Guidelines for Rolling in Cricket

Peter Shipton and Iain James

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GUIDELINES FOR ROLLING IN CRICKET

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Foreword

by Chris Wood

Pitches Consultant, England & Wales Cricket Board

If there is one defining image that represents cricket Groundsmanship and pitch preparation, it is the heavy roller. During my career I have seen (and used!) many weird and wonderful configurations of single, tandem or triple rollers, either purpose built for turf, or former road rollers. To this day, they remain that mythical tool that is called for by players, coaches and officials to “get more life, pace and bounce in the wicket”. There is no doubt that rolling is vital for producing an optimum and safe playing surface. However there has been centuries of debate over 'how heavy', 'when and how long to roll' and 'under what conditions?' Many groundsmen at the top of their profession have got it right over time with whatever equipment they had their disposal. Many have had lesser results, at most with educated guesswork, not entirely realising the consequences of the operation in relation to the underlying profile and moisture content.

I encountered such an experience in the very first year of my career, when as a young groundstaff lad at the Oval, I was fascinated by the huge, formerly horse-drawn, roller parked behind the old score-box. To my surprise, it was deployed for pre-season rolling in the spring of 1968, following adverse criticism of the dead, lifeless pitches on the square. I was asked to walk alongside the tractor-drawn roller and shout if I saw the surface “bubble” (looking for a bow wave). Back then of course I didn’t have a clue what I was supposed to observe or what the consequences were. All I knew was that the huge 4 tonne roller, affectionately dubbed “Bosser’s Pet” was back in use (see photo).

What happened that season? Well, the pitches were slower and lower than ever. That roller was never used again and eventually the pitches were dug up and re-laid.

"Bosser's Pet" being drawn by the Oval Groundstaff in 1922. TW 'Bosser' Martin was responsible for the batting pitches he produced between the two World Wars when this roller was used regularly for pitch preparation. **(Picture courtesy of W. Gordon Surrey CCC).**

In a drive to remove guesswork, the ECB set up the 'Pitches Research Group' (PRG) in 1995 to invite and commission the expertise of various scientific bodies to investigate the properties of pitches (including soils, grasses, ball bounce and deviation).

It was felt that research into the relationship between the moisture in the profile and the rolling regime would be the next progression towards the 'perfect pitch' – effectively the equal balance between bat and ball.

So the ECB PRG commissioned Cranfield University to conduct a 4 year research programme, of which this summary document is the result of the hard work and a large and extensive thesis undertaken by Peter Shipton. This is research that I’m pleased to say will go a long way to dispel the myths and legends and instil sound and economical rolling practices for the production of quality pitches across all levels of cricket.

Preface

In 2004, Cranfield University began a 4 year doctorate research programme to develop a set of guidelines for maintaining synthetic turf. The project, funded by England and Wales Cricket Board (ECB) (www.ecb.co.uk) and the UK Government's Engineering and Physical Sciences Research Council (www.epsrc.ac.uk), had the task of developing a scientific understanding of the rolling of cricket pitches so that pitch preparation by rolling could be optimised and from that to create a set of rolling guidelines to assist the ECB in driving forward the development of cricket. Following completion of that research, Cranfield University have prepared this document with the ECB – aimed at both professional and volunteer groundstaff.

At the beginning of the project we surveyed over a hundred groundstaff across England and Wales to see how groundstaff went about their rolling. We found that the average number of passes in pre-season rolling in the club game was 83 passes per pitch (it was 53 in the first class game) but the average is not as interesting as the range. It might not surprise you that some clubs only do five passes per pitch, perhaps more surprising is that somebody somewhere claims to do 540! You might think that rolling would be a bit more standardised in the first class game? Well the range there is 5 to 280 passes per pitch! What this told us was that there was plenty of room for optimisation – not everyone in a range of 5 to 280 (or even 540) could be getting it right.

Health and Safety

Cricket rollers are dangerous equipment and have caused deaths to operators. Service and maintain your roller regularly. Only trained personnel should use them. Do not carry passengers and keep children away from the roller when it is operating. Always ensure that you have carried out an up to date risk assessment and have a safe system of work in place. The Institute of Groundsmanship (IOG) have produced two documents:

1. IOG SSW 025: SAFE SYSTEM OF WORK (Level 2 work equipment) USING RIDE-ON ROLLERS (CRICKET)

2. IOG GENERIC RISK ASSESSMENT (Using Rollers On Sports And Amenity Turf)

We recommend that you obtain these documents from the IOG and incorporate them into your club rolling practices and your Health and Safety Policy and Procedures, which are subject to inspection by the Health and Safety Executive and form the basis of best practice in grounds management. Visit www.iog.org for details.

Table of Contents

Notes:

Throughout these Guidelines, words that are ***underlined and italic*** are explained in the Glossary.

We have used metric units throughout but for conversions:

For length/depth:	25 mm is about 1 inch
For mass:	1 tonne = 1000 kg which is about 2205 lbs
For pressure:	100 kPa = 1 bar which is about 15 PSI

1 INTRODUCTION

1.1 What are these guidelines and where do they come from?

These guidelines give you the key information you need to make your rolling more effective, whether it is pre-season rolling or match pitch / net preparation.

The guidelines address key questions such as:

- How much rolling should I do?
- When should I start rolling?
- What is the best moisture content for rolling?
- What weight and diameter of roller should I use?
- How fast should I roll and in what direction?
- Can I damage the pitch by rolling?

Rolling is an important process in cricket – it improves pitch performance by compacting the soil, reducing live grass cover and making the pitch more smooth and uniform. This improves both pitch performance and pitch safety. Good preparation ensures that all results are possible but that the pitch does not decide the result of the game. Just as under-rolling a pitch can have an effect on the game of cricket, over rolling can have negative effects too and we explore these, and how to avoid them.

The guidelines are based on a four-year, in depth research project at Cranfield University's Centre for Sports Surface Technology. The project was funded by the ECB and a government research council (EPSRC) to find out the answers to the above questions. The following guidelines are based on a series of detailed studies in both the laboratory and in field trials.

This document explains the science behind the recommendations and dispels myths such as:

- The more a pitch is rolled the harder and better it plays
- Rolling slowly helps compact the pitch
- Heavier rollers help get the pitch harder at depth
- Any pitch problem can be cured by just rolling it more

By knowing some key information about their roller and their pitches, most groundstaff can reduce the amount of rolling they do. This saves time and fuel, and helps save money and reduce *CO_2 emissions* from unnecessary rolling. Why do clubs over – roll? Usually it is because coaches, club officials and players believe that rolling the pitch all day and all night helps provide better surfaces for batting. These guidelines will show that this isn't true.

The guidelines are all set out in Part 2 and you can turn straight to them if you wish, but we strongly recommend reading through Part 1 to find out the basic principles behind the guidelines. And if you read the guidelines and are wondering whether you need to use them, read the Summary for good reasons as to why you should – including reducing your carbon footprint, saving time and reducing costs to your club, whilst preparing better cricket pitches.

1.2 Pitch compaction and rolling: moisture and air

The aim of rolling is to compact the pitch evenly so that it is harder and more *consistent*. A harder pitch will deform less on ball impact, giving more bounce and pace.

Compaction can be quantified by measuring the *dry bulk density* of a pitch, this measure is referred to as 'density' throughout this guide. The density is the mass of dry soil (measured in grams, g) in a fixed volume (cubic-centimetres or cm^3). Consider the two cores in Figure 1.

The left hand core is at a low density of 1.3 g/cm^3, there are 1.3 grams of soil in every cubic centimetre. When this soil is rolled, it is compacted vertically – squeezing the soil particles closer together. This reduces the volume taken up by the soil – this means that the density goes up – and the pitch is more compacted. Because the particles are closer together, they cannot move as far when the ball impacts the surface – so the pitch is harder, with good bounce and pace and a reduced risk of cracking.

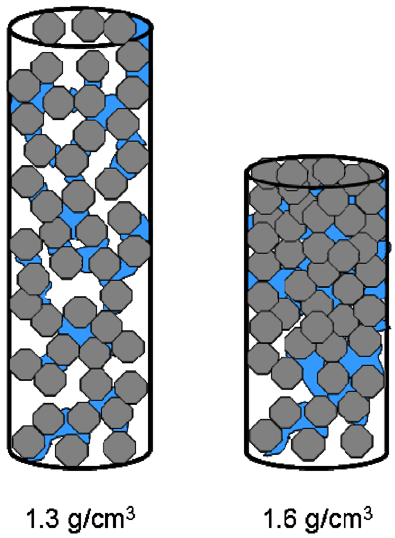

Figure 1 Compaction of soil particles (grey) in a core. The number of particles (and therefore the mass of particles) and the amount of water (blue) are exactly the same. The right hand core is more compacted into a smaller volume, so the density is greater (1.6 g/cm^3). Compaction is achieved by compressing air (white).

The pores, the spaces between the particles, are either filled with water (blue) or air (white). Notice that as the soil is compacted with the roller the quantity of water has not changed – this is important, when rolling there is not enough time for water to drain from the pores – the only way to compact the soil is by compacting the air. The mineral particles themselves cannot be compacted, nor the water because it is incompressible – only the air can be compacted.

This means that as the pitch is rolled there is proportionally more water in smaller and smaller pores – this makes the soil more and more difficult to compact. In fact, when it gets to about 5% air space (pores filled with air) it is almost impossible to compact the soil with a roller – and it is impossible at saturation (0% air space). Therefore once the pitch has been rolled to 5% air voids – which takes about 2 to 4 _passes_ (with a _tandem roller_), the pitch must be allowed to dry (decreasing the amount of water and increasing air in the pores) so that it can then be compacted again with the roller.

There is an _optimum moisture content for rolling_. If the soil is too dry then it will be hard and strong and cannot be further compacted with a roller, so groundsmen will normally irrigate dry pitches to wet them up before rolling. But if the pitch is too wet then the soil will not compact. Groundsmen must bear this in mind when preparing match pitches and when pre-season rolling.

Look at Figure 1 again. Notice that the compaction by the roller occurs at the top of the core – the bottom of the cores are similar. This is a key point that will be revisited: rollers compact the surface to a limited depth.

1.3 Compaction curves

The way cricket soils compact is illustrated by looking at '*Proctor compaction curves*', which show the relationship between moisture content and density for a particular soil. The standard Proctor Test uses a 2.5 kg hammer dropped onto the soil from a height of 300 mm, 27 times. The test is repeated at increasing moisture contents and the density after 27 drops is measured and plotted on a graph like Figure 2. Figure 2 shows the proctor curve (blue line) as moisture is increased from A to B. When the soil is very dry (A) adding a small amount of water allows the soil to be compacted more. This is because the water helps to weaken the soil.

Eventually the point 'O' is reached, which is the proctor maximum – the point at which maximum density is achieved (in this case 1.68 g/cm^3). This occurs at the optimum moisture content of 19%. Beyond this point as more water is added, air spaces fill up with water and the soil cannot be compacted, so at moisture contents between 'O' and 'B' maximum achievable density is lower and lower. Note that the 'O' to 'B' line follows somewhere between 0 and 5% air space – it is not possible to compact the soil to the full roller compaction potential when it is this close to *saturation* no matter how many passes are done.

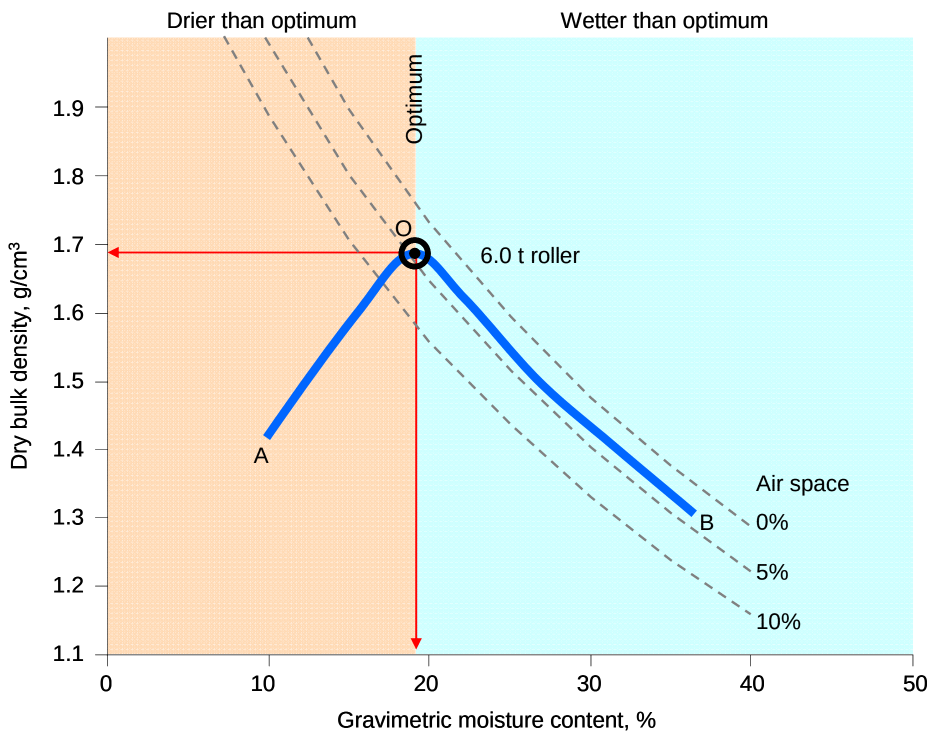

Figure 2 A Proctor compaction curve (blue line) for a cricket loam (loams with clay contents between 26 and 32% all plotted on the same line). Maximum density is 1.68 g/cm^3 and this occurs at the optimum moisture content of 19% (black marker and red lines).

The problem with Figure 2 is that the equivalent roller specification to the 2.5 kg hammer test is equivalent to a 6 tonne version of a typical cricket roller. Maximum weights of typical heavy, ballasted, cricket rollers are usually around 2 tonnes (although in our survey there were some that were 3 to 3.5 tonnes). The maximum density that can be achieved by a 2 tonne cricket roller is about 1.60 g/cm^3, shown in Figure 3. Note that this means that the optimum moisture content for rolling becomes slightly higher (22%) – this is really important for two reasons:

1. The heavier the roller, the greater the density increase that can be achieved - but the pitch has to be allowed to dry more.
2. Where clubs don't have covers, and pitches can sit wetter for longer, the extra cost of heavier rollers might not be justified (Figure 3 shows the same conditions for a 1.5 tonne roller).

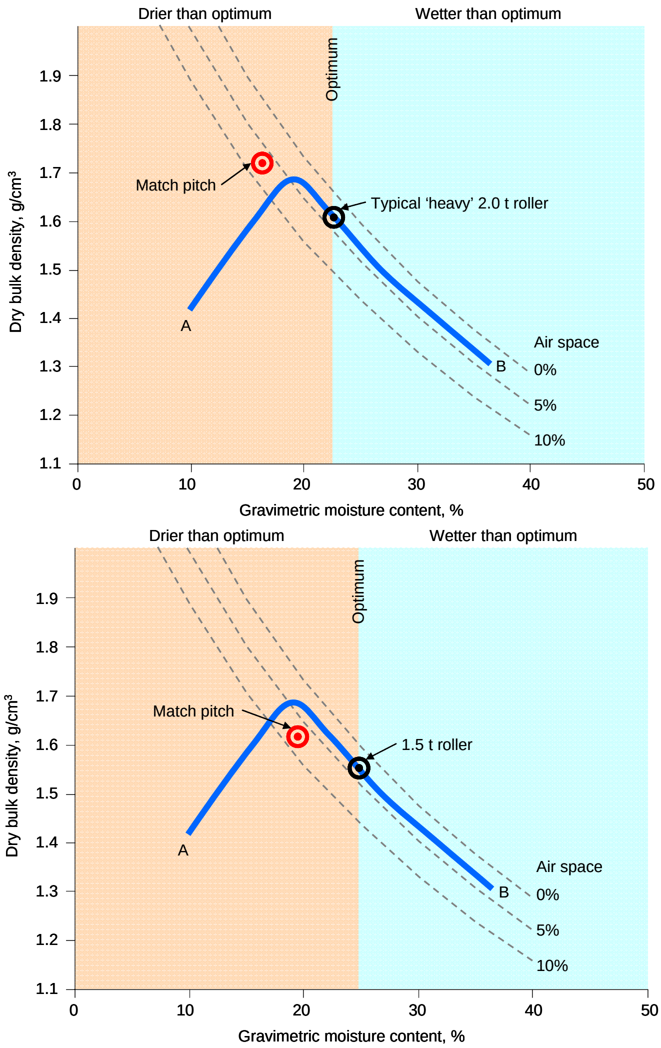

Figure 3 Maximum density for a 2 tonne roller (top) and a 1.5 tonne roller (bottom). The maximum roller compaction potential (black marker) is plotted on the same compaction curve as Figure 2 (blue line). Optimum moisture content for this roller is 22%. The red marker represents the density and moisture content of match pitches. The only way to get from the black marker to the red marker is by allowing the pitch to dry – this cannot be achieved by further rolling.

1.4 Cricket soils shrink and swell

When clay soils get wet, the water is absorbed into the clay particles and they swell. As the soil dries out, the water is removed and the clay particles shrink. Figure 4 shows what happens to clay loam soil as the soil draws water up. These are images from 0, 5 10 and 20 minutes after wetting. As water is drawn up the soil swells; after 20 minutes the soil volume has expanded by 30%. In this case, this decreases the density from 1.2 to 1.0 g/cm^3. The same behaviour happens with the clay loam soils used in cricket pitches. When the pitch gets wet (whether rainfall or irrigation) – it expands and the density goes down; as the pitch dries out its density increases and it becomes harder.

0 5 10 20

Figure 4 Expanding clay loam soil at 0, 5, 10 and 20 minutes after adding water from below the sample. After 20 minutes the sample has expanded by 30%. Want to see this in action? Check out the video at www.cranfield.ac.uk/sas/sst/rolling

Shrinkage due to drying is very effective at making pitches denser and harder. Figure 5 is a plot of soil density in our trial pitches over 80 days between March and June 2006. These plots were not rolled but density increased as the soils dried. Note that neither soil reaches the maximum density from heavy rolling (1.60 g/cm^3) but it illustrates the process.

Of course this works the other way – if the pitches become wet they swell and density is reduced. Because they have been compacted over the summer, the pitches do not swell by 30% (as in the example in Figure 4) but they do swell. The effect of over-winter swelling is shown in Figure 6. The density reduces over winter from September to March, particularly near the surface. Note that both these winters were relatively mild – so this effect has more to do with shrink-swell and soil moisture content than the commonly cited freeze-thaw effects of winter. In colder winters, such as 2008-2009, the effect could be magnified by freeze-thaw. All this means that for the majority of pitches, where they are allowed to get wet, pre-season rolling is necessary to increase (or 'restore') pitch density.

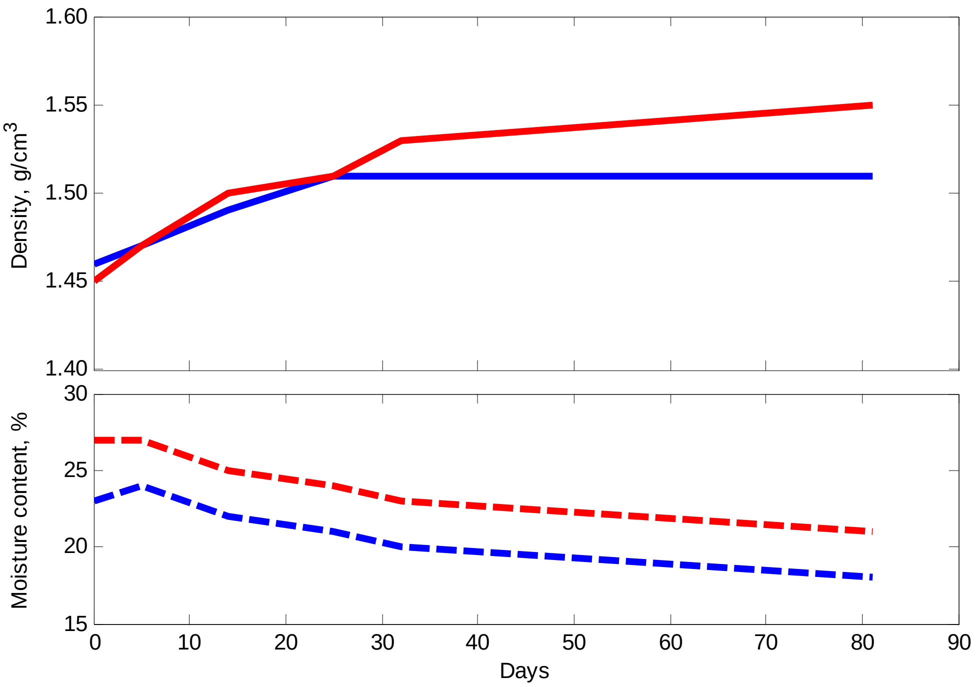

Figure 5 Shrinkage causing a reduction in density with moisture content over an 80 day period between March and June 2006. These soils were not rolled during this period. The blue line is for a 26% clay soil and the red line for a 30% clay soil. The higher clay soil (red) has more moisture content but shrinks more so the density is greater.

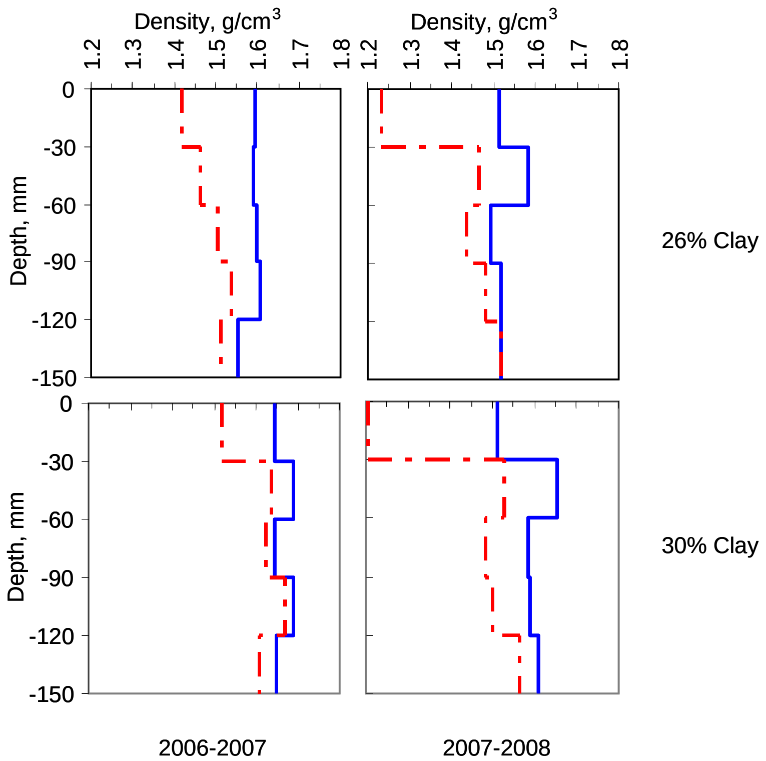

Figure 6 Over-winter expansion of cricket pitches. The blue line represents the density of the pitch in September and the red line, the density in the following March for two winters 2006-2007 and 2007-2008. Note that the density change is greater nearer the surface.

1.5 Rolling and Playability

The relationship between roller compaction and pitch performance is complicated. Groundsmen need to balance drying for shrinkage, hardness and ball rebound but also need to be wary of the effect of drying on cracking too. Figure 7 illustrates the relationship between ball rebound and cracking as a pitch dries. If a 2 tonne heavy roller is used to roll a cricket pitch to 1.6 g/cm^3 at a moisture content of 22% (shown by the black circle) then ball rebound will be 12% and there is no cracking. As the pitch dries out and becomes harder (and more dense) the ball rebound increases to 23% (shown by the red circle in the left-hand graph). The problem is that the number and severity of cracks also increases with the Cracking Score approaching 3; any higher than this and the pitch condition would be unsuitable for the start of play. **The 'art' of cricket groundsmanship is to balance soil moisture content with pitch playability and this art is assisted by the availability and use of covers.**

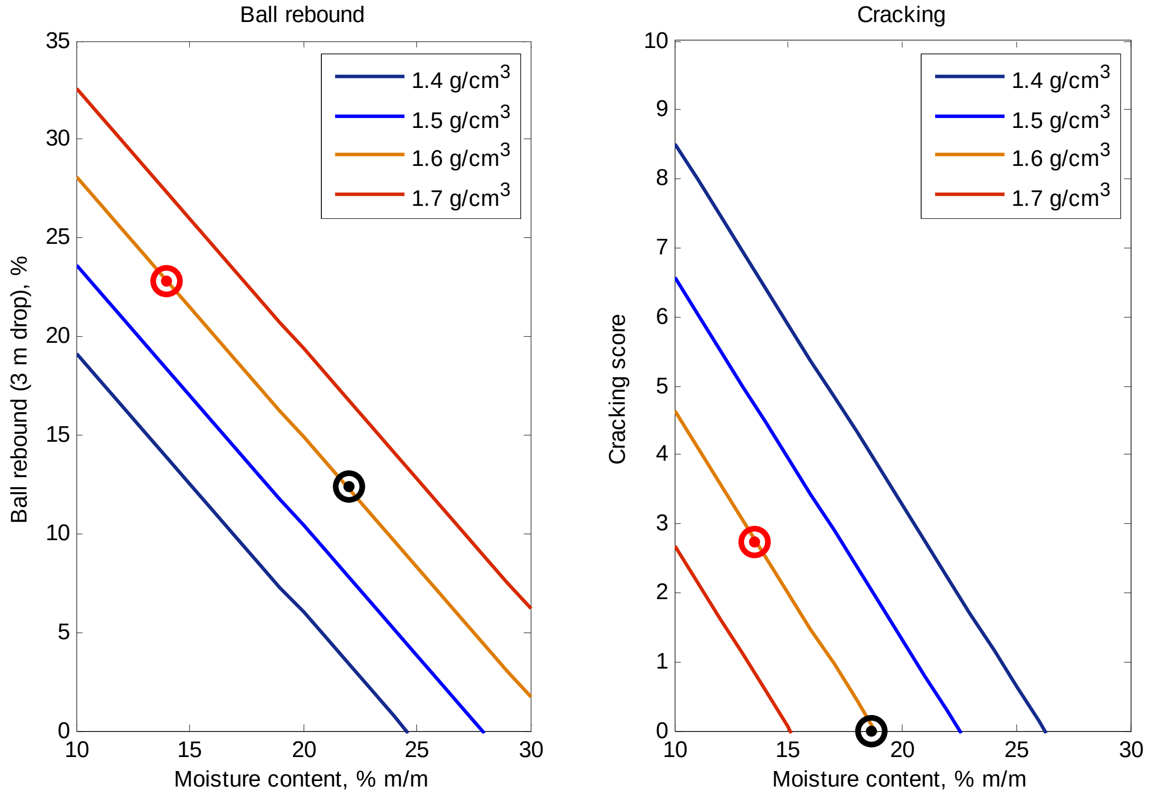

Figure 7 Relationship between initial pitch density achieved by rolling (black circle) and ultimate playability (red circle) after drying and shrinking. The roller is needed to increase density to the maximum possible as this reduces the risk of cracking as the pitch dries. For an explanation see the text.

1.6 What does the roller do?

The need to roll in the right moisture conditions has already been explained – too dry and the soil is too strong to be compacted, too wet and the soil cannot compact because there is no air to be compacted. But the effect of the roller also needs to be considered. Depending on three things – the roller mass, the roller diameter and the soil moisture content, the roller will either:

[1] Move the soil vertically

[2] Move the soil vertically and horizontally

[3] Do nothing.

When rolling, groundsmen should be trying to achieve [1] and trying to avoid [2] but when doing 80 passes per pitch like the survey mean suggests, then most of the time they will be just doing [3]!

1.6.1 Vertical and horizontal soil movement

The effect of roller weight, diameter and speed was investigated in a special rolling simulator that we built for this project (Figure 8). If you are interested in seeing more about how this works – have a look at the video on our website: www.cranfield.ac.uk/sas/sst/rolling.

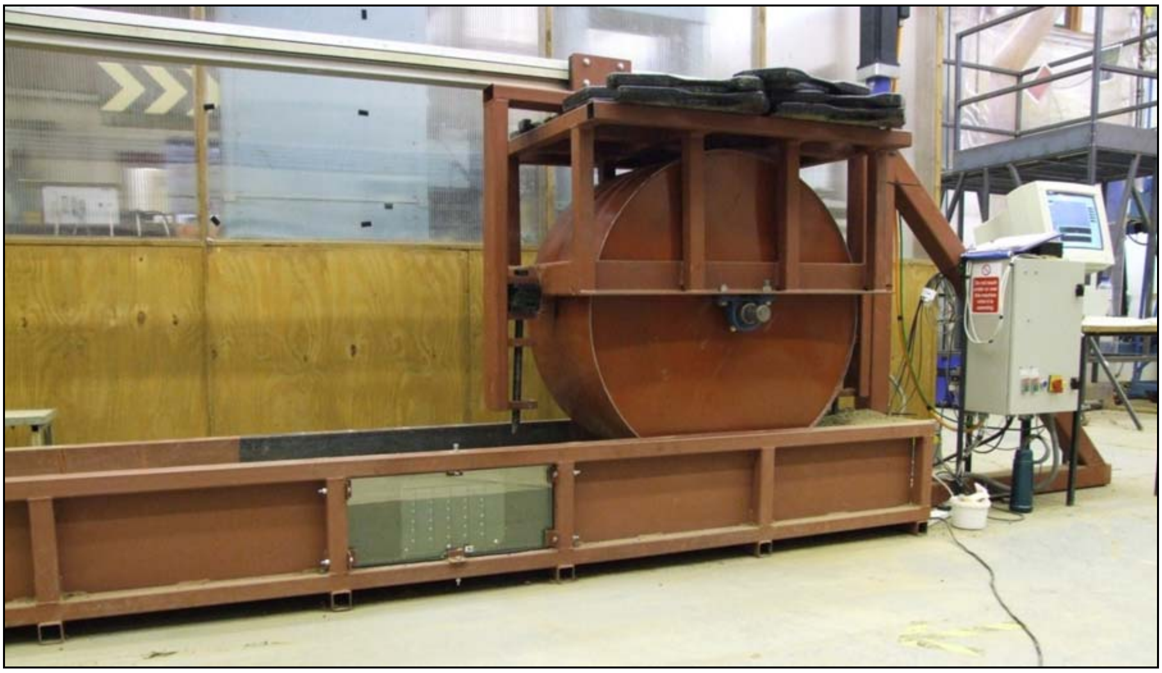

Figure 8 The Cranfield Cricket Rolling Simulator. In this configuration a 1 m diameter roller is rolling a 30% clay soil sample. Weights are added to the top of the roller which is towed and controlled by a computer. The tank can be removed and replaced with grass pitches too. The side window allows the deformation of the soil under the roller to be analysed with video processing software written at Cranfield University.

A range of factors were examined including roller diameter, roller mass, soil moisture content and the effect of grass. The soil movement and deformation was recorded using video and analysed using image processing software written at Cranfield University to track the movement of soil markers at 32 times per second as the roller passes over the soil.

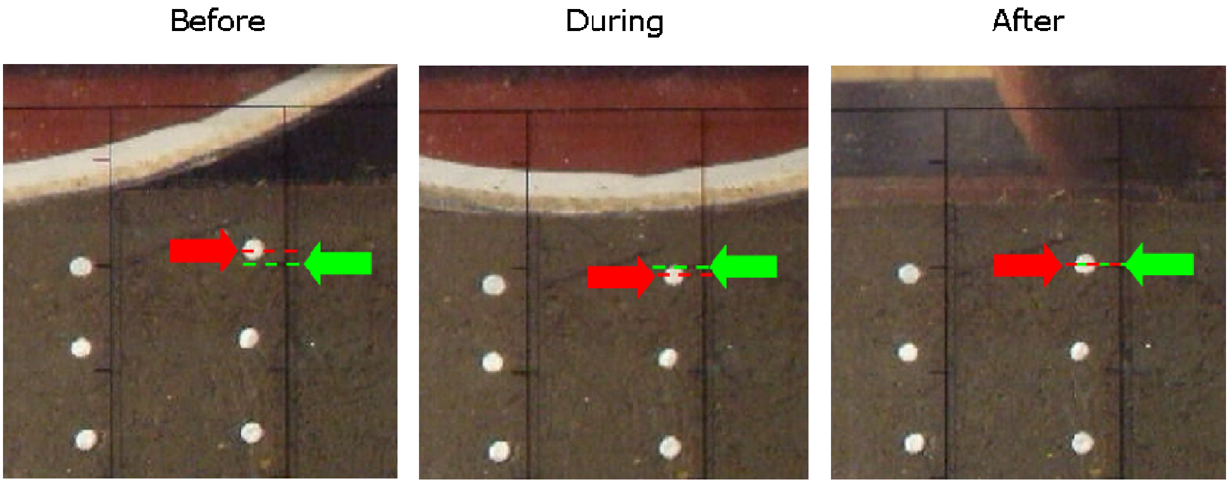

Figure 9 Tracking marker movement in the Cranfield Cricket Rolling Simulator. Vertical movement is measured by tracking the centre of the soil marker (white circle, red arrow) relative to fixed reference markers (green arrow). Before the roller reaches the marker, the red arrow is above the green arrow. During loading by the roller the red arrow moves below the green arrow. After the roller has passed, the soil recovers slightly and the red arrow ends up level with the green arrow. The final compaction is not the maximum deformation – this is because the soil is slightly elastic. We also observe the same effects with grass. The marker rows are initially at 15 mm, 30 mm and 50 mm below the surface in this figure.

The vertical movement of the soil is explained in Figure 9. It was observed that:

1. **Vertical movement increased as the roller mass increases.**
2. **Vertical movement is largest for the first two passes but is then relatively small for additional passes.**
3. **Rebound of the surface can be 50% of the maximum downward movement.**

What was also of interest is the horizontal movement, which was smaller but significant. Horizontal movement:

1. **Takes place in the top 35 mm of the pitch.**
2. **Is smaller for larger diameter rollers.**
3. **Increases significantly in wet soils**
4. **Is resisted by grass roots – meaning the grass roots reinforce the soil but are stressed by the roller.**
5. **Is forwards and backwards, particularly for the rear roller which is the one driven by the engine.**

The depth of this horizontal movement suggests that it could be a cause of root breaks and it is also known to corrugate wet pitches. So not only should groundsmen avoid rolling the pitch when wet because it doesn't compact the soil, it could actually harm the profile too. A 1 m diameter roller reduces horizontal movement by 25 to 75% compared to a standard 0.6 m diameter roller (Figure 10) – but this doesn't necessarily mean buying new, bigger diameter rollers, groundsmen just need to roll in the right conditions. The two golden rules are:

1. **Look after the grass plants (maintain good live grass cover) because they reinforce the soil and help dry it out.**
2. **Don't roll when the soil is above optimum moisture content for rolling.** (to work this out – have a look at the guidelines in Part 2).

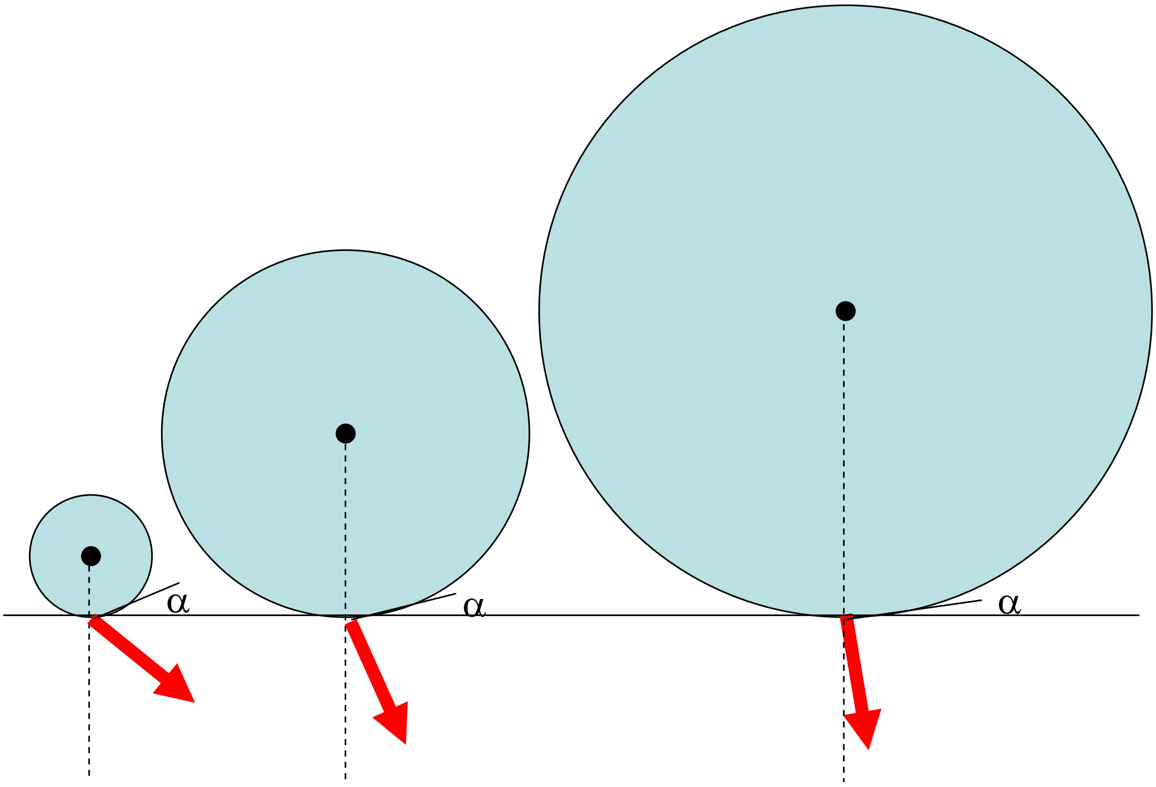

Figure 10. The effect of diameter on direction of rolling forces. As roller diameter increases from 0.2 to 0.6 to 1.0 m, the direction of force becomes increasingly more vertical. This is because the contact angle between the roller and the pitch (α) decreases with roller diameter.

1.6.2 Rolling speed

There is a saying that, 'if you roll more slowly, you get more consolidation'? Well, having spent the last four years investigating this, both in the simulator and in the field, this just isn't the case. Theoretically this is correct – when rolling very slowly water can drain from the pores in the soil – this is the effect that occurs when the roller is parked on the outfield all day long and it appears to 'sink in'. The problem is that the water movement rates in clay soils are so slow that the pitch would have to be rolled so slowly it would take at least a day to roll one pitch, once. Even going as slow as the roller will allow, is still going relatively quickly compared to clay soil drainage – so groundsmen might as well roll at normal speeds of 0.7 km/h (0.45 mph) – this is about 2 minutes to roll a full pitch so for most rollers, first gear, low revs. **Make sure that you drive both the front roller and the rear roller right off the pitch (except after the pitch has been marked out) because on some rollers they weigh more at the back than the front – so you could under roll one end of the pitch**.

1.6.3 Depth of roller and pitch construction

Quite simply, if pitch construction is not right, the pitch will not be right, and cannot be cured by rolling. Guidance on constructing pitches can be found in *TS4* available from the ECB website (see reference in the Glossary). Normally pitches are built up in 50 mm (2") layers – it is important to compact these layers as they are built up – this is because the depth of pressure from a roller is limited. Look at Figure 11, these are real measurements of roller pressure under two rollers (a typical 2 tonne heavy cricket roller and a 3 tonne roller) at different moisture contents. The data show that at 50 mm depth, the pressure is half that at 25 mm and at 75 mm depth it is only a third, so rollers are not effective at depths below this – so if the layers are not *consolidated* when

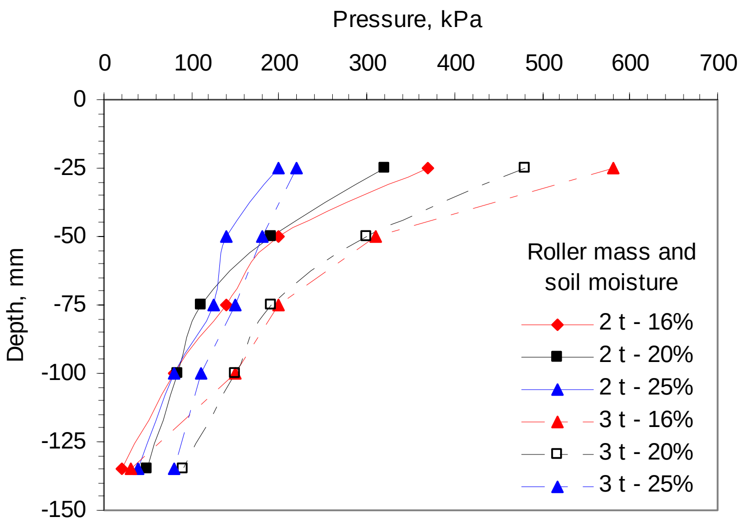

Figure 11 Roller pressure at different depths and moisture contents. Solid lines are for a 2 tonne roller (typical heavy roller), dashed lines are for a 3 tonne roller. The more dry the soil and the heavier the roller, the more pressure. Note that at 75 mm depth the pressure is one third of that at 25 mm – the roller has a limited effect at depth.

constructing it will be difficult to consolidate the whole pitch profile. It is also important to key each layer into the next so that inter-layer breaks do not form – especially near the surface where horizontal roller forces are greatest – otherwise a slip plane for a *root break* will be created.

1.6.4 Compactive potential of a roller

Each roller has a maximum density that it can compact to – its *Rolling Potential*. Rolling potential is dependent on the roller weight and the contact area of the roller drums with the soil. The easiest way to compare rollers is to divide the total width of all the roller drums by the mass of the roller which gives the *roller mass* per metre of *roller drum* (kg/m), or the *mass/width factor*.

$$\text{Mass/width factor (kg/m)} = \frac{\text{Total mass of roller (kg)}}{\text{Width of roller drum 1 (m)} + \text{Width of roller drum 2 (m)}}$$

What is really important is that once the soil has reached its rolling potential density, the density cannot be increased by extra passes – whether it is just one more pass or one hundred! If groundsmen know the rolling potential of their roller, they can stop wasting time and fuel by going over and over a pitch – they can begin to optimise their rolling efficiency to ensure that the roller's compactive potential is achieved. From then on it's down to drying and shrinking.

Table 1 Roller compaction potential to 50 mm depth for a 600 mm diameter roller. Optimum gravimetric soil moisture content required to achieve maximum density.

Roller mass/width kg/m	Roller equivalent (two drum; 1.2 m wide) kg	Roller compaction potential g/cm^3	Optimum moisture %	Percent of Proctor optimum density %
260	650	1.26	27	75
440	1000	1.40	27	83
638	1500	1.50	25	89
750	1800	1.55	24	92
840	2000	1.58	23	94
920	2200	1.61	22	96
1250	3000	1.66	20	99

Table 1 provides the maximum density for rollers of different *mass/width factors* when operated in the optimum soil moisture conditions. Groundsmen can measure the mass/width factor (mass per metre width) of a roller easily. The mass could be stated on the information plate riveted to the roller, in the handbook or in the original purchase documents – if the mass is unknown, it might be possible to fine a local farmer or quarry with a weigh-bridge to weigh the roller.

Then measure the width of the roller and divide the mass in kilograms (1000 kg in a metric tonne) by the width in metres of all the roller drums to get the mass/width factor for your roller. Don't forget to add the mass of the water if *ballast* has been added to the *drums*. To do this, use the following calculation:

$$\text{Mass of water in one roller drum (kg)} = \frac{(3.142) \times (\text{drum diameter (m)}) \times (\text{drum diameter (m)}) \times (\text{width of drum (m)})}{0.004}$$

Then look at Table 1 to get vital information on the roller's compaction potential. Note that the pitch must be at the optimum moisture content to achieve the roller compaction potential; above or below this and it will be impossible to pack the soil to the full compaction potential – if the soil is too wet there will not be enough air to compact and there is a risk of horizontal movement, and if the pitch is too dry, the soil will be too strong to compact. Note that the optimum moisture content decreases for heavier rollers.

1.6.5 Roller mass and when to ballast a roller

When rolling a loose soil – such as for the first pre-season roll, noticeable *crease marks* appear in the pitch at the edge of the roller – the depth of these will largely depend on the difference between initial pitch density and the compactive potential of the roller in the prevailing soil conditions i.e. the final density. Table 2 indicates the potential surface height drop (mm) resulting from a change in density through rolling.

Table 2 Reduction in surface height resulting from rolling between an initial and final density. Deduct initial density drop height (mm) from final density drop height to get actual drop in mm.

	Reduction in surface height, mm				
Initial dry bulk density, g/cm^3	Target dry bulk density, g/cm^3				
	1.2	1.3	1.4	1.5	1.6
1.2	0	4	7	10	13
1.3	-	0	3	7	9
1.4	-	-	0	3	6
1.5	-	-	-	0	3

If density is increased from 1.50 g/cm^3 to 1.60 g/cm^3, the drop in height is only 3 mm, which is unlikely to cause permanent pitch damage. If density was increased from 1.20 g/cm^3 to 1.60 g/cm^3, by using a heavy roller too quickly in pre-season rolling for example, then the drop in pitch height could be as much as 13 mm. Whilst most facilities have limited choice of roller, **building roller weight up through pre-season rolling is good**

practice and will create less damage but this can be done relatively quickly – lots of passes at lower weights are not needed because the rolling potential for light rollers is achieved quickly with a small number of passes.

1.7 The role of the grass plant

Grass roots play an important role in reinforcing the soil and also add vertical *elasticity* to the pitch. A deep root system is essential for strengthening pitches and reducing cracking. But there are more reasons to look after the grass plant.

Grass is the best pump system for drying pitches (Figure 12). Plants extract water through their root system and up through their leaves in a process called *transpiration*– this allows the pitch to dry at depth, providing that there is a good root system. The process of *evapotranspiration* (the combination of evaporation by the sun's energy and transpiration through the plant) is the only way to dry a clay soil below its *field capacity*.

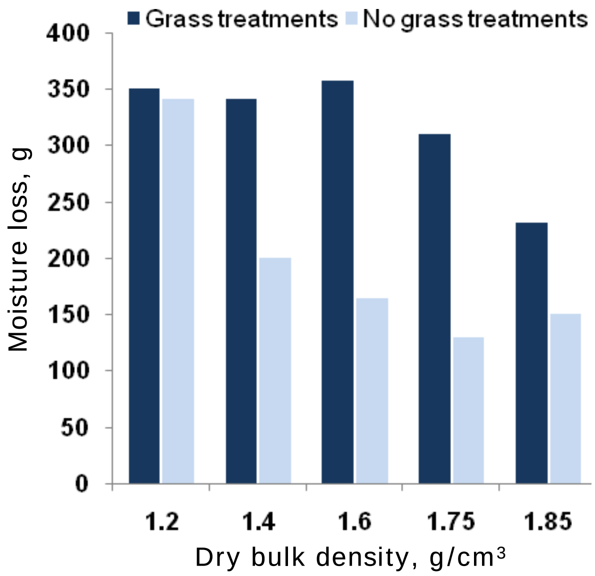

Figure 12 Moisture loss over a 14 day period for a cricket loam (26% clay) at different densities is significantly greater with grass than without, especially as density increases (the same pattern was observed in 30% clay loams).

Rollers are commonly used to dry-off grass surfaces by targeting rolling at the grass rather than the soil. This can be part of match pitch preparation as live grass can affect seam movement but good live grass cover should be re-instated as soon as a pitch has been used, by watering, over-seeding and the addition of nutrients where necessary.

When pitches are rolled it becomes increasingly more difficult for plants to grow and root distribution is affected. In our study we found that the amount of roots (by weight) was the same at 1.8 g/cm^3 as at 1.4 g/cm^3 – but the distribution was not even with depth (see Figure 13). In denser soils, roots tended to grow nearer the surface which would limit the plants ability to extract water at depth.

Consider carefully whether *aeration* and *decompaction* treatments are needed for pitches that have been compacted by rolling through the summer. Wetting-drying cycles do have a decompactive effect on pitches but this diminishes with depth – to encourage deeper rooting a mechanical operation might be required – recommendations on this aspect of pitch maintenance will be made following the completion of the ECB-IOG funded project on aeration and decompaction at Cranfield University.

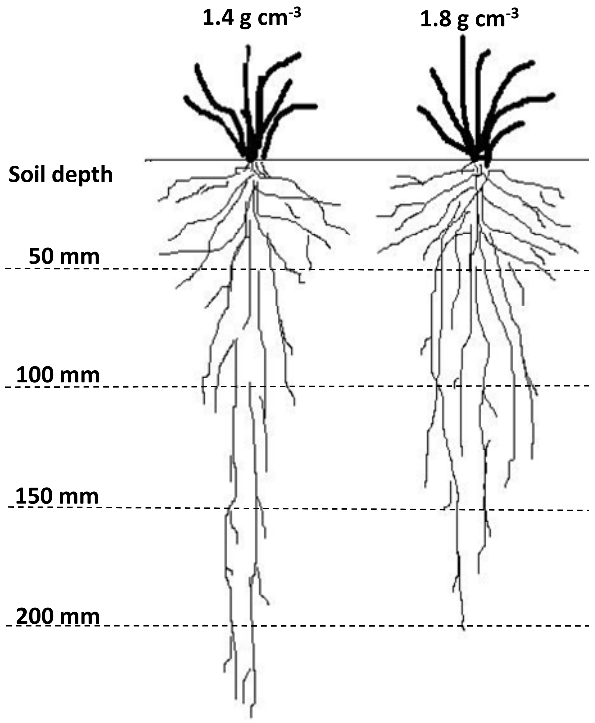

Figure 13 Effect of density on root distribution. The quantity of roots was the same at all densities but the depth of rooting reduced with increasing density. Over time this has a detrimental effect on root networks and tends to concentrate roots near the surface and slows the rate and evenness of drying through the profile.

1.8 How does your choice of loam affect rolling?

The maximum achievable density of a soil is a function of its clay content – generally as clay content increases the soil can be compacted to a greater density, but it is also important to look at the sand and silt contents – two clay loams with the same clay content but different silt content will compact differently, with the greater silt content allowing closer particle packing and a higher bulk density. From this discussion it would be tempting to think that greater clay contents (and

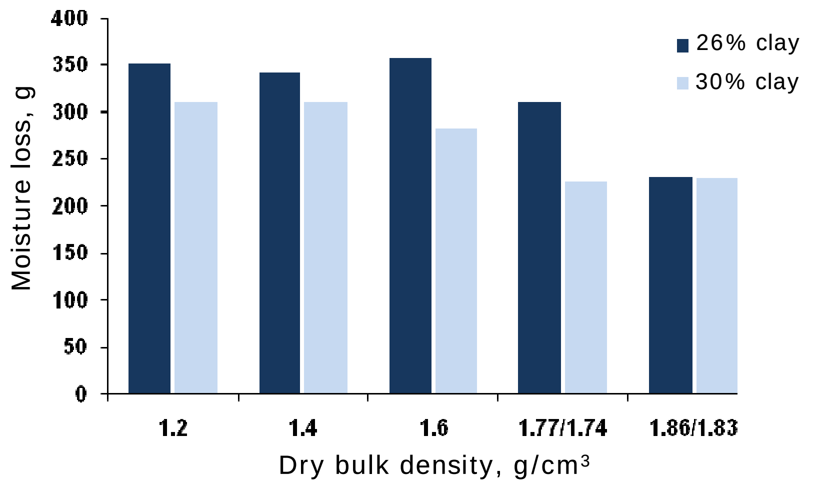

Figure 14 Moisture loss from saturation in a 14 day drying period for two cricket loam soils at densities of 1.2 to 1.8 g/cm^3

silt contents) would give better pitches – but then why are 50% clay content soils like the MCG (Melbourne Cricket Ground) or even 75% at the WACA (Perth) not used in the UK? The answer is that it would be difficult to get high clay content soils to dry enough to play on in this country with its climate. In Australia, summer temperatures regularly exceed 35-40°C so they can dry pitches of high clay content – in the UK it's simply too wet, too often. But even within the UK, it is important to select loams according to the resources available at a club. Figure 14 shows the difference in drying between two clay loam types with a significantly reduced moisture loss in the higher clay content soil.

It might be tempting to think that high clay content is always best – but **if you are a club that does not have covers** and is at the mercy of rainfall during pitch preparation then **a lower clay content soil will be an advantage because you will be able to roll sooner** – this issue will be dealt with further in the guidelines (Part 2) and is important in roller selection for your club (Part 3).

1.9 The effect of organic matter and thatch

Data from an ongoing ECB-IOG study is showing that one of the biggest problems in UK pitches is the build up of *thatch*. Thatch is the layer of fibrous organic material that builds up near the surface of the pitch. This thatch layer then behaves like a spring and damper – giving low and inconsistent ball bounce. The material is dead grass matter that takes a long time to decompose – this forms a mat near the surface. Generally topdressing and burying the thatch is not sufficient to prevent thatch accumulation – regular scarification is required to remove material, both in end-of-season renovation and raking out pitches during the season.

It might be tempting to think that by rolling more the thatch layer can be compacted and help ball bounce; unfortunately this is not the case. As explained above the thatch behaves like a spring – as it is rolled, it does compress, but it will just spring back after a short period. In pitches with high thatch contents, the problem cannot be solved by attempting to treat the symptoms by rolling more – the thatch content in pitches must be lowered and the cause treated. This can be done by deep scarification or even removing the top layer of the pitch and replacing with fresh loam – see *TS4* on the ECB website for details.

It is important not to confuse thatch with *organic matter* content– which occurs naturally in most cricket loams and builds up over time in pitch profiles. This occurs throughout the soil – so not in layers and helps provide some soil strength and nutrient retention – although this is not as important in a clay loam cricket pitch as it is in a sand-rootzone golf green. The very useful 'Pitch Properties and Performance'[1] booklet available from the ECB states that construction and topdressing materials should have no more than 8%, but more than 3% organic matter for construction and perhaps a bit lower for topdressing. Loam suppliers should be able to confirm the organic matter content of their loams, but it is likely that the organic matter content of a square will be higher due to natural organic matter accumulation such as thatch build up.

One of the best ways to get on top of your thatch and organic matter is to have a pitch investigation by your *County Pitch Advisor* – see the ECB website for details. The County Pitch Advisor will come along and take cores of your pitch so you can look at whether thatch is accumulating and they can send your soils off for a soil test for various things such as clay content and organic matter content.

In terms of rolling, organic matter is important too. A little bit is a good thing, as pointed out in 'Pitch Properties and Performance' and it helps moderate the compacting effects of the roller too. The same booklet also highlights the relationship between organic matter content and both moisture content and density – as organic matter goes up, moisture retention goes up and density decreases. The organic matter impacts on rolling because it limits the achievable density of any roller and decreases the rate at which pitches dry to the optimum moisture content for rolling. When organic layers occur in horizontal discontinuities (such as *root-breaks* or poorly keyed-in construction layers) this can prevent optimum compaction as is severely detrimental to pitch performance. **Knowing the organic matter content and thatch depth in the top 75 mm (3") is critical for rolling.**

[1] Adams WA, Baker SW, Carré MJ, Young RJ, James DM (2004) Pitch Properties and Performance. England and Wales Cricket Board, Lord's Ground, London NW8 8QZ.

2 GUIDELINES FOR ROLLING

2.1 Pre-season rolling

Guidelines

1. **Pre-season rolling is recommended for the majority of clubs.**

   Over-winter wetting reduces the bulk density of the square between cricket seasons (see Section 1.4). Following *autumn renovation* and during the winter period, many pitches / squares will have been subjected to some form of mechanical aeration or decompaction which can also reduce density.

   If groundsmen did no pre-season rolling at all, the soil would increase in density as it dries and shrinks but early rolling can help to reduce re-wetting of the soil from spring rainfall and encourage quicker natural recovery of soil density as the pitch will dry more quickly.

   Pre-season rolling is a good idea – it might be possible to get away without it, if there is: minimal post-season de-compaction (but not to the detriment of a healthy root system); a warm dry climate; and a good cover system – but that's not the case for most cricket clubs in the UK.

2. **Don't start until there have been at least two continuous good drying days – warm temperature (more than 10°C), a breeze and no rain.**

   There is an optimum moisture content for rolling. If the soil is too wet, compaction will not take place (see Part 1). Don't just get the roller out because it's February, don't start too early – it could be wasting time and fuel and causing horizontal soil movement

   Initial rolling can be undertaken after a minimum of 48 hours of dry weather but any increase in density will be minimal until soil drying increases later in the spring. This process does help with smoothing out surface levels on the pitch – removing any over-winter or autumn renovation irregularities.

   If there is a known high thatch or organic matter content then leave your pitch to dry for longer (minimum 3 good drying days) because moisture retention is increased.

3. **Start with light rollers but build up roller size and ballast as soon as soil conditions allow (i.e. without creating a bow wave or deep creasing between pitches).**

   The practice of starting rolling with very light rollers (mowers) early in the spring does little to increase pitch density other than in very low density pitches (below 1.25 g/cm^3) such as new constructions. Some sealing of the soil surface may occur, reducing rain infiltration into the profile and reducing moisture content a little, however any benefits will be limited and largely aesthetic.

   Whilst soil moisture remains high, the moisture/density combination within the soil rather than the roller weight is likely to be the limit to increasing density. A gradual increase in roller weight will result in the same final density as using the heaviest weight of roller throughout.

   Be cautious with roller weight to avoid surface damage from horizontal movement, **but the roller with the final desired compactive potential** (see Section 1.6.4) **should be used at the earliest opportunity to minimise the number of roller passes.**

4. **Limit rolling sessions to 4-5 passes of a 2-drum roller over each area then stop and allow a couple of drying days. Then build up roller weight and get out for another session of 4-5 passes. Finish with a session of 4-5 passes with the heaviest roller when the pitch has dried in-between.**

   Guidelines for spring roller passes have to be a broad recommendation as circumstances are different from club to club in terms of density and soil moisture. **No more than five roller passes would be beneficial at any one moisture content/roller weight combination.**

   After the initial rolling in spring, at least one further rolling session of 4/5 roller passes could be productive if soil moisture has reduced. Further rolling will only increase density if the roller used has not reached its compactive potential and the soil moisture content is close to optimum or if there has been rainfall for prolonged periods that has caused the pitch to swell.

5. **If possible, cover the pitches/square to help with drying but don't limit grass growth as healthy grass is a very effective pitch drying system.**

   Although spring rolling has an important effect on pitch density, the main benefit is from reducing the overall moisture holding capacity of the soil so that the pitch profile is ready for match preparation when the playing season begins. Playing seasons that start early, before vigorous grass growth, will need the use of covers to aid in the reduction of soil moisture, although the drying process will be slow due to low early season temperatures and high humidity under the covers.

6. **The practice of cross rolling in a 'Union-Jack pattern' over the square can help to ensure even compaction across the square.**

   Follow this method initially but be aware of variations in construction across the square which could cause different pitches to be at different moisture contents.

2.2 Match-pitch preparation

2.2.1 Guidelines

1. **The fundamental rolling principles remain the same as for pre-season rolling – wait for the right moisture content and limit passes.**

   Summer pitch preparation follows the same rolling principles as spring rolling but drying rates are quicker and therefore **timing is more crucial**. All the principles discussed above for general rolling guidelines and spring guidelines are important for pre-match summer rolling.

2. **Match rolling practice to your pitch performance aspirations but also your roller and whether or not you have covers**

   When preparing match pitches, be realistic about the quality of your pitches. Understanding the limitations of both your match preparation equipment and the quality of your pitches is essential. There is no point in trying to achieve a 'First Class' standard pitch in Table 3 unless you have higher clay content soils, with small amounts of thatch, the right roller and covers with a full time staff to take them off and put them back on again. This will just result in rolling at the wrong moisture content with the wrong roller.

Table 3 Target rolling and match day density and moisture conditions by performance level

	Rolling conditions			**Match day conditions**		
	Rolling density	Mass/width factor	Moisture content	Density	Minimum moisture	Ball rebound
Performance level	g/cm^3	kg/m	% w/w	g/cm^3	% w/w	%
First class	1.60	920	22	1.65-1.70	18-16	20-25
Club (premier league)	1.55	750	24	1.60	19	15-20
Club (mid leagues)	1.50	640	26	1.58	20	10-15
Club (lower leagues)	1.45	500	27	1.52	21	10

Be realistic about what can be achieved with the resources available. Pay particular attention to the limitation of your roller – what is the maximum ballasted mass/width factor? If it is not 750 kg/m but 640 kg/m then there is no point in targeting a Premier League club standard – you'll be at the wrong moisture content and your roller's potential will not be achieved.

Minimum moisture for match day conditions is based on the likely incidence of cracking and is therefore a guideline which should be monitored by groundstaff. Further drying is likely to increase ball rebound but reduce consistency as cracking increases.

3. **To achieve optimum moisture contents for rolling during the summer it will probably be necessary to irrigate the pitch. Table 4 shows approximately how the pitch will dry (although this varies with weather patterns). Don't roll when in the blue zone (See Table 4). Also if you there is a known high organic matter content or thatch, then during preparation time you might need to add a day or two to account for the extra moisture retention.**

Initial density will vary according to facility and if any spring rolling or previous match preparation has taken place; rolling a previously used pitch later in the season will still follow the same principles.

Moisture content may be below optimum for rolling and will therefore need to be increased through irrigation. If moisture content is not increased the maximum compactive potential of the roller will not be achieved (regardless of the number of roller passes) because the pitch is too dry.

Rolling at the optimum moisture content is crucial for optimising roller compactive potential. If an accurate soil moisture meter[2] is available then it will be possible determine actual soil moisture content but if this is not possible, Table 4 provides a guide for typical moisture contents for days after saturation of the pitch profile. Note these are only a guide – they are based on mid summer temperatures (mean 24 hour temp 16ºC) and could vary considerably with climatic conditions. Add an extra day (or even two) for drying if you there is high organic matter or thatch in your profile.

The table indicates the low clay content soil is at optimum moisture after 48 hours of drying for most density levels whereas the high clay soil can take longer to reach the optimum moisture (5-6 days).

[2] Electronic soil moisture meters are commercially available from specialist suppliers but costs are in the range of £800.

This table also provides a guideline number of days for drying to a required moisture content for match day. For example a medium level club performance requirement of 20% match day moisture content (Table 3) will occur at approximately four days after saturation on low clay soils and eight days for a higher clay content soil.

Table 4 Approximate moisture content for 0-50 mm depth for days after pitch saturation in low and high clay content soils resulting from good mid-summer drying conditions.

Low clay content (25-27%)

Days after saturation	Density			
	1.4 g/cm^3	1.6 g/cm^3	1.7 g/cm^3	1.8 g/cm^3
1	32	25	21	19
2	28	23	21	19
3	23	21	20	19
4	22	20	19	18
5	21	19	18	16
6	20	18	17	15
7	18	17	16	14
8	17	16	15	13
9	16	16	14	11
10	16	15	13	10
11	15	15	12	9
12	15	15	11	8
13	15	15	9	8
14	14	15	8	7
15	14	14	7	6

High clay content (> 28%)

Days after saturation	Density			
	1.4 g/cm^3	1.6 g/cm^3	1.7 g/cm^3	1.8 g/cm^3
1	33	26	22	20
2	32	25	20	19
3	31	25	18	18
4	29	24	18	18
5	27	23	17	17
6	26	22	17	17
7	24	21	16	16
8	23	20	16	16
9	21	19	15	15
10	20	18	14	14
11	19	17	13	13
12	18	16	12	12
13	17	16	11	10
14	16	15	10	9
15	15	14	9	8

4. A total of 10 passes (with a two drum roller) should do it.

Summer pre-match rolling requires a maximum of 10 roller passes (two drum roller) to achieve the roller compactive potential. With low clay soil this should be done in the period 36 to 56 hours after saturation in one or two sessions and with the maximum roller weight for at least six of these passes. After this time the full compactive potential of the roller will not be achieved.

For the high clay soil, the drying to optimum moisture content time is more likely to be influenced by the ambient weather conditions. However the following regime with a two drum roller is suggested:

- An initial rolling of two passes within 48 to 72 hours, preferably with the maximum roller weight but make sure that it is not too wet as there is a risk of horizontal soil movement (this depends on the initial pitch density).
- A further four roller passes per day for the next two days should be sufficient to achieve maximum potential.
- A total of 10 roller passes with at least the last six roller passes with the maximum roller weight.
- The timings of these will change according to the weather conditions however it is important not to leave rolling until the soil has dried below the optimum.

Further rolling beyond the recommended 10 roller passes is unlikely to increase pitch density and for reasons discussed previously should be only undertaken for other playability reasons. For this purpose it would be prudent to consider using a lighter roller to prevent excessive horizontal soil stress.

3 GUIDELINES FOR CHOOSING THE RIGHT ROLLER FOR YOUR CLUB

There are many things to consider when choosing a roller for your club but it is usually cost that is the over-riding concern, whether it is an outright purchase by the club or part of an ECB funded scheme. But it's not simply a case of buying the biggest roller you can afford. The discussions above have shown that by matching roller specification to the club's pitches and other resources, it is possible to buy an effective roller and save money or to improve pitch preparation by purchasing the right kit.

What is essential is that roller selection is based on:

1. **Soil type.**
2. **Whether or not covers are available.**
3. **The thatch management strategy.**

The first two factors, soils and covers relate to optimum moisture content. If there are high clay content soils and/or high organic matter and no covers then there is little point in getting a top of the range heavy 2.2t roller (and certainly not a 3t road roller) – it will be a struggle to get pitches dry enough for the roller to achieve its compaction potential. Consider purchasing a set of roll-on covers or if cover deployment is not possible for reasons of security etc then you might consider getting a 1-1.5 tonne roller which will have a compactive potential matched to the soil moisture conditions. This would save money. If there are different loams in the square then select a roller for the higher clay content loams – providing there are the covers to manage them.

As for the third factor then it is all about how successful thatch management is. If there is a thatch accumulation in the pitches and the specialist equipment for effective thatch reduction/control is not available then consider purchasing this as a priority – again **it is pointless purchasing a heavy roller without good thatch control.** An alternative would be to consider hiring a 1-1.5 tonne roller and investing the difference on thatch control equipment or removal/replacement of thatch surfaces. It is always possible to trade up to a heavier roller when thatch is under control. But while there is thatch, thatch will be the limiting performance factor, not the roller.

A question often asked by clubs is 'Do we have to acquire a cricket-specific roller?' The answer is no, providing that the roller meets certain criteria:

1. The roller should be balanced both left and right and ideally fore and aft. This is to ensure that pitches are compacted evenly.
2. The rollers should have a **minimum** diameter of 0.5 m (1.6 ft), but ideally 0.6 m (2 ft) or more. This is to reduce horizontal forces when rolling. Larger diameter rollers reduce these forces further but it is essential to consider height restrictions in storage sheds etc.
3. Select weight according to pitch soils, covers and thatch control as described above – but generally the heavier the better up to about 2.5 tonnes, then it becomes a case of diminishing returns. The minimum is 1 tonne un-ballasted, with the option to ballast to 1.5 tonnes.
4. Modern cricket-specific rollers tend to have curved edges on the roller to prevent mid-pitch creasing problems. They also tend to have hydrostatic transmissions which make operation and direction changing easier for the operator.

When resources are tight, buying on price is important but don't compromise on weight or diameter. Equally don't go for a large road roller that will not give you the flexibility to build up load through your pre-season rolling. Remember a roller is not a cure-all solution for problem pitches – make sure that you moisture content can be controlled, that thatch contents are being reduced and that your soils can be rolled to the rolling potential of your roller. **The roller doesn't get groundstaff all the way to hard pitches – they must be able to allow the pitch to dry.**

4 SUMMARY (AND WHY CHANGING YOUR ROLLING PRACTICE IS A GOOD IDEA)

The Guidelines for Rolling in Cricket we have developed are based on detailed, independent research. Part 1 covered many of the key scientific principles behind the guidelines including:

- **Understanding how soils compact**
- **The importance of moisture and air contents**
- **Soil shrink and swell behaviour and the importance of allowing pitches to dry**
- **Understanding what rollers do and don't do**
- **Limits of rollers: roller compaction potential**
- **The effects of grass, organic matter and thatch**

Rolling needs to be seen as part of good pitch preparation, rather than the single source of great pitches. Many clubs will benefit from thatch reduction – which will have much more of an effect on playing quality than doing 200 passes with the roller. **Follow the guidelines and you will then be able to achieve targeted, effective rolling without spending a lifetime on the roller.**

Give the guidelines a try, note that they will need adapting to individual, local situations (soils, organic matter, thatch, covers etc.). To provide further motivation, consider this. If the mean number of passes reported by groundstaff in our survey was reduced to the optimum recommended here, then there is the opportunity for the sport of Cricket in the UK to save 766,000 hours of rolling, 393 tonnes of CO_2 from reduced fuel use (equivalent to the carbon footprint of 42 households) and a total of £459,000 (which is typically £50-150 per club – depending on fuel prices).

Glossary

Aeration	The process of increasing the air content in a soil and connecting pore space to the atmosphere through the surface of the pitch. This allows air to get into pores and improve soil health. It is normally done as part of *autumn renovations* using mechanical equipment such as slitting knives and solid tines. It does tend to have a decompactive effect (see *decompaction*).
Autumn renovation	A group of procedures undertaken at the end of the playing season and in the off-season to repair pitches, restore grass cover and surface condition and improve conditions for grass growth.
Ballast	The addition of weight to the roller. This can be done by adding water to hollow roller cylinders on a typical cricket roller for example.
CO_2 emissions	The carbon dioxide released by burning fossil fuels such as diesel and petrol. This gas is known to contribute to global warming.
Compaction	The permanent compression of soil at speeds that are too quick for the soil to drain as it is loaded (a dynamic process).
Compaction potential	The maximum density achievable for a roller of a given *mass/width factor*.
Consistency	Pitch consistency is the extent to which the ball behaves the same – either across the pitch or time after time.
Consolidation	The permanent deformation of soil at speeds that are slow enough to allow drainage (a static process)
County Pitch Advisor	The ECB Pitch Advisory Scheme is funded by Sport England and the ECB. 45 County Pitch Advisors across England and Wales provide advice on pitch preparation and maintenance. Contact your local County Cricket Board for detail or see www.ecb.co.uk/development/facilities-funding/groundsmanship for more details.
Crease marks	These occur between pitches or on pitches when the roller deforms pitch height by a large amount – usually early in the season, when pitches are wet or in new constructions. They should be avoided.
Decompaction	The reverse of *compaction* – decreasing bulk density by lifting the soil.
Drum	A single 'wheel' or roller of a *tandem roller*.
Dry bulk density	The dry mass of a soil in a fixed volume. Usually measure in g/cm^3. Typical pitch densities are 1.5 to 1.8 g/cm^3 but rollers can't increase density much above 1.6 g/cm^3.
ECB	England and Wales Cricket Board – the National Governing Body for Cricket in England and Wales www.ecb.co.uk
Elasticity	The recovery of shape when a load is removed – push your finger into a pencil eraser and when you remove your finger, it will recover its shape. This property of a pitch is important in ball bounce.
EPSRC	The Engineering and Physical Sciences Research Council – a UK government funded research council. www.epsrc.ac.uk
Evapotranspiration	A combination of evaporation and *transpiration* of water from a soil.

Field capacity	When a soil has been at saturation and drained for approximately two days. The natural moisture content of a pitch during the winter when *evapotranspiration* is ineffective due to low temperatures
Hardness	Either: 1. How difficult it is to push something into a soil or pitch 2. A function of ball rebound
Mass/width factor (of a roller)	The ratio of the mass of the roller to the combined width of its *drums*.
Match pitch	A *pitch* prepared for playing a specific game.
Optimum moisture content for rolling	The moisture content of maximum achievable density (defined by the *compaction potential* of a roller) on a *proctor curve* for a particular soil.
Organic matter	Material of organic origin in a soil. Most soils contain organic matter (dead plant matter, organisms etc). Too much organic matter can affect pitch performance.
Pass	The movement of a tandem roller over the target area of a pitch in one direction.
Pitch	A strip (typically 3.05 m or 10 ft wide) allocated for play and preparation at some point during the season.
Proctor compaction curves	The output of a standard compaction test for soils that drops a hammer of 2.5 kg 27 times from 300 mm onto soils of different moisture contents.
Roller drum	See *drum*
Roller mass	The weight of the roller, including *ballast* but excluding the operator.
Rolling potential	See *compaction potential*
Root break	A phenomenon seen in many cricket pitches at 35-50 mm depth. A horizontal plane in the pitch has dislocated the top layer from those below – if left untreated, roots grow horizontally creating a spring effect and ruining ball rebound. Root breaks can be revealed when cores are removed from the pitch.
Saturation	When all the pores in the soil are filled with water. The soil can not be compacted in this state.
Tandem roller	A roller comprising two *drums* typically one of them is driven at the rear, and the front steers and rolls.
Thatch	The accumulated fibrous *organic matter* from grass growth that forms a sponge layer at the surface of a pitch. Often dark in colour and made up from poorly decomposed grass leaf, crowns and roots. Undesirable in cricket pitches – see *TS4* for details on prevention and control.
Transpiration	The removal of water from a soil to the atmosphere through a grass plant, by the grass plant.
TS4	ECB Technical Specification 4: Recommended guidelines – cricket pitches and outfields at all levels of the game. See ECB website for details