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In 2002, QDPI&F turf agronomist Dr Don Loch teamed with engineer Les Zeller to develop a device that would provide more accurate data on traction measurements for sports fields. Since its construction, the QDPI&F automated turf tester has been used on numerous occasions on trial plots and in assessments of playing surfaces on several community sports fields and elite venues in Brisbane.

Photo courtesy of Star News Group

Traction on natural turf is determined by the combined effects of the grass and the soil medium, as well as the choice of footwear by players

Putting science behind traction measurement

The overall aim on sports fields is to prepare a surface that plays well (both for players and for spectators) and one that is safe for the players. In terms of player-surface interactions, there are two major components of playing quality: hardness (relating to running and falling on the surface) and traction (provided by player-shoe-surface contact).

However, before the playability and ultimately the safety (the associated injury risk) of a sports field can be assessed properly, we need objective methods that will give reproducible measurements relating to these two important parameters of playing quality.

These days, hardness is routinely assessed through Clegg Impact Tester measurements, but little has been done in the past 20 years or so to improve the information on traction provided by relatively inexpensive equipment.

WHAT IS TRACTION?

'Footing' describes the effect of the playing surface on surface-shoe (player) interaction. Friction and traction are the surface properties which enable players to move on the field without excessive slipping or falling over and without causing excessive stress to joints or ligaments. More specifically, 'friction' applies to smooth-soled footwear while 'traction' relates to footwear with studs, cleats or spikes that provide extra grip.

The conventional studded disc apparatus used to measure traction

Traction comes in different forms, depending on the particular forces involved in each case (McNitt 2005). Translational (linear) traction refers to the resistance to a shoe sliding across the surface. For players, this relates to the grip that a shoe has on the surface, with low translational traction meaning that the shoe tends to slip.

Rotational traction refers to the traction that resists rotation of the shoe during pivoting movements. For players, the higher the rotational traction the greater the tendency for a foot to become fixed in its original position during changes of direction. Being able to take accurate and meaningful measurement of rotational traction is therefore important in terms of minimising the risk of knee and ankle injuries to players with studded shoes.

McNitt (2005) also recognised static and dynamic traction, which represent slightly different aspects of shoe-surface interaction. Static traction is the resistance to sliding or pivoting when there is no movement between the shoe and the surface. Static traction forces tend to resist the initiation of sliding or pivoting. Dynamic traction is the resistance that occurs during a sliding or pivoting motion. Dynamic traction forces tend to resist or decelerate pivoting motions.

MEASURING TRACTION

Over the years, researchers have developed a variety of methods and devices to measure traction, both on artificial and natural turf. Obviously, the method that best simulates the interaction of a player's foot in contact with the surface should provide the most meaningful measurement of traction.

Methods that measure traction via linear movement have included pendulum tests, towed sledges, the sliding distance for a trolley with a test foot, and shear vane tests. However, the method most widely used has been to determine resistance to the rotation of a studded disc.

The initial studded disc apparatus was developed by Canaway (1975) and further improved by Canaway and Bell (1986). The central component is a 15cm diameter ▶

horizontal disc into which football studs, etc, are fitted equidistant from the central vertical shaft. The disc (weighted with at least 40kg) is dropped onto the playing surface to ensure stud penetration, and the torque required from the rotating disc to tear the turf is measured with an industrial torque wrench. The dropping and twisting actions to operate this apparatus are done manually by the operator. The various models available commercially either provide a single reading for the break point or indicate that the break point was under or over a set figure.

The most notable advance in traction measurement since the mid-1980s has been the development of Pennfoot by McNitt et al. (1997). The hydraulically-operated Pennfoot consists of a framework supporting a leg and foot assembly that can be used to measure both rotational and linear traction using different footwear under various loading weights.

DEVELOPMENT OF THE QDPI&F AUTOMATED TURF TESTER

In 2002, Queensland Department of Primary Industries and Fisheries turf agronomist Dr Don Loch teamed up with engineer Les Zeller to incorporate new ideas into the rotating studded disc apparatus. Their aim was to generate new data on aspects of traction that had not hitherto been possible to quantify, as well as giving more reliable and repeatable measurements than the still current 1980s design of the studded disc apparatus.

The result was an automated traction tester now covered by Australian patent number PAT/AU/2004270767. As described in the patent application (see Figure 1), the central components of the QDPI&F automated turf tester are:

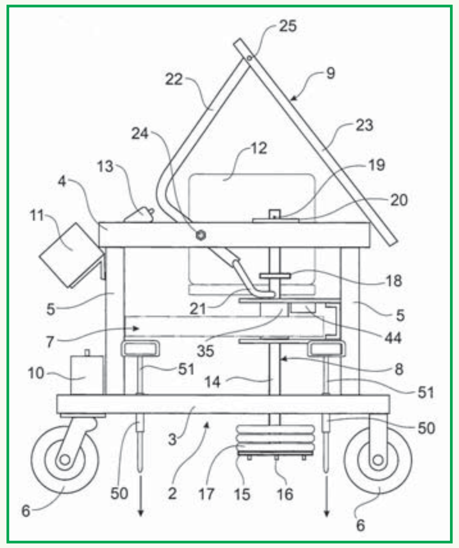


Figure 1. Diagrammatic representation of the QDPI&F automated turf tester

- A rotatable shaft (14) with a ground engaging foot (15) mounted at a lower end of the rotatable shaft for rotation with the rotatable shaft;
- A drive device (7) to rotate the shaft;
- A measurement device for measuring the torque experienced by the rotatable shaft whilst the shaft is rotating and the ground engaging foot is in contact with the surface; and
- A control device (11) that receives the torque readings as determined by the measurement device.

This apparatus is able to create a profile of torque with respect to angular displacement of the rotatable shaft to define accurately the characteristics of the surface under test.

The ground engaging foot is based on the design by Canaway and Bell (1986), but has been modified to eliminate friction caused by the lifting weights rubbing on the drive shaft. The drive shaft is threaded to allow removal from the main drive shaft for transportation or disassembly. The footplate has been drilled and taped to allow testing of different stud configurations (size, shape, pattern, etc). A battery-operated electric motor is used to control the position and movement of the main drive shaft.

To facilitate comparisons with data from earlier equipment, the drop height has been set at 60mm. At the start of each test, the drive shaft is rotated until a horizontal pin drilled through the shaft aligns with slots in the support plate, at which point the ground engaging foot is free to fall from the set height and rotate through approximately 150° at a constant pre-set speed.

After each test, the main drive shaft (with ground engaging foot and 40kg mass) must be lifted back into the pre-test position so that the apparatus can be moved. A manually-operated lever is used until the horizontal pin clears the support plate, at which point a limit switch is activated to rotate the drive shaft into the transport position.

Operation of the apparatus is coordinated through an electronic controller, which also directs the flow of serial data from the digital indicator to a laptop computer. Currently, serial data is transmitted from the digital indicator at approximately 10 readings per second.

Species	Number of readings	Torsion (Nm)	
		Range	Mean
Cynodon dactylon (vegetative types)	13	66-86	75.5
Cynodon dactylon (seeded types excluding ‘Princess’ and ‘Riviera’)	8	57-76	66.4
Cynodon dactylon (‘Princess’ and Riviera’)	2	73-80	76.7
Cynodon dactylon x transvaalensis	13	63-93	75.3
Digitaria didactyla (Qld blue couch)	2	68-72	69.6
Digitaria didactyla (Swazi grass)	3	77-91	82.3
Paspalum vaginatum	7	55-73	64.9
Pennisetum clandestinum	2	54-57	55.7
Stenotaphrum secundatum	3	59-70	61.8
Sporobolus virginicus	2	45-53	48.9
Zoysia japonica	10	55-76	65.1
Zoysia matrella	3	55-70	60.2

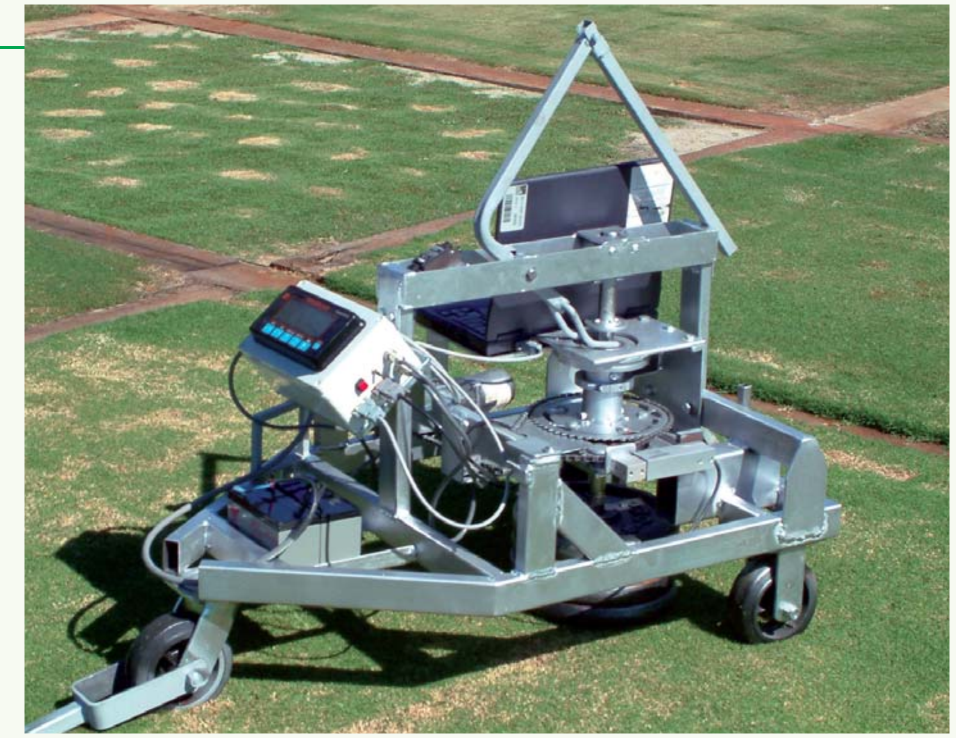
Table 1. Maximum torsion values (Newton metres) for established plots of warm-season turfgrasses maintained without wear (May 2003)

EFFECTS OF TURFGRASS AND ENVIRONMENTAL CONDITIONS ON TRACTION

Over the past four years since its construction, the QDPI&F Automated Turf Tester has been used on numerous occasions on trial plots and in assessments of playing surfaces on several community sportsfields and elite venues in the Brisbane area. This has led to minor mechanical and software modifications to improve its operation. More importantly, it has also generated a substantial body of data on the effects of different turfgrasses and environmental conditions on traction.

We have recorded substantial differences among warm-season turf species and even within species in terms of the maximum torsion reached on well-maintained plots not subject to traffic wear injury. McNitt et al. (2004) have also reported species differences in traction, with Kentucky bluegrass and tall fescue reaching higher peak traction values in their work than perennial ryegrass and chewings and red fescue.

In plots not subject to wear, Swazi grass (*Digitaria didactyla*) and vegetative green



The QDPI&F automated turf tester has helped to generate data on the effects of different turfgrass and environmental conditions on traction

couch (*Cynodon dactylon*) varieties tended to have the highest traction readings (Table 1). At the other end of the scale, stolon stems of marine couch (*Sporobolus virginicus*) were less flexible under pressure and so tended to break more easily than those on the green couches. Stolons on the Zoysia species were also stiffer and easier to break than green couch stolons.

Kikuyu (*Pennisetum clandestinum*) has quite thick stolons, but these are relatively soft and easily broken giving relatively low traction readings. Buffalo grass (*Stenotaphrum secundatum*) stolons are similar to kikuyu in thickness, but harder to break, hence its higher traction readings. Seashore paspalum (*Paspalum vaginatum*) has finer stolons but still recorded roughly the same traction as the buffalo grass cultivars tested.

Within *D. didactyla*, the newer Swazi grass varieties form denser swards and gave higher traction readings than the traditional Queensland blue couch. Among the green couches, the vegetative types recorded higher traction readings than the seeded types with the exception of ‘Princess’ and ‘Riviera’.

With the exception of kikuyu, all of the grasses tested showed similar patterns in the way that rotational traction (torque) built up to peak levels. The major difference we found was that some reached peak traction at a lower value and therefore peaked earlier than others which reached higher traction levels (Figure 2). Even weakened couch oversown with ryegrass followed a similar pattern (Figure 3). Traction in kikuyu increased more slowly than in the other grasses, and was slower to reach a lower and broader peak.

Recently, Orchard et al. (2005) and Chivers et al. (2005) have postulated that a heavier thatch layer leads to higher traction and trapping of players' boots, thereby contributing to anterior cruciate ligament injuries. Our experience, however, is that the main plant factor determining traction is the stolon and/or rhizome growth on and just within the ground surface.

Provided the rhizomes are still intact in areas where the top growth including thatch has been completely worn away, we have recorded almost no change in traction in these bare areas compared with nearby areas where the top growth is still intact.

We expect that differential amounts of thatch in the different treatments of replicated wear trial on eight Cynodon varieties at Redlands will give us more definitive information on this point over the next few months as thatch in some areas is gradually worn away.

CONCLUSION

As McNitt et al. (2004) observed, traction on natural turf is determined by the combined effects of the grass and the soil medium, both of which can be managed to reduce the deleterious effects of traction if necessary. It is also heavily influenced by the choice of footwear, as different studs or cleats can give greater or lesser amounts of grip irrespective of the grass type or condition.

Ideally, traction measurements in the future need to be correlated with these effects to ensure that player safety is not compromised by the use of inappropriate footwear. This is another fruitful area for future research. We also need more definitive data on what is the threshold level of rotational traction that is potentially dangerous in terms of injury, and on the angle of foot rotation up to this point.

These are just some of the many exciting areas that the development of the DPI&F automated turf tester will allow us to investigate properly in the future to the benefit of both grounds managers and players.

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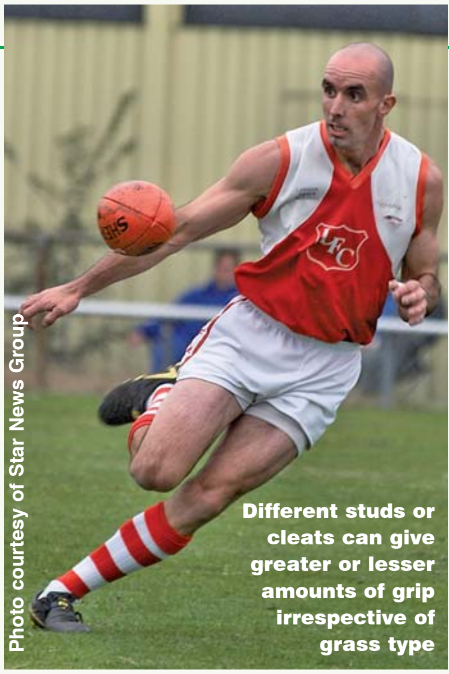

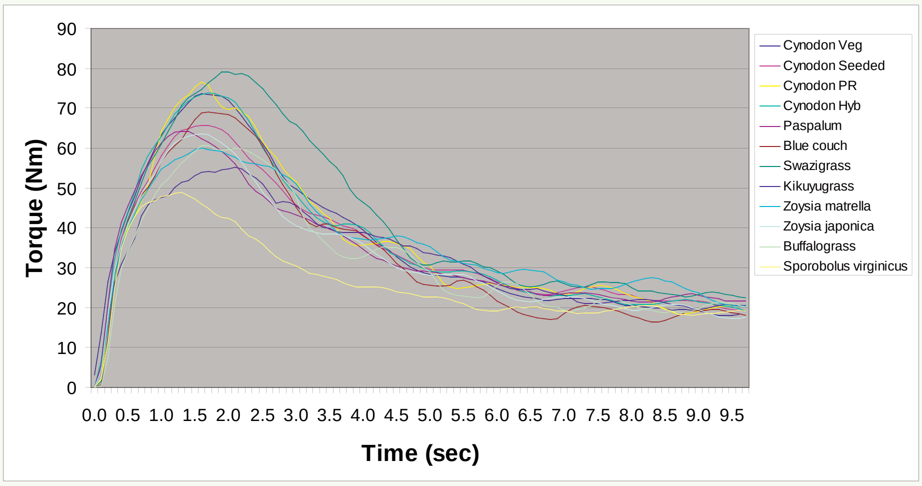

Figure 2. Effect of turfgrass type on the pattern of rotational traction over time

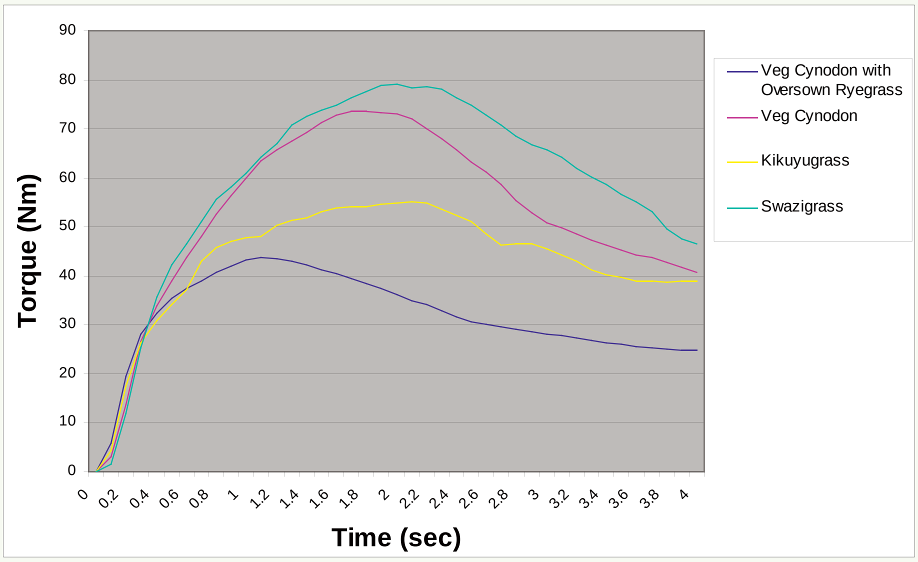

Figure 3. Comparison of oversown ryegrass in couch with representative warm-season turfgrasses