrient mix 1/year – base on plant tissue test.
- Ca, Mg as per soil test. Suggest applying Gypsum @ 1 kg/100m²/month and Magnesium sulphate @ 0.1 - 0.2kg/100m² with N and K.

**N and K best applied every 2 weeks as a soluble fertiliser. Rates and frequency of applications will vary depending on the time of year. The idea is to provide minimal clippings while maintaining good turf density, a good putting surface and no scalping.*

Mowing

Need to mow as frequently as possible during peak growth (e.g. 5 times per week), spring and autumn – 3 to 5 times a week, winter – 2 to 4 times per week.

Dethatching/grooming

Most frequently in peak growth – work on grooming every 2 weeks – this is a judgment call depending on the quality of the surface.

Irrigation

Deficit irrigation based on about 60 – 75 % of Epan (varies depending on grass type and overall “look/quality”) once fully established. Deep and infrequent irrigation is required. Also use a moisture sensor to monitor.

Thatch control through dusting

Dust every 7–14 days during peak growth using about 0.1m³ of sand/100m².

Renovation

Scarify and core in late spring. Need to evaluate on a regular basis.

Weed control

You may wish to allow the weeds to invade as part of evaluating the plots or use pre-emergent such as Ronstar (need care on Seashore Paspalum).

Disease and Insect control

Allow disease and insects to invade to evaluate species/cultivars and then treat to avoid excessive damage.

APPENDIX 2

EVALUATION RESULTS – GREENS TRIAL WORKSOP – 12 MAY 2009

Location: DEEDI Redlands Research Station, Qld.

SUMMARY

Workshop was attended by: Industry 41 members (all male) and 7 DEEDI staff.
Number of completed surveys received back from industry = 13. Response rate = 32%.

Rating scale:

1	2	3	4	5
Failed to Satisfy Expectations	Minimally Satisfied Expectations	Partially Satisfied Expectations	Completely Satisfied Expectations	Exceeded Expectations

Issue	Average Rating
Pre-workshop	4.2
a) The workshop was well planned	4.2
b) Adequate information was provided in advance about the day	4.5
Content	4.1
a) The information content was useful	4.1
Purpose	4.1
a) The workshop was relevant to my employment	4.1
b) The workshop was relevant to the needs of your industry	4.1
Processes	4.2
a) There was good interaction between participants and speakers	4.2
b) Delivery methods were varied and interesting	4.0
c) Facilities and equipment were suitable	4.4
Value for Time Spent	4.2
(a) The workshop was of suitable length	4.2
(b) The workshop delivered what it promised	4.1
(c) The venue was suitable	4.5
(d) The food was appropriate	4.3
Overall Rating	4.3
(a) Please provide a general assessment of your overall experience at this workshop/farm walk (inspection of DEEDI greens test facility and turf demonstration plots)	4.3

EVALUATION RESULTS

Workshop was attended by: Industry 41 members (all male) and 7 DEEDI staff.
 Number of completed surveys received back from industry = 13. Response rate = 32%.

Results in maroon type.

Rating scale (1-5):

1	2	3	4	5
Failed to Satisfy Expectations	Minimally Satisfied Expectations	Partially Satisfied Expectations	Completely Satisfied Expectations	Exceeded Expectations

Issue	Count per Rating of responses Received					Comments
	Average Rating	3	4	5	No ans.	
Pre-workshop						
a) The workshop was well planned	4.2	0	10	3	0	x1 a very good day
b) Adequate information was provided in advance about the day	4.5	0	6	6	1	
Content						
a) The information content was useful	4.1	1	10	2	0	
Purpose						
a) The workshop was relevant to my employment	4.1	2	7	3	1	
b) The workshop was relevant to the needs of your industry	4.1	2	8	3	0	
Processes						
a) There was good interaction between participants and speakers	4.2	1	8	4	0	
b) Delivery methods were varied and interesting	4.0	1	11	1	0	
c) Facilities and equipment were suitable	4.4	0	8	5	0	
Value for Time Spent						
(a) The workshop was of suitable length	4.15	1	9	3	0	
(b) The workshop delivered what it promised	4.1	1	10	2	0	
(c) The venue was suitable	4.5	0	7	6	0	
(d) The food was appropriate	4.3	0	8	4	1	very good
Overall Rating						
(a) Please provide a general assessment of your overall experience at this workshop/farm walk	4.3	0	9.5	3.5	0	x 2 very good x 1 very interesting

Q. Please indicate how you might see the DEEDI purpose-built Greens Facility being used in the future?

- Disease research/ Nutrition/ Compost tea
- Nutrient pot research/ herbicide pot research
- Continued research in other aspects of turf management
- Improve turf quality
- Fertilizer, chemical (weeds, pests, diseases)/ Organic amendments (compost teas)
- Continued research into turf
- Fungicide trials
- Selective cull
- Best management

Q. What other workshops or information could we provide that would meet your needs?

- Disease research/ Nutrition/ Compost tea
- More business workshops as all have budgets
- Research for domestic market
- Location map
- Spray workshops

Q. Do you currently have easy access to the internet? Yes No

- Yes x 12
- No x1

Q. Would you like more information on QPIF turf research in Queensland to be available over the internet?

- On turf Australia website
- Yes x 9
- No x 1

Q. Any suggestions/ comments for improvement of the workshop?

- Nil x 1
- More specific workshop on nutrition, weeds, disease and pests.

Q. What did you like most about the workshop?

- The whole presentation
- Getting notes to take away
- Networking with other professionals
- New information on topics.
- x 2 Turf plot inspection
- Good interaction.
- Talking to other people.
- Everyone's participation.

Q. What best describes your current role (Please tick or circle) ?

- x 4 Greens/fairway maintenance/development
- x 2 Parks maintenance/ development
- x 1 Sod production
- x 2 Education
- x 3 Supplier of products to turf industry
- x 3 Independent consultant to turf industry
- x 3 Research/ extension
- x 1 Other.....Industry development Manager

Q. What days of the week are most convenient for workshops/ training?

Mon x 1 Tues x 6 Wed x 4 Thur x 1
 Fri x 2 Sat No responses Sun No responses

Q. How long would you prefer workshops/ training to be? Please tick or circle.

One night No responses	Half a day x 6	One day x 9
Two days No responses	Longer than 2 days if needed No responses	

Q. What time of the year is best for you for workshops/ seminars/ training?

- x 3 Winter
- x 4 Anytime
- x 1 Autumn
- x 1 May to August
- x 1 Autumn/ Winter
- x 1 May to September

Q. Any other comments (use back page if needed)?

- You may be able to supply training under the Farm Ready program.
- Take advantage of overseas or international speakers to talk to industry, not just DEEDI.

APPENDIX 3

MEDIA SAMPLES

- In search of a perfect green, *The Courier Mail* (28/07/2009)
- Perfect putts a step closer, *The Australian* (31/07/2009)



Courier Mail
28/07/2009
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Circulation: 214468
Type: Australian Capital City Daily
Size: 84.57 sq.cms
MTWTFS-

In search of a perfect green

Peter Morley

QUEENSLAND'S 250 golf courses do not come up to par so scientists are trying to make the perfect green.

Many are designed, developed, maintained and resurfaced according to the specifications of the US Golf Association.

But this type of green and maintenance comes at a hefty price.

The bill has prompted scientists to look for a way of meeting the American standards in a more cost-effective way.

"This research will help to significantly improve the quality of golf courses throughout Australia," Primary Industries Minister Tim Mul-



PAR: Primary Industries Minister Tim Mulherin.

herin said yesterday. He said the perfect green had great colour and dense coverage without any disease patches.

And it should grow to a low height so it did not get "scalped" when the mower was used.

"We want to make sure only poor putting

can be to blame for a bad day on the green," Mr Mulherin said.

A purpose-built green had been established at the Redlands Research Centre to help scientists try to find the best possible surface.

Senior scientist Matt Roche said golfers would be amazed how much science and research went into a good playing surface.

"Over the past three years we have analysed nine different types of grasses," he said.

"What we have found is that different grass varieties perform in very different ways, depending on where they are planted and how they are managed."



Perfect putts a step closer

Christopher Jay

The Queensland government is hoping to develop the perfect golf green for Australian conditions, a move that could eventually displace the current US Golf Association standard used for most Australian golf courses.

Queensland scientists have established a purpose-built golf green at the Queensland Primary Industries and Fisheries (QPIF) Redlands Research Centre to assess specifications for soil, drainage and grass varieties best suited to the Australian environment.

QPIF senior scientist Matt Roche said a large amount of science and research was needed to produce good playing surfaces for golf.

"Over the past three years we have analysed nine different types of greens-quality grasses, including *Cynodon* hybrid and seashore *paspalum*," he said.

"We have put these varieties under rigorous testing," including various mowing, nutrition and watering rates.

The joint research project began in 2006 with involvement from QPIF, Horticulture Australia Limited, the Australian Golf Course Superintendents Association and the Golf Course Superintendents Association of Queensland.

State minister for primary industries, fisheries and rural and regional Queensland Tim Mulherin said: "We want to make sure only poor putting can be to blame for a bad day on the green."