Background to the approved beneficial Cynodon spp. vegetative cultivars within Australia.
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Background to the approved beneficial Cynodon spp. vegetative cultivars within Australia

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The growth of the Australian turfgrass industry has significantly expanded over recent decades. One reason for this occurring has been with development of better suited or higher quality turfgrass cultivars for Australia's harsh climatic conditions. In recent years drought has widely affected the turfgrass industry and as such, greater drought tolerant C4 grasses such as *Cynodon* spp. have been used.

In 2008 as part of the 24th Australian Turfgrass Conference Proceedings, Peter McMaugh wrote an extensive article on the couch grass breeding history in Australia. Following contains an extension to Peter's work detailing the current (1950s to 2010) *Cynodon* species found in Australia. Detailed information has been sourced in relation to the origin and development of the grasses which are suitable for turfgrass use. At no stage within the Australian turfgrass history have such particulars been collated and made available in a single publication. 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. The information adds to the bigger picture of that contained in the preceding thesis, the morphological and agronomic attributes and how closely each selection or cultivar is related.

The cultivars discussed in this article (listed alphabetically) are derived from one of the four classifications, being (i) *Cynodon* sp. (although the cultivar contained within the taxa fits best being classified as a *Cynodon* hybrid), (ii) *Cynodon dactylon* x *C. transvaalensis* (*Cynodon* hybrid), (iii) *Cynodon dactylon* (green couch) and (iv) *Cynodon dactylon* x *C. magenissii*. The latter cultivar is debatable and may be best suited as a green couch or a *Cynodon* hybrid. However, until further information is made available, that cultivars within the species will remain as identified by the breeder/author.

I would like to thank Peter McMaugh, Garry Beehag, David Aldous, Peter Semos, John Neylan and Don Loch for assisting with the finer details and often providing firsthand knowledge of historical importance concerning a number of cultivars.

AGRD

'AGRD' [*Cynodon dactylon* (L.) Pers. X *C. transvaalensis* Burtt-Davy] was a result of a spontaneous mutation that was selected by the breeder, Dr Warren Hunt, from a variant area of winter active turf (probably 'Tifway' or 'Tifgreen') on a Hong Kong Golf Course in Apr. 1996 (Roche and Loch, 2008b). A selection of this material was imported through vegetative quarantine via New Zealand for evaluation. Following a favourable assessment of its potential as a warm-season turfgrass variety under New Zealand conditions based on its superior comparative performance relative to other *Cynodon* accessions in glasshouse and field trials, the New Zealand registered (Plant Variety Rights grant number 1566, which is to expire on 14 Jul. 2019) variety 'Grasslands AgRiDark' was released in New Zealand in 1999 (Roche and Loch, 2008b).

Material of 'AgRiDark' was sent from Grass Technology Ltd, New Zealand to the Australian Quarantine Inspection Service (AQIS) facility, Eastern Creek, New South Wales on 16 Dec. 2004 to undergo testing. Following testing and clearance, vegetative material was released to DEEDI Redlands Research Station, Queensland. Initially 500m² of 'AGRD' was vegetatively (asexually) propagated and grown on as foundation stock beginning on 1 Aug. 2008. It was of the opinion that DEEDI would multiply sufficient vegetative material to supply a licensee in each desired state

and/or territory within Australia upon the request of the now owners Cervadon Ltd, New Zealand. Following this task, it is then anticipated that the research group will stop multiplication of 'AGRD' material and hold only a supply (<100m²) of what will then become foundation material. First sale of the cultivar of 100m² was to City of Casey, Melbourne on 27 Jan. 2010.

Bosker™ (C3)

The accession number S-282 (Robinson, 2008), later designated 'C3' [*Cynodon dactylon* (L.) Pers.] was selected from a series of trails initiated by The Victorian Department of Agriculture (Daratech) and the Melbourne Cricket Club (Semos, 2006). The trials setup as the National Bentgrass and Couchgrass Evaluation Trials involved a selection and evaluation process which was carried out between 1986 and 1991 and was one of the first [earlier studies were undertaken at ATRI (McMaugh, 2009)] of its kind to be formally undertaken within Australia (Robinson and Neylan, 1997). At the time, this was made possible with Turfgrass Technology (a division of Daratech) receiving funding from a succession of financial contributors including the Australian Golf Union, Victorian Golf Association, Victorian Golf Course Superintendents Association, the Melbourne Cricket Club and the Horticultural Research and Development Corporation (Robinson and Neylan, 1993). A total of six couchgrass trial sites were setup across Australia with the majority of the sites being established between Sep. and Nov. 1991, but a later site was also established in Victoria during Oct. 1994 (Robinson and Neylan, 1997). The six trial sites were located in Perth (Collier Park Golf Course, Como, Western Australia), Melbourne (Turfgrass Technology's Research Station at Frankston, but later transferred to the Peninsula Country Club, Frankston, Victoria in Nov. 1992 due to the uncertainty of the future of the research station and a second site at the Greenacres Golf Club which was the last site to be established in 1994), Sydney (The Australian Golf Club, Kensington, New South Wales), Adelaide (Riverside Golf Club, West Lakes, SA) and the Gold Coast (The Gold Coast Burleigh Golf Club, Miami, Queensland), providing different environmental and climatic conditions in a variety of regions across Australia (Robinson and Neylan, 1993). The trial evaluated some 400 couchgrass accessions (Semos, 2006). The tetraploid (2*n* = 36) 'C3' was one of the 400 accessions which had initially been collected as a vegetative collection from the Ladies 4th Tee of the Wonthaggi Golf Club, Victoria in November 1987 by John Neylan (Ho, 1999; Robinson, 2008) who was at the time, an agronomist with the Turf Research and Advisory Institute, Victorian Department of Agriculture.

'C3' was selected from the trial and later trademarked as Bosker™ (Semos, 2006) by the Australian turf company StrathAyr Turf Systems Pty Ltd. Vegetative material of 'C3' from the National Couch-Grass Trial was later provided to StrathAyr for subsequent multiplication, yet the cultivar was never released for commercial production by StrathAyr. Lowlands Lawn Turf (which is now combined with Qualturf Pty Ltd and Saliba Turf Supplies Pty Ltd), Windsor, New South Wales has sold material of Bosker™ some years ago, and M. Collins and Sons Pty Ltd, Revesby, New South Wales have a licence to sell Bosker™ but have not cultivated any material as yet (Beehag, 2009a).

Champion Dwarf

'Champion Dwarf' [*Cynodon dactylon* (L.) Pers. X *C. transvaalensis* Burtt-Davy] was selected from a 'Tifdwarf' *Cynodon* hybrid golf green that had been planted in 1969 (Kaapro, 1999a) by Richard Morris Brown in Walker Country, 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, 1999a).

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, 1999a). 'Champion Dwarf' was first sold in the United States in Mar. 1996 (Brown et al., 1997).

Brown *et. al.* (1997) 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. 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 (Brown et al., 1997).

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 (Brown et al., 1997).

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 (2009a) for the purposes of a Plant Breeders Right's comparative testing. The first, a sward trial planted on 7 Jun. 2002 tested the greens quality grasses 'Champion Dwarf', 'FloraDwarf', 'MS-Supreme', 'TifEagle', 'Novotek', 'Tifgreen' and 'Tifdwarf'. DEEDI researches recorded 'Champion Dwarf' as having produced inflorescences with a mean value of 0.67 per plot [1 plot measuring 1 x 0.9 m by 3 replicates (=3 plots)] with a minimum value of 0 and maximum value of 2 inflorescence counts at 343 to 344 DPP when using a 0.1225m^2 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 value of 11.73 per plant [5 plants measuring up to 1 x 1 m by 6 replicates (=30 plants)] with a minimum value of 0 and maximum value of 61 inflorescence present within a 0.1225m^2 quadrat.

Material of 'Champion Dwarf' which was sent by Coastal Turf, Texas to Australia, arrived and was planted in the turf demonstration plots at DEEDI Redlands on 9 Nov. 2001. The latter 7m² observational plot over the years has been vegetatively (asexually) multiplied to obtain 70m² of foundation turf which is also situated at Redlands and has over the years supplied planting material for numerous regional trial sites across Australia. One such trial was the Horticulture Australia Limited funded study 'Management of new warm-season greens grasses in Australia' (project code TU05001). All seven trial sites tested 'Champion Dwarf' for the duration on the trial which ran between 2006 and 2010. They included, Glenelg Golf Club (SA), Sanctuary Cove Golf Club (Qld), Horton Park Golf Club (Qld), Twin Water Golf Club (Qld) and the central test facility at DEEDI Redlands (Qld).

Conquest™ (Riley's Evergreen)

Conquest™ was a result of a selection acquired from common *Cynodon* sp., discovered by the late Rod J. Riley in 1991 growing in a *Cynodon dactylon* 'Wintergreen' bowling green at Homebush Bowling Club, Homebush, New South Wales, Aus. (Kaapro, 1999b). Conquest™ [*Cynodon dactylon* (L.) Pers.] which also goes by the name of 'Riley's Evergreen' was granted Plant Breeder's Rights on 19 May 1998 (Kaapro, 1999b) and was released soon after. Conquest™ was selected as it displayed good low temperature leaf colour retention and a broad leaf width in comparison to the parent plant. Conquest™ also has reasonable wear recovery, low thatch and actively grows throughout the year showing good colour retention.

CT-2

'CT-2' [*Cynodon dactylon* (L.) Pers.] was discovered by breeder Hughbert F. Whiting through a series of cross-pollination of selected varieties of *Cynodon dactylon* grass plants (Whiting, 1989) at Fallbrook, California, USA (Whiting, 1988). The parental grass plant being commonly known as 'Wintergreen' was the male grass plant and the female grass plant was commonly known as 'Greenlees Park' (Whiting, 1988). Following crossing, the desired plant was

then selected and asexually repropagated as the new and distinct variety of *Cynodon dactylon* grass plant 'CT-2'(Whiting, 1989). 'CT-2' is trade marked by the Greg Norman Turf Company as GN-1™ in the USA. GNTC identifies the cultivar on their web site (www.sharl.com) as a medium textured hybrid green couch; however the breeder identifies the cultivar as a straight *Cynodon dactylon* cultivar.

Whiting (1989) described the *Cynodon dactylon* cultivar 'Wintergreen' (C84-135) as the closest known variety to his cultivar 'CT-2', however the breeder of the former cultivar, Peter McMaugh explained that this was "incorrect" (McMaugh, 2009). The results contained in this thesis support McMaugh's assertion. 'CT-2' was selected for improved colour, winter colour retention and less thatch build-up (Whiting, 1988). The grass plant 'CT-2' is entirely pubescent and has anthers before dehiscence, of light yellow green colour (Whiting, 1989).

'CT-2' was initially made available through Tyagarah Turf, Byron Bay, New South Wales in 1991 and was "widely" used on sports fields, golf courses and school playgrounds (Anonymous, 1995). PBR protection of the cultivar in Australia has since expired and a renewal was not applied for by the breeder Hugh Whiting following the 20 year term post the original filing date of 6 May 1988.

CynoMax™ (LEG13A)

'LEG13A' [*Cynodon dactylon* (L.) Pers.] was a result of open pollination followed by seedling selection carried out by Todd Layt, Clarendon, New South Wales in 2008 (Paananen, 2008). The seed parent 'C1' (Legend®) is characterised by a large number of inflorescences produced on each plant. 'LEG13A' is trademarked as CynoMax™ and is characterised as having fast 'speed' of growth, strong sod strength, low seed head production and dark leaf colour (Paananen, 2008).

From initial observations made by Todd Layt, CynoMax™ produces less seedheads than other common green couches, is fast growing and produces minimal thatch which is preferred for oversowing (Layt, 2009).

At the time of publication, this cultivar had not yet been released in Australia and little information was available.

FloraDwarf™

The cultivar FloraDwarf™ was assigned by Dudeck & Murdoch (1998) as being a *Cynodon* sp., but following morphological and agronomic studies by Roche & Loch (2005) the fine textured turfgrass would be better identified as a *Cynodon* hybrid [*Cynodon dactylon* (L.) Pers. x *C. transvaalensis* Burtt-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 Jan. 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, Alabma, 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 Oct. 2001. The latter 7m² observational plot over the years has been vegetatively (asexually) multiplied to obtain 70m² of foundation turf which is also situated at Redlands and has over the years supplied planting material for numerous regional trial sites across Australia. Once such trial was the Horticulture Australia Limited funded study 'Management of new warm-season greens grasses in Australia' (project code TU05001). All seven trial sites tested FloraDwarf™ for the duration on the trial which ran between 2006 and 2010. They included, Glenelg Golf Club (SA), Sanctuary Cove Golf Club (Qld), Horton Park Golf Club (Qld), Twin Water Golf Club (Qld) and the central test facility at DEEDI Redlands (Qld).

FLoraTeX®

FLoraTeX® [*Cynodon dactylon* (L.) Pers.] is thought to have been introduced into United States under the name 'Franklin' on 18 Feb. 1954 by African Explosives and Chemical Industries Ltd, Johannesburg, Transvaal, South Africa (Juska and Hanson, 1964),(Dudeck et al., 1994). The selection was assigned the plant introduction (PI) number 213385, by the USDA New Crops Research Branch, Crops Research Division. 'Franklin' was originally collected from a putting green that was severely damaged by mealybugs, *Antonina indica* Green, at Mount Edgecomb Golf Course, Natal, South Africa (Dudeck et al., 1994).

Between 1955 and 1962 experimental work was undertaken on the PI 213385 accession in Alabama, Arizona, California and Georgia. During this period breeder Arden A. Baltensperger noted that he had received contaminated plant material from the Southern Regional Plant Introduction Centre, New Orleans, Louisiana. Baltensperger continued to test three vegetative off-types from PI 213385, including the accession 119 (FB-119) which was later designated as FLoraTeX® (Dudeck et al., 1994).

FLoraTeX® was jointly released by the Florida Agricultural Experiment Station in 1992 and the Texas Agricultural Experiment Station (TAES) in 1993 (Dudeck et al., 1994; Dudeck et al., 1995; Hale, 2003; Juska and Hanson, 1964) [Busey (Busey and Dudeck) says it was released in 1994]. FLoraTeX® is a prolific seed head producer that may produce viable seeds (Dudeck et al., 1994; Dudeck et al., 1995), deep rooted, excellent colour retention in the autumn and early spring 'greenup' with superior dehydration avoidance. The true origin of FLoraTeX®, however, was lost over time due to vegetative contamination and misplacement of original stock material of PI 213385 from the Southern Regional Plant Introduction Station, USDA-ARS-SAA, Griffin, USA (Dudeck et al., 1994).

Vegetative material of FLoraTeX® was brought into Australia from the United States and planted at DEEDI Redlands Research Station, Queensland in their turf demonstration plots on 9 Nov. 2001. Rochedale Turf Pty Ltd is the sole Australian licensee of the turfgrass.

Grand Prix

'Grand Prix' [*Cynodon dactylon* (L.) Pers.] is a cultivar that was produced by control pollination followed by selection of 'Wintergreen' and 'Couch 5' (also designated 'C5') by breeder David Nickson. 'Couch 5' [accession number S-130 (Robinson and Neylan, 1993)] an experimental breeding line that was selected from seed provided to the breeder by Arden Battensperger (McMaugh, 2008) was a selection from an earlier series of crosses by the breeder between 'Wintergreen' and a number of *Cynodon dactylon* accessions, which were collected from the Peninsula Country Club Fairway 8B, Frankston, Victoria by Peter McMaugh in Feb. 1987 (Neylan, 2005; Robinson, 2008). A series of other *Cynodon* collections were carried out between 1986 and 1990 from the Peninsula area of Victoria, Australia. Random open pollination (McMaugh, 2009) was carried out by the breeder in 1998 and subsequent seedlings and selected plants were observed between 1998 and 2000. In the spring of 2000, the remaining potted seedlings were planted into plots at the Evergreen Turf farm at Pakenham, Victoria, Australia and allowed to expand fully (Roche and Loch, 2006a). The final selection of Seedling 12 (later designated DN12)

in late 2002 was based on shoot density, leaf colour, turf quality and reduced thatch accumulation (Roche and Loch, 2006a). 'Grand Prix' also showed superior signs of wear tolerance and recovery in a *Cynodon* spp. study conducted at DEEDI Redlands Research Station, Queensland. Wear tolerance was associated with high shoot density, a dense stolon mat strongly rooted to the ground surface, high cell wall strength as indicated by high total cell wall content, and high levels of lignin and neutral detergent fibre (Roche, 2009b). As a result the cultivar was chosen to be planted as the playing surface at Skilled Park, Robina, Queensland. The first sale of the variety 'Grand Prix' anywhere in the world was on 21 Oct. 2006 by Evergreen Turf Pty Ltd to a homeowner on Dandenong Road, Frankston East, Victoria (Nickson, 2007).

Greenlees Park (Greenleaf Park™)

'Greenlees Park' was selected from Greenlees Park Bowling Club (Ho, 1999) at Concord in New South Wales by the late Rod J. Riley in January of 1965 following the Australian Bowls Championship (McMaugh, 2008). 'Greenlees Park' [*Cynodon dactylon* (L.) Pers.] has been referred to as the first single-strain couch grass in Australia (McMaugh, 1988); following the initial planting of the accession at the latter bowling club in late 1969 (Beehag, 2006) after subsequent propagation and growing-on of the grass. Multiplication and commercialisation of 'Greenlees Park' was undertaken by Beverina Estate, Cobbitty and Qualturf, Windsor which were both located in New South Wales (McMaugh, 2002). Beverina Estate trademarked the cultivar as Greenleaf Park™ (McMaugh, 1988). The selection and vegetative material from Greenlees Park Bowling Club was used as source for numerous bowling greens and golf courses throughout Sydney, other parts of Australia and even Indonesia from the early 1970s (McMaugh, 1988). Floreat Park Bowling Club, Floreat had the first 'Greenlees Park' green in Western Australia, however this was acquired by accident; the latter club had arranged to obtain the *C. dactylon* cultivar 'National Park' from a club on the east coast, however when the time came to have it sent over the club concerned said they did not have material of 'National Park' and recommended that another club had a plentiful supply of 'Greenlees Park' (Vernon, no date). As a result, the Floreat Park Bowling Club established their green with 'Greenlees Park'. Following the success of the cultivar for lawn bowls use in New South Wales, 'Greenlees Park' moved into commercial turf production with the first supply being developed by George Dukats at Theresa Park and Peter McMaugh at Qualturf in Windsor (McMaugh, 2008). Today, the purity and origin of guaranteed 'Greenlees Park' is debateable. It is believed that a true to type supply of 'Greenlees Park' is still present at Greenless Park Bowling Club, but clean material is also being grown on sportsfields in and around Cairns, Qeensland (i.e. Cairns Saints Australian Football Club Inc. and Gladstone Race Course, which are both located in Queensland).

Hardi Turf™ (JT1)

'JT1' [*Cynodon dactylon* (L.) Pers.] was a result of a spontaneous mutation or chance seedling discovered in the mid 1990s by Lynn Davidson as a superior plant growing in a commercial field of "Common" *Cynodon dactylon* on Jimboomba Turf Company's farm at Jimboomba, Queensland, Australia. (Loch and Roche, 2003b). The selection by now Owner/Manager of Jimboomba Turf Company, Lynn Davidson, was taken from the "Common" field in 1999 after observing a superior turf quality, vigorous lateral spread, high shoot density, darker green colour and low presence of inflorescences of this mutant plant (Loch and Roche, 2003b). The cultivar was released on 13 Sep. 2002 (Davidson, 2010) and is now sold and trade marked as Hardi Turf™ for commercial and home plantings through Jimboomba Turf Group Pty Ltd.

Hatfield

A *Cynodon* selection was made by Graham Hatfield from a population growing in soil excavated from a building footing in 1983 at 43 Sheilds Street, Gympie, Queensland, Australia. (Loch and Roche, 2003a). The breeding process involved a single cycle of selection to separate out material of the selected plant for vegetative propagation (Loch and Roche, 2003a). The

selected plant was given the experimental name ES302 and later designated as 'Hatfield' [*Cynodon dactylon* (L.) Pers.] producing a dense, mat-forming, dark-green turf. Paul Nunn of Turfworld, Kilcoy, Queensland (at the time of this publication) the sole grower of 'Hatfield' first sold sod of the cultivar on 6 Sep. 2007 as 'cover grass' (because the sod was contaminated with another *Cynodon* spp. cultivar) to Tinamba Turf (Scattini, 2008). 'Hatfield' was next sold to Diggit Landscapes for Kilcoy High School, Queensland on 22 Feb. 2008 and was identified as the informal release date for the *Cynodon* cultivar (Scattini, 2008).

Legend® (C1)

The accession number S-49 (Robinson, 2008), later designated 'C1' [*Cynodon dactylon* (L.) Pers.] was selected from a series of trails initiated by The Victorian Department of Agriculture (Daratech) and the Melbourne Cricket Club (Semos, 2006). }. The trials setup as the National Bentgrass and Couchgrass Evaluation Trials involved selection and evaluation processes which were carried out between 1986 and 1991 and were one of the first [earlier studies were undertaken at ATRI (McMaugh, 2009)] of its kind to be formally undertaken within Australia (Robinson and Neylan, 1997). At the time, this was made possible with Turfgrass Technology (a division of Daratech) receiving funding from a succession of financial contributors including the Australian Golf Union, Victorian Golf Association, Victorian Golf Course Superintendents Association, the Melbourne Cricket Club and the Horticultural Research and Development Corporation (Robinson and Neylan, 1993). A total of six couchgrass trial sites were setup across Australia with the majority of the sites being established between Sep. and Nov. 1991, but a later site was also setup in Victoria in Oct. 1994 (Robinson and Neylan, 1997). The six trial sites were located in Perth (Collier Park Golf Course, Como, WA), Melbourne (Turfgrass Technology's Research Station at Frankston, but later transferred to the Peninsula Country Club, Frankston, Victoria in Nov. 1992 due to the uncertainty of the future of the research station and a second site at the Greenacres Golf Club which was the last site to be established in 1994), Sydney (The Australian Golf Club, Kensington, New South Wales), Adelaide (Riverside Golf Club, West Lakes, South Australia) and the Gold Coast (The Gold Coast Burleigh Golf Club, Miami, Queensland), providing different environmental conditions in a variety of climatic regions across Australia (Robinson and Neylan, 1993). The trial evaluated some 400 couchgrass accessions (Semos, 2006). The 'C1' tetraploid ($2n = 36$) which was one of the 400 accessions was a vegetative collection taken from Shepparton Tennis Club (court nearest the road), Victoria in Mar. 1986 made by John Neylan (Ho, 1999; Robinson and Neylan, 1993), who was at the time, an agronomist with the Turf Research and Advisory Institute, Victorian Department of Agriculture. Released in 1993, 'C1' was selected from the trial and in 1997 trademarked as Legend® (Semos, 2006) by the Australian turf company StrathAyr Turf Systems Pty Ltd. Vegetative material of 'C1' selected from the National Couch-Grass Trial, was later provided to StrathAyr Turf Systems Pty Ltd for subsequent multiplication and later production. Today 'C1' is used as a turf cover in a range of low and high input facilities, including major sporting stadia.

In recent years there has been much debate among members of the turf industry about the purity and possible contamination or evolution (production of "off-types") of 'C1'. This is evident in Chapter 7 of this thesis. In terms of how extensive the problem is, further research needs to be carried out. However, it is likely that human error through mishandling and or contamination occurred throughout various stages of multiplication. For the Legend® growers with any doubt about their ability to guarantee they are providing the purist form of 'C1' they will need to go back to a clean, identified (DNA, morphological and agronomic study) source and grow this on as foundation stock. This material should then to be supplied to Legend® growers and be used to plant new, clean fields for the sale of Legend®.

MiniVerde™ (P18)

'P18' trademarked as MiniVerde™ [*Cynodon dactylon* (L.) Pers. X *C. transvaalensis* Burtt-Davy] was first produced in 1992 by the late Howard Kaerwer 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 (Kaerwer, 2001). MiniVerde™ posees 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, 2008a) 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 Jul. 2005 (Roche and Loch, 2008a).

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 100m^2) was planted at DEEDI Redlands on 10 Nov. 2006 to multiply and supply to the Australian licensee(s) but is not expected to be commercially available within Australia until mid 2010.

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.

MiniVerde™ has also been trialled at various regional trial sites across Australia between 2006 and 2010. Once such trial included the Horticulture Australia Limited funded study 'Management of new warm-season greens grasses in Australia' (project code TU05001). A total of seven sites were constructed as part of the project, of which all seven trialled the cultivar. They included Glenelg Golf Club (SA), Mornington Peninsula (Chisholm) TAFE College (VIC), Bermagui Golf Club (NSW), Sanctuary Cove Golf Club (Qld), Horton Park Golf Club (Qld), Twin Water Golf Club (Qld) and the central test facility at DEEDI Redlands (Qld).

Mountain Green™ (TL1)

Mountain Green™ was observed in about 1989 by Barry McDonagh on the No. 8 green at the Townsville Golf Course, Townsville, Queensland, Australia. Designated by Tropical Lawns Pty Ltd, Cairns, Queensland and trialled as 'TL1', the dark green chance seedling was selected from a 'Tifgreen' putting green as a distinctly coarser, densely matted turfgrass. Although Mountain Green™ was selected from a sward of the hybrid bermudagrass, its inflorescence structure (4, not 3, racemes per inflorescence), agronomic attributes (e.g. its tolerance to certain herbicides), and its DNA profile are consistent with a chance seedling of *Cynodon dactylon* rather than a mutant plant of a hybrid (*C. dactylon* x *C. transvaalensis*) origin (Loch and Roche, 2003c). Distinct characteristics of Mountain Green™ [*Cynodon dactylon* (L.) Pers.] include having very short internodes, prostrate growth habit, dark green colour, and a deep, strong rhizome system. Mountain Green™ is suited to moderate wear situations and tolerates shaded environments better than other warm-season *Cynodon* cultivars, with the exception of 'Plateau'. Mountain Green™ has been sold since about mid-2002 as a golf greens grass and is in play in areas of the wet tropics of North Queensland, namely the courses at El Arish, Dunk Island and Babinda (Anderlini, 2009). Anderlini (Anderlini, 2009) from Tropical Lawns Pty Ltd stated that to date, at no stage has Mountain Green™ been sold for home lawns or landscaping. However, this does not mean that the cultivar would not meet the requirements of a commercial or home lawn particularly in areas of far North Queensland.

MS-Choice

'MS-Choice' [*Cynodon dactylon* (L.) Pers.] [(Krans and Philley, 1998c; Krans et al., 1995a; USDA et al., 2006b)], released on 21 May 1991 was developed at the Plant Science Research Centre, Mississippi Agricultural and Forestry Experiment Station, Mississippi. 'MS-Choice' originated from a single clone collected from the 13th fairway at the Shady Oaks Country Club, Jackson, MS on Aug. 21 1980 (Krans et al., 1995c). Persons knowledgeable of Shady Oaks Country Club's history have said the fairway where the selected accession had been collected had not been intentionally replanted with bermudagrass seed, sprigs, plugs or sod since 1913 (Krans and Philley, 1998c). MS-Choice's origin may be from any one of the following sources: (a) a seed within the original seed lot; (b) a seed or plant introduced unintentionally to the site; or (c) a plant which developed as a result of an environmentally selected mutation(s) (Krans and Philley, 1998c).

The bermudagrass is characterised by a dark green colour, high-shoot density, low seed-head density, medium-coarse leaf texture, good autumn colour retention, average sod strength, good cold tolerance, excellent shade tolerance as compared to other bermudagrasses, some dollar spot, and average leaf-spot resistance (Krans and Philley, 1998c).

Breeding and foundation stock of 'MS-Choice' is maintained by the Mississippi Agricultural and Forestry Experiment Station. Certified sod and sprigs are marketed by the Mississippi Sod Producers Association (Krans et al., 1995a).

Vegetative material of 'MS-Choice' was obtained from Mississippi State University and later planted at DEEDI Redlands Research Station, Queensland on 11 Jan. 2005.

MS-Express

'MS-Express' *Cynodon* x *magennisii* Hurc. (Krans et al., 1995a; USDA et al., 2006a)], released on 21 Oct. 1991 was developed by the Plant Science Research Center, Mississippi Agricultural and Forestry Experiment Station, Mississippi. 'MS-Express' originated from a single plant collected from the 10th fairway at the Shady Oaks Country Club, Jackson, Mississippi, on 21 Aug. 1980. Fairways from where the collection was taken at Shady Oaks Country Club had been previously planted with bermudagrass seed between 1913 and 1933.

'MS-Express' origin may be from anyone of the following sources: (a) a seed within the original seed lot; (b) a seed or plant introduced unintentionally to the site; or (c) a plant which developed as a result of an environmentally selected mutation(s) (Krans and Philley, 1998a).

The identifying features of the original clone of 'MS-Express' were characterised by a medium green colour, prostrate leaf growth, high shoot density, moderate seed-head density, very fine leaf texture, autumn colour retention, average sod strength, excellent cold tolerance, good shaded tolerance compared to other bermudagrasses, good dollar spot and good leaf-spot resistance (Krans and Philley, 1998a).

Breeder and foundation stock of 'MS-Express is maintained by the Mississippi Agricultural and Forestry Experiment Station. Certified sod and sprigs are marketed by the Mississippi Sod Producers Association (Krans et al., 1995a). Vegetative material of 'MS-Express' was obtained from Mississippi State University and later planted at DEEDI Redlands Research Station, Queensland on 11 Jan. 2005.

MS-Pride

'MS-Pride' *Cynodon* x *magennisii* Hurc., (Krans et al., 1995b; USDA et al., 2006a)], released on 21 Oct. 1991, was developed at the Plant Science Research Center, Mississippi Agricultural and Forestry Experiment Station, Mississippi. 'MS-Pride' originated from a single selection collected from the 5th fairway at the Vicksburg Country Club, on 20 Aug. 1980. Persons knowledgeable of Vicksburg Country Club's history have said that the fairway was established with Bermudagrass seed in the mid-1960's and had not been intentionally replanted with bermudagrass seed, sprigs, plugs or sod since 1960. 'MS-Pride's' origin may be from anyone of the following

sources: (a) a seed within the original seed lot; (b) a seed or plant introduced unintentionally to the site; or (c) a plant which developed as a result of an environmentally selected mutation(s) (Krans and Philley, 1998b).

The identifying features of the original clone of 'MS-Pride' were characterised by a medium to dark green colour, short-head density, low seed-head density, fine leaf texture, excellent autumn colour retention, excellent sod strength, average cold tolerance, good shade tolerance as compared to other couchgrass, excellent dollar spot and leaf-spot resistance (Krans and Philley, 1998b).

Breeder and foundation stock of 'MS-Pride' is maintained by the Mississippi Agricultural and Forestry Experiment Station. Certified sod and sprigs are marketed by the Mississippi Sod Producers Association (Krans et al., 1995b). Vegetative material of 'MS-Pride' was obtained from Mississippi State University and later planted at DEEDI Redlands Research Station, Queensland on 11 Jan. 2005.

MS-Supreme

The 'MS-Supreme' *Cynodon* x *magennisii* Hurc. (Krans et al., 1999 ; USDA et al., 2006a) 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 Jun. 1999 (Loch and Roche, 2003e).

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 Feb. 2001. The latter cultivar was subsequently trialled in a study to assess the 'Management of new warm-season greens grasses in Australia' as part of Horticulture Australia Limited funded initiative (project code TU05001). Seven sites participated in the four year study (2006-2010) which saw a range of greens quality grasses being trialled at venues positioned predominantly down the eastern coast of Australia. They included Glenelg Golf Club (South Australia), Mornington Peninsula TAFE College (Victoria), Bermagui Golf Club (New South Wales) and the three Queensland venues at Horton Park Golf Club, Twin Water Golf Club and the central test facility at DEEDI Redlands.

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, 2003d). Later designed 'TL2' the triploid (2n = 27) (Loch and Roche, 2003d) interspecific hybrid [*Cynodon dactylon* (L.) Pers. X *C. transvaalensis* Burtt-Davy] was included 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, 2003d)."

Novotek™ was subsequently trialled in a study to assess the 'Management of new warm-season greens grasses in Australia' as part of Horticulture Australia (HAL) funded initiative (project code TU05001). Out of the seven regional trial sites positioned predominantly down the eastern coast of Australia, three trialled the cultivar between 2006 and 2010. They included the

Queensland venues at Horton Park Golf Club, Twin Water Golf Club and the central test facility at DEEDI Redlands.

OZ TUFF™ (Oz-E-Green)

'Oz-E-Green' [*Cynodon dactylon* (L.) Pers.] was discovered by Robert W. Morrow in 2001 as a superior plant growing among "Common" green couch (*Cynodon dactylon*) on his turf farm, Oz Tuff Turf at Berries Road, Childers, Queensland, Australia (Loch and Roche, 2004). Trademarked as OZ TUFF™ the cultivar was released on 13 Apr. 2006 (Morrow, 2006). The selection criteria for 'Oz-E-Green' included a dense prostrate growth habit and limited inflorescence production, high turf quality, and a dark green leaf colour (Loch and Roche, 2004).

Patriot

'Patriot' [*Cynodon dactylon* (L.) Pers. X *C. transvaalensis* Burtt-Davy] was commercially released in Jun. 2002 by the Oklahoma State University/Oklahoma Agricultural Experiment Station (Anonymous, 2004). 'Patriot' is a tetraploid (2*n* = 36) having received 27 chromosomes (three basic genomes) from the 'Tifton 10' *Cynodon dactylon* var. *dactylon* hexaploid (2n=6x=54) parent and 9 chromosomes (one basic genome) from the *C. transvaalensis* (parent) (Taliaferro et al., 2004). Although 'Patriot' has the same chromosome number as most *C. dactylon* var. *dactylon* plants, it is highly sterile only rarely producing seed (Taliaferro et al., 2004).

'Patriot' previously designated OKC 18-4 [OKC represents Oklahoma State University Clonal (vegetative) Type (Martin, 2002)] was developed and extensively tested between 1997 and 2001 by the Oklahoma State University Bermudagrass Breeding and Development Team. The interspecific F_1 hybrid 'Patriot' offers a dark blue-green colour, high shoot density, medium-fine texture, improved cold hardiness, a level of resistance to spring dead spot, rapid establishment and speedy divot recovery.

'Patriot' is currently available only as certified sprigs or certified sod and is a proprietary variety, exclusively licensed for production in Oklahoma to Easton Sod Farms (ESF), Inc. (Anonymous, 2004).

Material of 'Patriot' which was sent by Oklahoma State University arrived in Australia and was planted at DEEDI Redlands Research Station, Queensland in their turf demonstration facility on 11 Jan. 2005.

Plateau

'Plateau' is the result of a "spontaneous mutation" of an unnamed and unpatented common *Cynodon dactylon* growing on the property of the inventor, Peter Brown, at Collaroy Plateau, New South Wales, Australia in 1975 (Brown, 2002). 'Plateau' [*Cynodon dactylon* (L.) Pers.] is described by Brown (2002) as being infertile, however studies undertaken by Professor Peter Martin of the University of Sydney concluded the cultivar is fertile (McMaugh, 2009). 'Plateau', released in 1996, exhibits low growing height, prostrate spreading habit, prostrate shoot growth, short internode length, high sward density, wide stolon to rhizome width ratio, and medium seed head frequency (Brown, 2002). Due to the low compact growth and broad leaf of 'Plateau' the cultivar is one of the more favourable selections of *Cynodon* currently available for shaded environments (>30% sun).

Brown (2002) acknowledges in the PBR application that the most similar known variety of *Cynodon dactylon* is 'Riley's Super Sport' that forms a dense turf of low growing height; the next cultivar of morphological comparison is the cultivar 'Greenlees Park'. However, morphological and developmental studies undertaken by Loch & Roche (2003c) confirm that this assertion is erroneous. The most similar cultivar, today, is Mountain Green™ ('TL1'); however 8 out of the 19 characteristics measured in the spaced plant experiment conducted at DEEDI Redlands, Qld are significantly different ($P \leq 0.01$) (Loch and Roche, 2003c).

Premier

'Premier', which was discovered by Donald La Verne Parsons and Virginia Gail Lehman under cultivated conditions in a golf course fairway near Seal Beach, California, USA (Parsons and Lehman, 2007). Since 'Premier' was introduced into Australia by Virginia Leman, Oregan, USA, in 2007, observations made by Dr Donald S. Loch (former Principal Scientist, DPI&F) and Matthew B. Roche (Senior Scientist, DEEDI) believed the cultivar was not a *Cynodon dactylon* (L.) Pers. as first identified by Parsons & Lehman (2007). Following morphological and agronomic studies undertaken between 4 Oct. 2007 and 6 Feb. 2008 at DEEDI Redlands Research Station, Queensland, the results obtained from this work (refer to Chapters 2-6) strengthened Loch and Roche's claim. More recently, following communication with Dr Milton C. Engelke, he said that the cultivar was in fact a *Cynodon* hybrid (*C. dactylon* x *C. transvaalensis*) (Engelke, 2009). Dr Engelke is married to Dr Virginia G. Lehman who's turf farm, Blue Moon Farm, Lebanon, Oregon, USA, has ownership of 'Premier'.

The cultivar was identified as a distinctly different vegetative patch or segregated clonal plant differing by darker green leaf colour from the suspected parental variety 'Tifgreen' (Tifton 328) (Parsons and Lehman, 2007).

Vegetative material of 'Premier' obtained from Virginia Leman is currently being held at DEEDI Redlands Research Station in their turf nursery and will be planted in their turf demonstration plots in 2010.

Riley's Super Sport

'Riley's Super Sport' [*Cynodon dactylon* (L.) Pers.] was granted Plant Breeder's Rights 11 Apr. 1995 (Kaapro, 1996) and was released in Australia soon after. The cultivar which is marketed as Celebration™ in the USA, was also released in the latter country by Sod Solutions Inc. 'Riley's Super Sport' was a result of "spontaneous mutation" from 'Greenlees Park' and selected by the late Rod J. Riley, Guilford, New South Wales in 1988 (Kaapro, 1996). The infertile (McMaugh, 2008) 'Riley's Super Sport' exhibits a very prostrate growth habit thereby having minimal vertical growth (that is, very prostrate growth habit), extensive leaf production, short internode length, very low seed head production, and deep green coloration (Riley, 2000).

Royal Cape

'Royal Cape' [*Cynodon dactylon* (L.) Pers.] was discovered [in about 1930 (Taliaferro, 2003; USDA et al., 2006a)] on the Royal Cape Golf Course at Wynberg, Cape Town, South Africa (Taliaferro, 2003). The turfgrass PI 213387 was selected in around 1930 by C. M. Murray of South Africa (Busey, 1989) and released by the University of California, Los Angeles, and the Crops Research Division, ARS, USDA in 1960 (Younger et al., 1972). 'Royal Cape' was chosen for use along the lower Colardo River Basin (Younger et al., 1972) and was released on the basis of late-autumn and early spring growth, good colour, texture, tolerance to saline soils, and limited production of seed heads (Hanson and Juska, 1969).

A selection of 'Royal Cape' was introduced into Australia prior to 1956 by the Royal Botanic Gardens in Sydney (McMaugh, 2008). Vegetative material was obtained from R. J. Weppner, Toowoomba, Queensland and planted at DEEDI Redlands Research Station, Queensland, in their turf demonstration plots on 25 May 2000. A proportion of this material was taken and trialed in a Plant Breeder's Rights spaced plant trial at RRS in 2003. Post planting on 4 Mar. 2003 significant variation within the cultivar was observed and a collection of the two genotypes were made, highlighting the inconsistency within the cultivar. A selection of superior quality 'Royal Cape' was made by M. B. Roche and Dr D. S. Loch of DEEDI and later named 'RCII'. 'RCII' was vegetatively propagated to obtain sufficient material to trial in further spaced plant trials (10 Jun. to 15 Dec. 2004) undertaken by the research team at DEEDI. 'RCII' has not been commercially protected nor

released. Vegetative material of 'RCII' is maintained in a pure state at DEEDI Redlands Research Station for subsequent trialling and development.

Santa Ana

'Santa Ana' [*Cynodon dactylon* (L.) Pers. X *C. transvaalensis* Burtt-Davy] was developed by researchers at the University of California, Riverside, Los Angeles, USA for parks, playground, sport fields (Augsdorfer, 1995) and general home use. Named after the Californian city, the cultivar was a result of a deliberate cross (McMaugh, 1987) with grasses from South Africa and Iran (Augsdorfer, 1995) by the late Dr Victor B. Younger. The parentage was from crossing the South African *C. dactylon* cultivar PI 213387 (Anderson and Sharp, 1995), otherwise known as 'Royal Cape' and a fine leaved, dark green seedling selection of *C. transvaalensis* which was originally introduced from the Orange Free State (Younger, 1983) [McMaugh (1987; McMaugh, 2009) said Iran]. PI 213387 which was released in 1960 was selected by C. M. Murry (Anderson and Sharp, 1995) from the Royal Cape Golf Course near Mowbray, Cape Province, Union of South Africa in 1930 (Taliaferro, 2000).

The result was a seedling that was selected from the University of California agronomy program in 1956 and was identified as RC145 (Beehag, 1987). A source of RC145 was planted into field plots at the Santa Ana Research Station in 1958 (Beehag, 2009a) and observations were undertaken at locations throughout Chaffer and in several other states as RC145 (Anonymous, no date). RC145, later designated 'Santa Ana' was released in the USA in 1966 (Hanson, 1959; Hanson and Juska, 1969; Younger et al., 1972) [Beehag (1987) and Augsdorfer (1995) said it was released in 1967] by the California Agricultural Experiment Station.

'Santa Ana' a sterile triploid (2*n* = 27) hybrid (Anderson and Sharp, 1995) is characterised by a deep blue-green colour, medium-fine texture, good colour retention, early green-up of the turf following winter (Anderson and Sharp, 1995), high wear tolerance and *eriophyid* mite (*Eriophyes cynodoniensis* Sayed) resistance (Hanson and Juska, 1969). Observations made by the late Dr Victor B. Younger was that 'Santa Ana' also possessed good tolerance to smog in Los Angeles and above average salinity tolerance (Beehag, 1987). Even with these positives, 'Santa Ana', at first, was not well accepted by the sod growers in the USA with the growers arguing that they didn't want it. This was because the growers at the time were already growing the *Cynodon* hybrids 'Tifgreen' and 'Tifway', and it was thought to be a huge investment to plant additional acres of an additional hybrid turf to make it worth their while (Augsdorfer, 1995). This mindset was soon forgotten and the turf was widely used and popular for recreational and sports turf use within the USA.

In Australia, 'Santa Ana' was released by the Plant Quarantine Service of the Commonwealth Department of Health (Australian Capital Territory) in late 1976. The cultivar had been introduced by City Parks Research in Canberra to compliment the work being undertaken by Dick Powell, John Mortimer and Peter Semos (McMaugh, 1988). Soon after, sod farms were producing commercial supplies of 'Santa Ana' in Adelaide, Sydney and Perth (McMaugh, 1987). The cultivar was widely accepted for use on bowling greens with the most concentrated use at the time being in Adelaide, where over half the bowling clubs decided to adopt 'Santa Ana' as their preferred turf for their greens (Beehag, 1987).

'Santa Ana' was also a choice for use on cricket wicket blocks. One example of its use is when it was planted at the Melbourne Cricket Ground following a problem with their wicket table. This problem led to the subsequent rotary hoeing of the wicket table in late 1981 under the direction of the then secretary, Ian Johnson (McMaugh, 2008). 'Santa Ana' is still widely used as a suitable turfgrass for wicket blocks.

'Santa Ana' performs well in cooler climatic zones like that of Melbourne and Sydney. Further north, in Queensland 'Santa Ana' does reasonably well during cooler periods; however in the warmer months, the turfgrass undergoes higher stress levels which results in a significant reduction in turfgrass quality. However, Goddard (1999) made a note that 'Santa Ana' was well suited to Western Austalia's hot dry summers and cool, wet winters when the cultivar was

introduced into that state in the early 1980s. 'Santa Ana' also produces high thatch levels all year round and often results in management problems.

SS-2

The *Cynodon dactylon* cultivar was selected by Max Stephenson of Twin View Turf, Qld. The cultivar identified as 'SS-2' or "secret stuff two" was made from a natural selection at undisclosed location. The cultivar to date has not yet been released.

Tifdwarf

There were two sources of vegetative material produced of 'Tifdwarf' [*Cynodon dactylon* (L.) Pers. X *C. transvaalensis* Burtt-Davy], being for a test plot at the Georgia Coastal Plain Experiment Station and for later 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 like other "ultradwarfs" "Tifdwarf" is assisted by its basic purple plant colour in the warmer months and becomes very noticeable when temperatures drop in winter. As a consequence, 'Tifdwarf' takes on a purplish cast that is aesthetically objectionable to some.

'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, 2009b). The material imported by greenkeeper Cliff Meredith (McMaugh, 2009) was provided to Vic Phelps in 1968 to establish a nursery at his home for use at the then development 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, 2009b). 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, 2009b). 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 Sep. 1973 using material from the same source as was Broadwater Bowling Club (Beehag, 2009b). The green was in play on 21 Nov. 1973 (Beehag, 2009a). 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, 2009a).

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, 2009a).

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, 2009a).

'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, 2009a).

'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, 2009b). In Brisbane, an early club that had changed to 'Tifdwarf' was Salsbury Bowling Club, Salsbury, Queensland (information ex Les Rowan) (Beehag, 2009a).

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 *Cynodon dactylon* (L.) Pers. x *C. transvaalensis* Burtt-Davy (Hanna, 1997b; Hanna and Elsner, 1999) 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 Jan. 12 1988 (Hanna and Elsner, 1999). 'TifEagle' is a dense, fine-textured triploid ($2n = 27$) (Hanna, 1999b; Hanna, ; Loch and Hanna, 2001a) 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, 1999b). Test plantings on experimental plots and putting greens since 1991 indicate that 'TifEagle' can withstand routine cutting height of 3 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, 2001a) 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.

Tiffine

Hybridisation of *Cynodon dactylon* types with South African Bermuda (*Cynodon transvaalensis*) produced 8 (Hanson, 1959) [Hein (1953) said 8 or 9; and Robinson & Latham (1956) mistakenly wrote 89, which is likely to be a result of a possible typographic error from Robinson and Burton (1953) writing eight-nine at the start of a paragraph insteasd of using numerical identifiers], hybrid plants from which Tifton 127 later named 'Tiffine'. The *Cynodon*

dactylon (L.) Pers. x *C. transvaalensis* Burtt-Davy cultivar was selected and released by the Georgia AES, Tifton, and Crops Research Division, ARS, USDA in 1953 (Robinson and Latham, 1956). An F_1 hybrid and tested as Tifton 127, Tiffine is lighter green, more disease resistant, and much finer than common couchgrass (Hanson and Juska, 1969). The cultivar was introduced into Australia by Doug Corbett, former teacher of Greenkeeping at the Ryde School of Horticulture, New South Wales, following an informal visit to Sports Turf Research Institute (STRI) in Palmerston North, New Zealand. However, the material was mishandled and subsequently its identity lost by the staff at the Ryde School of Horticulture following building extensions in 1970 where the cultivar had been established in the field (McMaugh, 2008).

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-leafed South African bermudagrass (*C. transvaalensis*) [Hanson (1959) says it was from East Lakes Golf Course, Atlanta, Georgia; while Hanna & Anderson (2008) says it was from Egypt]. The result was a completely sterile F^1 hybrid [triploid (2*n* = 27) (Anderson and Sharp, 1995; Hein, 1961)] tested as Tifton 328 and later registered as 'Tifgreen'.

'Tifgreen' [*Cynodon dactylon* (L.) Pers. X *C. transvaalensis* Burtt-Davy] 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 & 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 (2009a) 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, 2009a).

Material of 'Tifgreen' was planted at the Gold Coast Burleigh Golf Club, Burleigh Heads, Queensland in 1974 (Beehag, 2009b), 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 the Georgia Coastal Plain Experiment Station, USA.

Tifgreen-II

'Tifgreen-II' a sterile triploid (2*n* = 27) [*Cynodon dactylon* (L.) Pers. X *C. transvaalensis* Burtt-Davy] is an improved mutant of 'Tifgreen' (Tifton 328) developed cooperatively by the US Department of Argiculture, ARS, the Georgia Costal Experiment Station, the US Golf Association Green Section, the Golf Course Superintendents Association of America (GCSAA), and the Department of Energy (Burton, 1985b).

Beginning in 1970 Powell et al. (Powell et al., 1974) irradiated to 7000 rads of gamma irrigation (Burton, 1985b) thousands of rhizomes of 'Tifton' bermudagrass cultivars, including 'Tifgreen'. The treated dormant sprigs were then grown on as spaced plants and selections were made on the basis of plants or sectors of plants that appeared different (Burton, 1985b). In 1971

(Burton, 1983), one year following irradiation, 'Tifgreen-II' was selected for having many desirable traits of 'Tifgreen' but has a lighter green colour and usually develops less of the undesirable purple colour when temperatures are low, is more vigorous, denser and exhibits much better spring recovery (Burton, 1985b).

One of the two clonal cultivars to be released from this work included a 'Tifgreen-II' in 1983 (Burton, 1983; Busey, 1989).

'Tifgreen-II' was included in the article; there was one report of the cultivar being introduced into Adelaide, however insufficient evidence has been made available and no further information has come to light as to its use here in Australia.

Tiflawn

'Tiflawn' is a hybrid [*Cynodon dactylon* (L.) Pers. X *C. transvaalensis* Burtt-Davy] between two selections of *Cynodon* that was released by the Georgia AES, Tifton, and Crops Research Division, ARS, USDA, in 1952 (Hanson and Juska, 1969); tested as Tifton 57 was developed in cooperative investigations between the latter station and the Division of Forage Crops and Diseases, BPISAE (Hein, 1953). 'Tiflawn' was released in the US in 1956 (Hanson, 1959) [Robinson & Latham (1956) say it was released in 1950]. An F_1 hybrid that requires less fertiliser and is more wear resistant than common couchgrass (Hanson and Juska, 1969).

'Tiflawn' was included in the article; however no information has come to light on its introduction or use here in Australia.

TifSport™ (Tift 94)

'Tift 94' [*Cynodon dactylon* (L.) Pers. X *C. transvaalensis* Burtt-Davy] (Hanna et al., 1997) was developed by United States Department of Agriculture-Agricultural Research Service (USDA/ARS) geneticist Dr Wayne Hanna at the University of Georgia Coastal Plain Experiment Station in Tifton, Georgia. The fine textured bermudagrass released in 1994 (Hanna et al., 1997) was a result of a mutant selected from sixty-six plants established from dormant stolons (each with two nodes) of the 'Midiron' cultivar [*Cynodon dactylon* (L.) Pers. x *C. transvaalensis* Burtt-Davy] treated by gamma radiation on Jan. 20, 1983 (Hanna, 1997a; Hanna, 2006). After 12 years of multi-location testing, mutant number 40 was released as 'Tift 94' (Hanna, 1999a) and was first sold in the USA in Jun. 1998 (Loch and Hanna, 2001b).

Trademarked as TifSport™ the cultivar is a vigorous triploid ($2n$ = 27) (Hanna, 1997a; Hanna, 1999a; Hanna, ; Loch and Hanna, 2001b) selected for close mowing, texture, density, resistance to southern mole cricket (*Scapteriscus borellii* Giglio-Tos; syn. *S. acletus* Rehn & Hebard), non-preference green-up characteristics and in particular its wear tolerance and recovery (Roche, 2009b).

TifSport™ patented in 1997 (White, 2006) is licensed exclusively to the University of Georgia Research Foundation for commercialisation and is protected by a USDA patent. Within Australia TifSport™ can only be sold as genetically certified turf or sprigs by a licensed turf producer. TifSport™ was brought into Australia from the USA and planted at DEEDI Redlands Research Station, Queensland in their turf demonstration plots on 3 Feb. 2000. Twin View Turf Pty Ltd of Wamuran, Queensland is the only Australian licence holder of the cultivar TifSport™.

Tifway

'Tifway' [*Cynodon dactylon* (L.) Pers. x *C. transvaalensis* Burtt-Davy] released collaboratively in 1960 by the USDA-ARS and the Georgia Coastal Experiment Station (Anderson and Sharp, 1995; Hanna, 1997a), was selected from a presumed chance hybrid between *C. transvaalensis* and *C. dactylon* that appeared in a seed lot shipped by D. Meredith, Johannesburg (Anderson and Sharp, 1995), South Africa to the USA in 1954 (Burton, 1966). 'Tifway' is a triploid

(2*n* = 27) (Burton, 1960) bermudagrass that produced a darker green colour and stiff leaves, earlier spring growth, greater resistance to frost and to sod webworm [*Herpetogramma licarsisalis* (Walker)] and mole cricket [*Gryllotalpa orientalis* (= *africana*) Burmeister], better herbicide tolerance; the cultivar does not shed pollen and produces stiffer leaf blades than that of 'Tifline' or 'Tifgreen' (Anderson and Sharp, 1995). Hanson and Juska (1969) rated 'Tifway' as equal or superior to 'Tiffine' and 'Tifgreen' in disease resistance, density, weed resistance, seed head production, and rate of spread. Vegetative material of 'Tifway' was introduced into Australia via New Zealand in 1956 by Doug Corbett, former teacher of Greenkeeping at the Ryde School of Horticulture, New South Wales, (McMaugh, 2008) and material was later planted (around 1965) at Beverina Estates, Cobbitty, New South Wales under the trademark Sportsway™ (McMaugh, 2002). Horsfall Turf also had extensive plantings at about the same time (McMaugh, 1988). Mc Maugh (2002) suggested the cultivar suffered its ill-fated demise following mishandling and poor labeling similar to that of the introduction of 'Tiffine' into Australia. However, Beehag (2009a) noted that 'Tifway' had been planted at Campbelltown Golf Club, Campbelltown and Cranbrook School, Bellevue Hill which are both located in New South Wales and still exist. Vegetative material of 'Tifway' which was also supplied to DEEDI Redlands Research Station, Queensland by Col Shiller of Walsh's Seeds Garden Centre, Toowoomba City, Queensland and later planted in their turf demonstration plots on 25 May 2000. This plot also remains in existence.

Tifway II

'Tifway II' [*Cynodon dactylon* (L.) Pers. x *C. transvaalensis* Burtt-Davy] originated by exposing gamma irradiation to dormant 'Tifway' sprigs in 1971 and then selecting plants or sectors that appeared to be different (Burton, 1981). 'Tifway II' was released cooperatively on 13 Apr. 1984 [There are numerous variances of the date of release of which include: 1984 (Hale, 2003); April 1981 (Anderson and Sharp, 1995); 1991 (Hanna, 1997a); 1981 (Busey, 1989; Busey and Dudeck); the article by Burton (1981) titled 'Tifway II Bermudagrass Released' was published in 1981 but no specific date was published], by the USDA-ARS, the Georgia Coastal Plain Experiment Station, the U.S. Golf Association Green Section, and the U.S. Department of Energy. Burton (1985a) noted that the sterile triploid (2*n* = 27) cultivar 'Tifway II' looked like 'Tifway' and had the same desirable characteristics but made a denser, more weed-free turf, more resistant to root knot, ring and sting nematodes, is more frost tolerant, establishes faster from sprigs, exhibits a little better quality, and often greens up slightly earlier in the spring.

The Georgia Coastal Plain Experiment Station, Tifton, has maintained a breeding stock of 'Tifway II' material.

'Tifway-II' was included in the article; however no information has come to light on its introduction or use here in Australia.

WGP3

'WGP3' [*Cynodon dactylon* (L.) Pers.] was a result of open pollination followed by seedling selection carried out by Todd Layt, Clarendon, New South Wales, Australia in 2008. The seed parent was identified by breeder Todd Layt as being *Cynodon dactylon* (cultivars present included 'Wintergreen', 'Greenlees Park' and 'C1'). The seed parent is characterised by a large number of inflorescences produced on each plant. 'WGP3' is characterised as having fast 'speed' of growth, strong sod strength, low seed head production and dark leaf colour (Paananen, 2008). The characteristics identified by Pannanen (Paananen, 2008) are identical to that of 'LEG13A'.

At the time of publication, this cultivar had not yet been released in Australia and little information was available.

Windsor Green

'Windsor Green' [*Cynodon dactylon* (L.) Pers.] was the first cultivar in Australia to be put through the PBR process (McMaugh, 2008). Released in 1993, the cultivar was a induced mutant from 'Wintergreen' through radiation. 'Windsor Green', a tetraploid (2*n* = 36) (Ho, 1999) was selected from 22 other mutants post radiation and screening showing superior density, colour and wear tolerance as well as lower seed head production (McMaugh, 1993). Additional attributes included low temperature growth and high fibre (McMaugh, 2009).

Winter Gem

'Winter Gem' [*Cynodon dactylon* (L.) Pers.] was a cultivar produced by control pollination followed by selection of 'Wintergreen' and 'Couch 5' (also designated C5) by breeder David Nickson. 'Couch 5' [accession number S-130 (Robinson and Neylan, 1993)] an experimental breeding line (that was selected from seed provided to the breeder by Arden Battensperger (McMaugh, 2008)) was a selection from an earlier series of crosses by the breeder between 'Wintergreen' and a number of *Cynodon dactylon* accessions, which were collected the breeder started collecting from the Peninsula Country Club Fairway 8B, Frankston, Victoria, Australia with mentor Peter E. McMaugh in Feb. 1987 (Neylan, 2005; Robinson, 2008). A series of other *Cynodon* collections were carried out between 1986 and 1990 from the Peninsula area of Victoria, Australia. Crossing was carried out by the breeder in 1998 and subsequent seedlings and selected plants were observed between 1998 and 2000. In the spring of 2000, the remaining potted seedlings were planted into plots at the Evergreen Turf farm at Pakenham, Victoria, Australia and allowed to expand fully. The final selection of Seedling 9 (later designated DN9) in late 2002 was based on shoot density, leaf texture and retention of winter colour (Roche and Loch, 2006b). 'Winter Gem' was first sold to Victorian Parks Constructions in Feb. 2007 for use at the Grand Prix racetrack, Albert Park, Melbourne, Victoria, Australia (Holden, 2009).

Wintergreen (C84-135)

'C84-135' or more commonly known as 'Wintergreen' [*Cynodon dactylon* (L.) Pers.] was discovered by Peter E. McMaugh in 1969 (Ho, 1999; Ho et al., 1997) growing on a small bowling green surface at Nyngan, New South Wales, Australia. 'Wintergreen' was selected for its vigorous growth, dark green olive colour and colour retention compared to other *Cynodon dactylon* cultivars in Australia at the time. Following 10 years of experimenting under test and development (McMaugh, 1988) 'Wintergreen' was released in 1983 (McMaugh, 2008). The tetraploid (2*n* = 36) cultivar which was described by John Neylan, then AGCSA Technical Manager 'as an oldie but a goodie' ((McMaugh, 2005) ;(McMaugh, 2008) is still widely used today within sub-tropical and warm temperate zones within Australia. However, being able to identify a true-to-type source of "Wintergreen" through years of sod production and variation through either (i) seed within the original seed lot, (ii) seed or plant introduced unintentionally, or (iii) a mutation, is difficult. The truest to type available of 'Wintergreen' had been planted since 1998 or 1999 in a commercial nursery block at the breeders Windsor farm, New South Wales, Australia (McMaugh, 2006). The latter sod farm was sold in Jul. 2005.

Hubert F. Whiting was not involved in the collection and/or breeding work of 'Wintergreen' as listed in the US Patent (McMaugh and Whiting, 1988). McMaugh states that Whiting was given shared patent rights of the cultivar in America in the USA (McMaugh, 2009).

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