The Aeration of Cricket Pitches

Draft for Consultation
Commercial in confidence

Iain James and Simon Parsons
Centre for Sports Surface Technology
Cranfield University

22 June 2012

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Health and Safety

Aeration equipment is hazardous and can cause serious injury or death. Service and maintain equipment regularly. Only trained personnel should use them. 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 x documents:

We recommend that you obtain these documents from the IOG and incorporate them into your club grounds management 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.

Contents

1 Introduction

1.1 Background

These guidelines help volunteer and professional grounds managers to use soil aeration technology to improve the performance of cricket pitches and outfields. They are based on the findings of a four-year research project at Cranfield University, sponsored by the Institute of Groundsmanship (IOG) and the England and Wales Cricket Board (ECB).

Natural turf sports surfaces are routinely aerated in many sports to help relieve compaction and to promote healthy grass growth, but cricket pitches are different because they are commonly made of clay soils that exhibit shrink-and-swell behaviour and are deliberately compacted. The challenge for the grounds manger is how to provide a hard pitch with good pace and bounce that holds together under wear from bowlers and batsmen, whilst still maintaining good grass cover that aids seam and spin, and helps to dry the surface out so it shrinks and becomes even harder.

A roller is used to compact the pitch to improve ball bounce and pace. As the pitch becomes more compact it becomes harder, absorbing less energy when the ball impacts the surface – meaning faster pace and bounce. But if this was the only requirement of pitches, the game could be played on tarmac. For a proper balance between ball and bat the natural variation of soil and grass over time (and space) is needed. Good grass growth is an essential component of pitch production in UK conditions.

1.2 Why is aeration necessary?

The grass plant plays an important role in a cricket pitch. The above ground parts (leaves, crowns and stolons) affect ball seam and spin. Below the surface, the roots help to bind the pitch together, helping it resist cracking and wear. The Cranfield-ECB Rolling guidelines show that plants have a role in drying pitches at depth, which helps the soil to shrink and the pitch to become harder. To thrive and to regenerate from the wear caused during play, the grass plant needs to obtain water, oxygen and nutrients from the soil through its root system. Although above the surface plants are producing sugar through photosynthesis, taking in carbon dioxide (CO_2) and giving out oxygen (O_2), below the ground the plant roots respire (just like humans), taking in O_2 and giving out CO_2. For healthy grass growth it is essential to provide enough oxygen in the soil whilst not poisoning the plant with carbon dioxide. Soil is porous, with small interconnected pores between clay aggregates and other soil particles such as sand, silt and organic matter. The packing of the soil particles and aggregates can be measured by the dry bulk density of a soil (the mass of soil in a fixed volume). As the density increases, the percentage of pores decreases as more soil particles are packed in. Dry bulk density in cricket pitches can range between 1.4 g/cm^3 (club pitch, small roller) and 1.8 g/cm^3 (1st class pitch, heavy roller). The total porosity (the volume of pores in a fixed volume of soil) will range from 47% at a density of 1.4 g/cm^3 to 32% at a density of 1.8 g/cm^3. Grass typically requires a minimum of 10% air-filled porosity, which doesn't leave a lot of room for water. In reality in compacted cricket soils air filled porosity is much lower than 10% and when the pitches are very wet can be close to 0%. It is not just the total volume of pores that changes, as the soil is compacted pores become smaller and less well connected. This is illustrated in Figure 1 which shows how increasing density reduces the size and connectivity of pores. This slows down the rates of transport of soil gasses and water. Smaller pores are more likely to be filled with water and will quickly be exhausted of oxygen and filled with carbon dioxide. For the plant root this is a bit like moving a human from a large corridor connected to different rooms and the outside into a small broom cupboard with the door shut. The plant will respond with shallow rooting (being nearer the surface air supply) and poor growth.

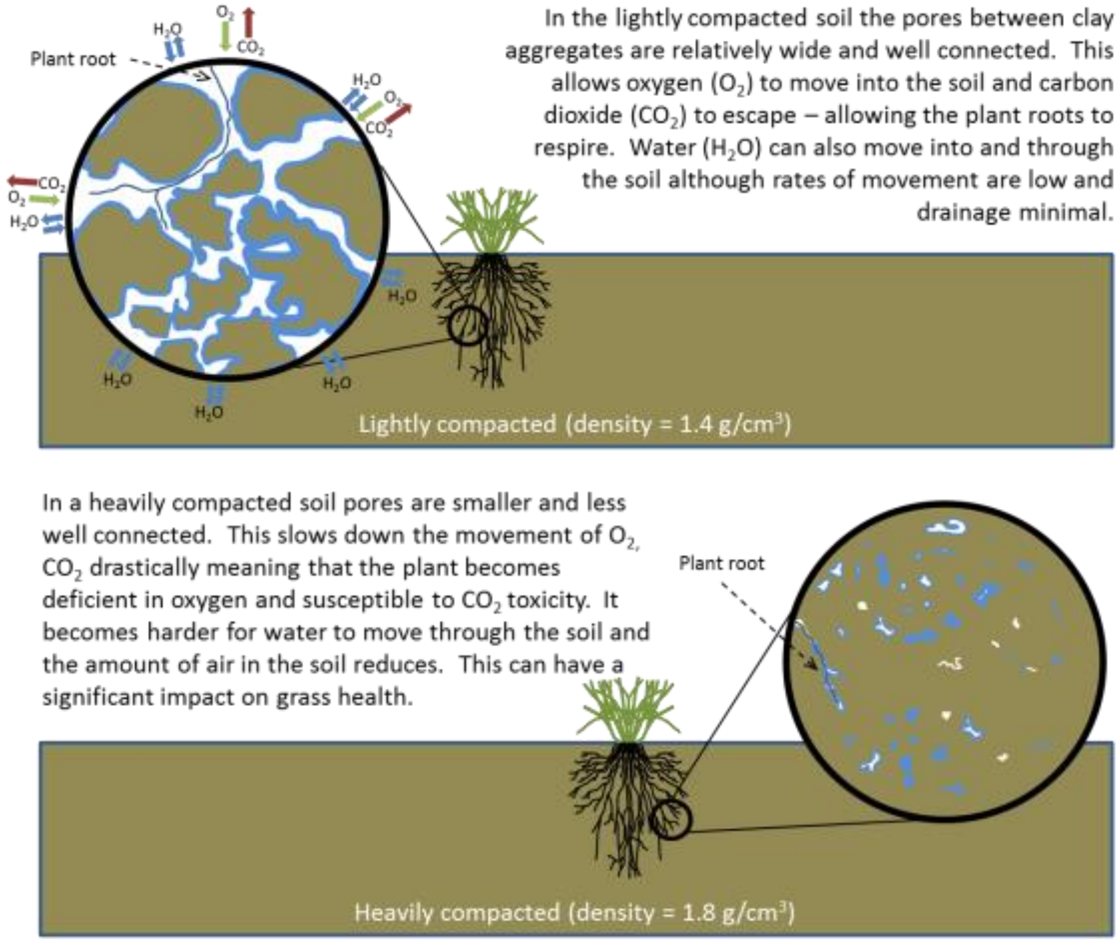

Figure 1 Illustration of the effect of compaction by rolling on pore size and pore connectivity in a clay soil. As density is increase dby compaction the size and connectivity of pores reduces meaning that there is less oxygen available to the plant and the risk of carbon dioxide toxicity increases.

A lack of oxygen also affects other respiring organisms such as soil microbes and other soil life. This can mean that the rate of organic matter breakdown is slow and thatch begins to accumulate. Thatch and organic matter can make the pitch slower by absorbing ball energy on impact.

Compaction increases the strength of the soil which is good for ball bounce and wear resistance but makes it more difficult for roots to grow through a soil, and reduced pore connectivity limiting the opportunity for roots to exploit pre-existing channels in the soil.
The aim of aeration is to improve grass growth and reduce thatch accumulation by loosening the soil to increase total porosity and the connectivity of pores in the soil. A range of machinery is used to manufacture artificial porosity that is intended to move air and water freely and to breakdown the mechanical resistance to rooting in high-strength compacted clay soils.

This definition is important. In our research we surveyed cricket grounds staff and asked 'what is the purpose of aeration in cricket?' We got a range of replies including 'decompaction' (soil loosening), 'exchange of soil gasses', 'improving infiltration' (moving water into the surface) and 'breakdown and removal of thatch'. After four years of research we can now report that in cricket pitches:

1. Aeration might slow the rate of thatch accumulation but it is not thatch removal – removing thatch requires different machinery and techniques (to be discussed further below).

2. Some aeration techniques achieve these objectives of gas and water movement and decompaction, some of the time.

The purpose of these guidelines is to advise the grounds manager on when to aerate, with which tool and how to maximise the benefit of the aeration operation.

1.3 Why might aeration be unnecessary?

In our experiments we often found that despite being subject to frequent rolling our control plots (the plots not receiving any aeration treatment) performed just as well as any of the aeration treatments. This does not mean that aeration is not worth doing – the case for aeration will be made later but it does highlight a big difference between the aeration of golf greens and the aeration of cricket pitches: most cricket soils shrink and swell (hence they crack), whereas the sands used in golf greens do not. In sandy soils compaction is a one-way process, the soils get more and more compact until they are mechanically loosened. In the clay loam soils used in cricket in England and Wales, the clay minerals shrink and swell as they dry and wet meaning that these internal soil forces can help to structure the soil and create a connected pore network. This can reduce the need for aeration but can cause other problems related to cracking and root breaks. The development of structure can be seen in Figure 2 which shows how a cricket loam with 30-32% clay shrinks as it dries out – forming cracks.

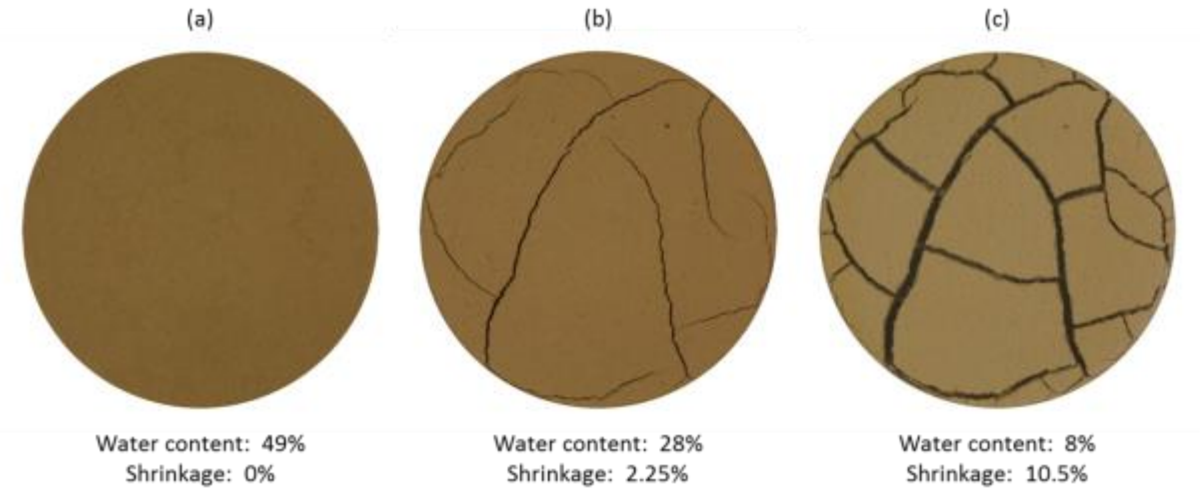

Figure 2 Shrinkage of a cricket loam as it dries. These images are from a method developed at Cranfield University to measure shrinkage rates in cricket soils. All water contents are on a mass basis, shrinkage is on an area basis.

2 Recommended approach

Our research has shown that routine aeration of cricket pitches could be a waste of resources (money, time and diesel) and therefore we recommend a problem solving based approach. We recommend a four stage approach:

1. Find out what the problem is
2. Select an appropriate solution for dealing with the problem
3. Apply the solution
4. Review whether your solution has worked

The rest of this guide is set out along that four stage process and starts with 'Identifying Pitch Problems'.

3 Identifying pitch problems

There are three ways to identify that there is a problem with a pitch:

1. **The way the pitch plays** – this is the most common starting point, asking questions such as how does the pitch play, is it batsman friendly, is it too batsman friendly, is it slow and low, is there good carry?

When it comes to pitch problems, looking at the way the pitch plays describes the symptoms but does not reveal the cause. When players and umpires look to the cause of pitch problems they use the second option:

2. **The way the pitch looks on the surface** – this queries visual features such as grass cover, grass colour, cracking, surface levels, weeds, foot marks, how hard it feels, how wet it feels, ball rebound and other features.

These properties of a pitch undoubtedly affect the ball and how it behaves. Generally a green, lush pitch will seam, whereas a dry, dusty pitch with low grass cover might offer some turn. It can be hard to predict how a pitch will bounce using these visual indicators but dropping a ball and looking at how high it rebounds is one method.

The grounds manager has one more investigation tool that is not available to players and umpires and that is:

3. **The way the pitch looks beneath the surface** – this is analysed by taking a core out of a pitch and looking at how the soil is structured and the grass plant is growing.

The cause for most pitch performance problems lies below the surface and yet in cricket there is too much time spent looking at the surface and not enough time looking below the surface. There is often a hesitancy to make holes in a cricket pitch for fear of it affecting play but as long as the core is taken with an appropriate device in an appropriate area of the pitch (from an area not critical for ball bounce – avoid taking a core on a good length), and the core is replaced or the hole filled, then there will be no effect on ball bounce.

Getting a good sample from a heavily compacted cricket pitch can be a challenge. A good device for taking a core is the 2" (50 mm) diameter split corer supplied by BMS products. Each half of the corer is driven into the surface to a depth of 250 mm using a rubber mallet. The corer is then removed and one half of the corer pulled up to reveal the profile. This is the method used by County Pitch Advisors who are able to offer a core sampling and analysis service – contact your County Cricket Board for details.

Figure 3 Taking a core from a cricket pitch using a split corer. The mallet is used to drive each side of the corer into the pitch in alternate parts. Picture courtesy of Chris Wood © ECB 2012.

Aeration is a sub-surface process – it involves putting implements into the ground. It is not possible to use aeration effectively without exploring what is beneath our pitches. The reason for this is that different aeration tools are required for different pitch problems – there is no single 'Wonder Aerator' – different machines do different jobs and it is important to match the machine to the job correctly. Good aeration begins with identifying the problem and then matching the tool for the job. Sub-surface problems have to be identified using cores taken from the pitch – they provide invaluable information on thatch depth, root depth, density down the profile, layering of incompatible loams and any breaks and discontinuities.

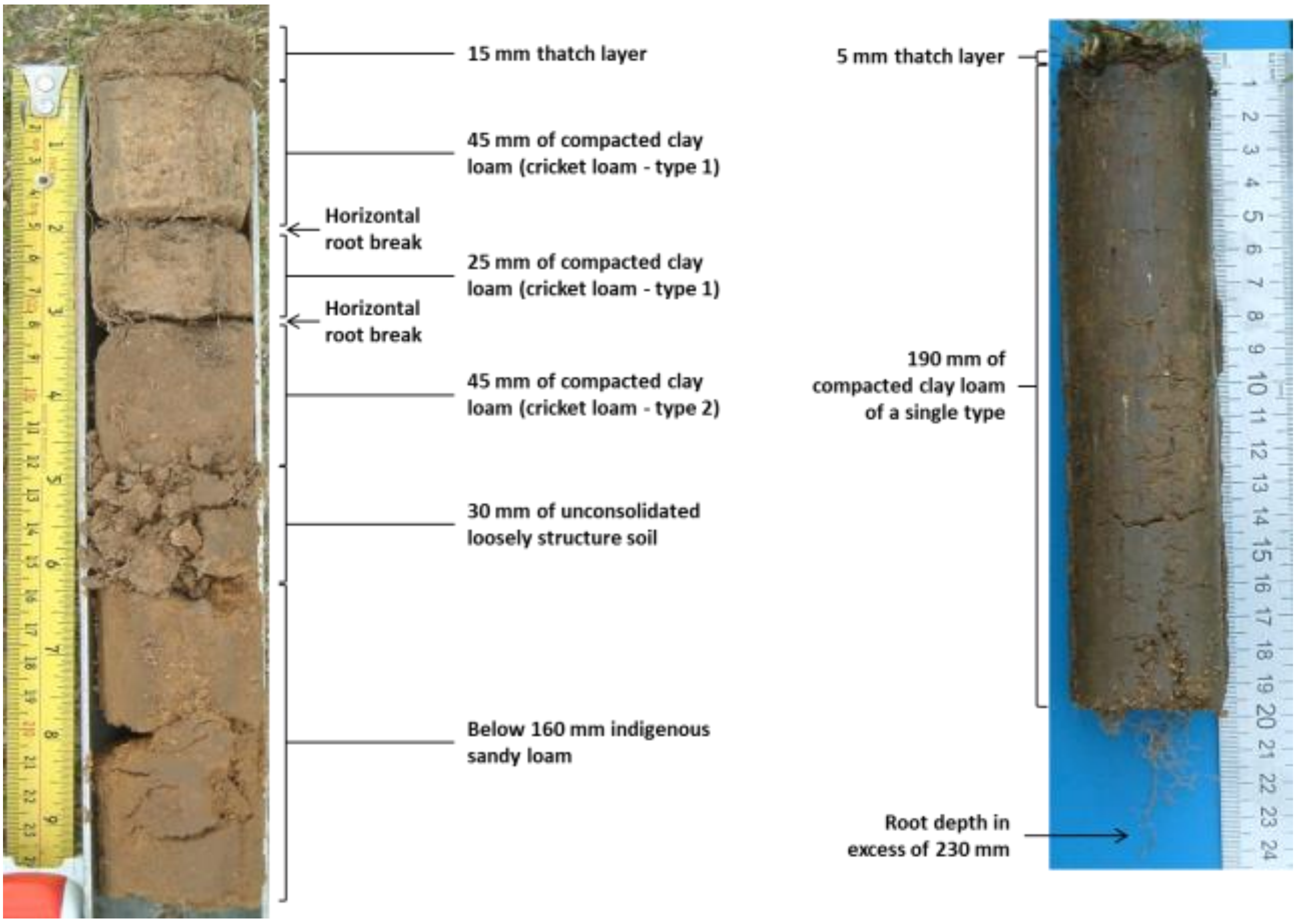

Figure 4 Left: a core taken from a poorly performing pitch showing a thatch layer and two root breaks the first one within the same loam and the second one between two layers of different loam. Further down the profile there is a loosely structured layer of loam interfacing with the indigenous soil (sandy loam). Photo courtesy of Chris Wood © ECB 2012. Right: a core taken from a trial pitch at Cranfield University three years after construction. There is a small thatch layer forming already but at less than 5 mm does not affect ball bounce. The core comprises 190-200 mm of uniformly structured clay loam of a single type. The pitch was constructed in approximately 50 mm layers possibly corresponding to the horizontal cracks at 55, 100 and 140 mm, however these do not affect root growth which exceeds the length of the core.

3.1 Shallow rooting and compaction

Healthy grass plants with deep roots are less susceptible to drought, are able to access more nutrient resources within the soil and can help dry the soil to a greater depth. Shallow rooting in cricket pitches occurs for two reasons:

1. As the grass is cut shorter the plant responds by reducing rooting depth.
2. As the soil is compacted it becomes harder for the roots to grow through the soil.

The first cause cannot be solved by aeration, it is just a case of allowing grasses to be longer when pitches are not in preparation for play and even longer over winter to encourage deeper rooting. The second cause is related to rolling and compaction. Figure 5 shows the results of an experiment that looked at grass growth in a cricket loam packed at 1.20, 1.55 and 1.90 g/cm^3. These densities represent a pitch that hasn't been rolled, a typical club pitch situation and a first class pitch density respectively.

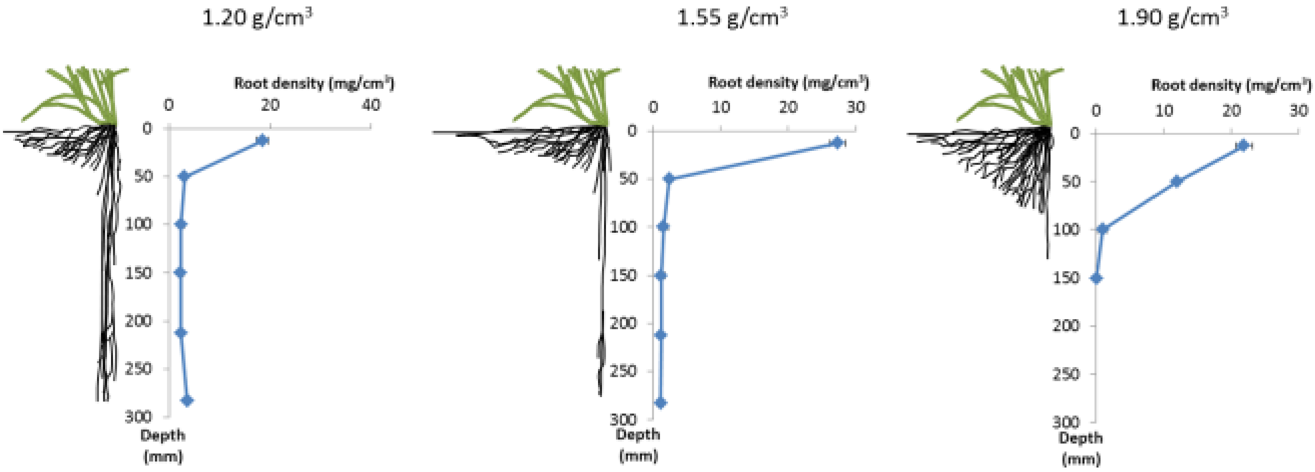

Figure 5 The effect of soil dry bulk density (1.20 - relatively loose, poorly compacted cricket pitch; 1.55 - a well prepared club pitch; & 1.90 g/cm^3 - extremely dense, 1st class cricket pitch) on grass root density. Increasing soil dry bulk has a minor effect on the total root density over the whole profile but has a large effect on the distribution of roots. Increasing soil density through compaction results in more shallow roots, particularly at 1.90 g/cm^3. This results in a grass plant that is extracting water and nutrients from a smaller volume, making it susceptible to nutrient and drought stress.

The total mass of roots in the soil is actually similar it is the depth of rooting that decreases with density. Grass roots will grow and establish in a high density (1.90 g/cm^3) soil, it is just that they are all in the top 75 mm of the profile. Near-surface roots dominate at lower densities but the quantity of roots at depth increases as the soil bulk density decreases. In high density soils the plant cannot physically break through to lower depths so it increases near-surface rooting to compensate.

This has an interesting effect on density. Figure 6 shows how at 1.20 g/cm^3 the original packing density is not affected. At 1.55 g/cm^3 original density there is some reduction of density near surface but at 1.9 g/cm^3 there is a significant reduction in density near the surface where the roots can exploit any soil porosity and reduce soil density. Immediately this creates a 50 mm layer of lower density soil over a higher density base (>100 mm).

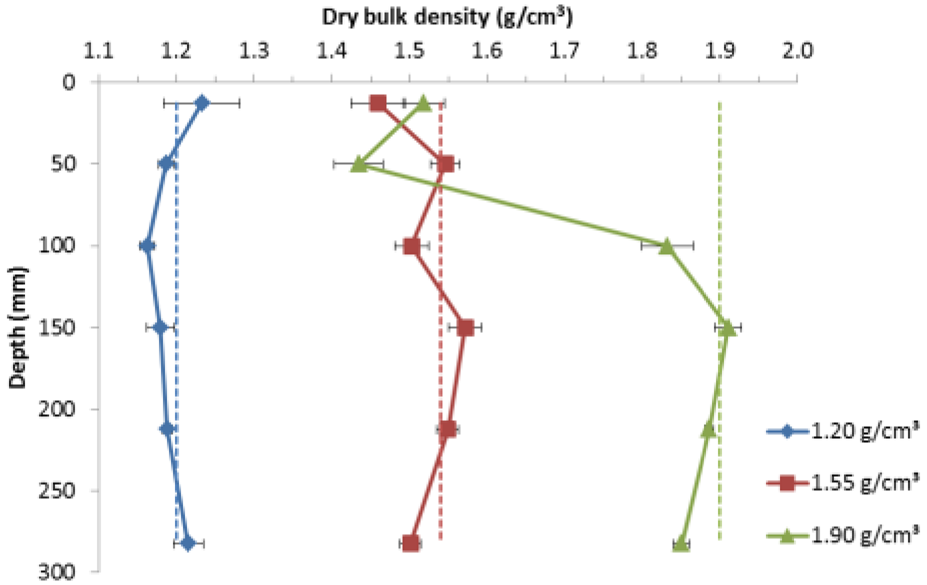

Figure 6 The effect of grass root growth on soil dry bulk density. The dashed lines represent the initial dry bulk density condition with profiles packed at 1.20, 1.55 and 1.90 g/cm^3. After seven months of plant growth (October 2010 to June 2011), the soil density is not changed significantly at 1.20 g/cm^3 (relatively loose, poorly compacted cricket pitch) where roots are able to grow freely (see Figure 5). At 1.55 g/cm^3 (a well prepared club pitch) a small, near-surface reduction in soil density takes place. At 1.90 g/cm^3 (extremely dense, 1st class cricket pitch) the shallow rooting observed in Figure 5 reduces soil dry bulk density significantly. This is because the roots loosen and replace the soil.

Shallow rooting is easily identified in a core. If you look at the bottom of the core and can see live roots (live roots are usually light in colour and are flexible), then you have roots to that depth. Start to break the core up from the base and you will see where the root network extends to. Good quality pitches will have a root depth in excess of 125 mm. If your roots are limited to the top 50 mm then aeration could be helpful in increasing rooting depth – this is discussed further in the Aerating Cricket Pitches section.

Shallow rooting is related to two further problems – root breaks and thatch.

3.2 Thatch

Thatch is the accumulation of slowly decomposing grass organic matter near the surface of the pitch. A small amount of thatch can be beneficial on outfields because it helps cushion players but on a pitch it makes ball bounce low and slow because it is highly compressible – meaning that more ball energy is absorbed on impact, reducing the bounce.

When the pitch is cut, the majority of organic matter is removed as clippings but more woody parts of the plant including stolons, crowns and roots and any leaf matter buried in topdressing will be incorporated into the surface and break down. The rate of breakdown is slow because microbial activity is low due to the lack of oxygen and the chemical suppression of earthworms. Active soil microbial biomass in the cricket pitches in our research was only 100-300 μg/g of soil. This is less than the 300-400 μg/g measured in golf greens and 700 μg/g

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measured in golf fairways[a] due to the high density compacted nature of cricket pitches. Outfields are expected to be similar to golf fairways in their microbial activity but the low biomass in cricket pitches means that there are less microbes to feed on the plant organic matter meaning that it accumulates faster than it breaks down, leading to the build-up of thatch.

Thatch build-up limits pitch performance. Work by Martin Ford for the ECB and IOG investigating the performance quality standards of premier league cricket clubs has shown that thatch control is limiting performance in the majority of pitches.

The removal of thatch requires specific treatments that are discussed in 'Aerating Cricket Pitches' below.

3.3 Root breaks

Root breaks are a complex feature of cricket pitch profiles and are evident in the left hand profile in Figure 4. Root breaks can occur at any depth within the profile but the nearer the surface they are, the more likely they are to affect ball bounce. As the layer forms, grass root growth exploits the large void created and tends to grow horizontally (Figure 7). This creates a shock absorbing layer that reduces the ball energy on impact and slows the pace and bounce of the pitch. It also will vary across the pitch, making it more variable.

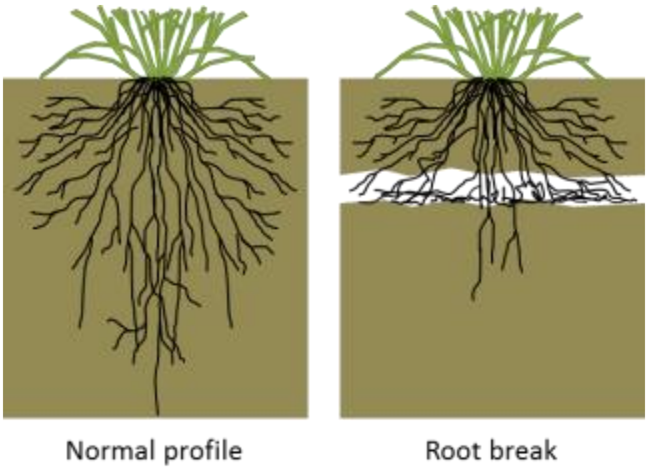

Figure 7 The effect of root breaks in cricket pitch profiles on grass growth. The root break provides a low resistance path for grass roots to grow when compared to the compacted soil below.

[a] Bartlett MD, James IT, Harris JA, Ritz, K (2008). Size and phenotypic structure of microbial communities within soil profiles in relation to different playing areas on a UK golf course. European Journal of Soil Science, 59:835-227.

Root breaks are caused by a combination of factors including:

1. **The construction of pitches in layers**
   Typically pitches are constructed in compacted layers of 50 mm. If the next layer is not keyed into the previous layer by raking or scarifying the surface of the lower layer then breaks at 50 mm will be manufactured into the profile. Even when constructed in 50 mm layers the top of the 50 mm layer will be more compacted than the soil below so careful construction is essential.

2. **Topdressing with incompatible soil loams**
   It is essential that any topdressing or reconstruction work uses the same loam as soils lower in the profile, otherwise they could shrink and swell at different rates which could lead to a fissure developing between soil layers.

3. **Natural shrink-swell behaviour**
   The clay loam soils used for cricket pitches shrink and swell and they do this more nearer the surface because there is less overburden from other soil above confining the shrink and swell. Without careful rolling to maintain near surface compaction, significant differences in density can occur.

4. **Rolling when the soil is too wet**
   The Cranfield University research on rolling (www.cranfield.ac.uk/sas/sst/rolling) showed that roller can move the soil backwards and forwards as well as downwards during rolling. This horizontal stress on the soil can cause soil in the top 50 mm to move relative to the soil below when the soil is too wet. This is particularly a problem with heavy, small-diameter rollers (diameters < 500 mm). Rolling in the right conditions is essential to prevent this damage.

5. **Root growth impedance in high density soils**
   The effect of compaction on root growth is shown in Figure 5 and Figure 6 which show how high density soil causes shallow rooting and a near-surface reduction in density. The grass itself creates a layer as it loosens the soil.

6. **Shallow aeration practices**
   Cultivating the soil near the surface to make shallow slits and spike holes can create a loose layer over a more compacted deeper layer. This is then exploited by the grass roots, creating a break.

In reality it is likely to be a combination of these factors that lead to the formation of a break but pitch construction and the use of the correct soils is essential in limiting their development. Strategies for addressing root breaks vary with the depth of the root break, the extent of the root break across the pitch/square and the available budget.

4 Identifying solutions

4.1 Reducing thatch content

A large number of cricket pitches in England and Wales are affected by thatch. Getting on top of this problem requires a two pronged strategy:

1. Mechanical removal of thatch layers
2. Prevention of further thatch build-up by good grounds management.

The first point is critical – accumulated thatch layers need to be physically removed using machinery. The cricket pitch environment is naturally low in the oxygen used by microbes to break down thatch, that is why it accumulates in the first place. Encouraging microbial activity by solid tine aeration or by adding microbial stimulants such as sugars to the surface might help slow the rate of accumulation but it will not remove thatch layers.

Where thatch layers are less than 10 mm thick and less than 10 mm deep then a programme of post-season deep scarification using a suitably designed machine (these are sometimes called linear aerators or verticutters). The machine comprises a series of fast spinning blades mounted on an axle with a 25-40 mm spacing. Pedestrian versions are available but heavy duty versions tend to be tractor mounted and PTO driven.

Thicker and deeper thatch layers will need to be removed using fraise mowing or even deeper surface removal with soil replacement to restore surface levels (Figure 8). Such work should be carried out carefully to ensure that pitches remain playable. Seek experienced independent advice when undertaking such work.

Figure 8 Removal of surface layers and organic matter using a Koro Field Topmaker on a cricket square at Cranfield University

Once any thatch layers have been removed, there are techniques that the grounds manager can use to help reduce the rate of thatch accumulation. These fall into two groups:

1. Reduction of the amount of organic matter available

2. Increase of the rate of breakdown

A reduction in the amount of plant material available for accumulation can be achieved by regular scarification between matches, ensuring the clippings are removed through good mower maintenance and by limiting the amount of nitrogen applied to ensure that excess growth does not occur.

Increasing the rate of breakdown can be a challenge in heavily compacted clay soils. In our four year research project we found no evidence of aeration reducing the organic matter content or increasing microbial activity. We did find that these properties varied seasonally in response to rainfall and temperature. The reason for this is that water slows the transport of oxygen in a soil significantly – limiting the activity of microbes. We also found that in cricket loams high in silt and clay content, solid tine aeration did help to reduce surface moisture contents through increased evaporation and this helps increase air-filled porosity in these soils. In soils with a higher sand content and lower silt content there was less effect. In high clay and silt content soils – solid tine aeration can help reduce thatch accumulation rates.

4.2 Improving shallow rooting and anoxic soils

If your pitch is suffering from shallow rooting (less than 100 mm), the grass shows signs of anaerobic conditions such as leaf yellowing or high disease susceptibility then vertical solid tining or the deep drill could improve grass health and pitch quality and help to reduce the risk of a root break forming due to near-surface dense rooting.

These conditions are most common in soils high in clay content (over 30% clay) and especially those with clay and silt contents over 28% each. Soils with higher sand contents and lower clay contents (24-28%) are less susceptible to this type of soil anoxia and respond less well to the aeration treatments described in this section.

Neither of these operations 'decompacts' the soil. Decompaction occurs when the bulk density of the soil is reduced by increasing the volume of soil. The only way to do this in a sports pitch is to lift the soil upwards (Figure 9a). Doing this on a cricket pitch can have disastrous results – leaving the pitch unplayable in the following season. These methods work by creating vertical holes in the surface. These holes do three things:

1. Reduce the distance that oxygen has to travel through the soil to reach soils at depth.

2. Provide a low resistance pathway for grass roots to grow down to a greater depth in the profile.

3. Increase the surface area for evaporation and infiltration.

The classic view of solid tine aeration is that insertion of the tine into the soil creates a series of cracks in the soil, radiating from the tine hole that help introduce air to the soil at depth and conduct water from the surface (Figure 9b). For this to happen the soil must be in a relatively dry and brittle state (it will crumble and fracture as it is disturbed). However this soil state is often too hard to allow tine penetration in solid tine aeration, and even with the deep drill. This brittle soil condition is likely to exist at the end of the season but aeration of this type is commonly delayed until late October – November when the soil is wetter and tine penetration is easier and results in less surface deformation. But at this case the soil is more plastic and it will mould like plasticine around the tine. In this state, soil is moved sideways creating compaction around the hole walls (Figure 9c). Over time this compaction is restructured by shrink and swell allowing water and gas to move through the tine hole walls. Because the deep drill removes soil in the thread of the drill bit, there is less side-wall compaction but it is not used in very hard and dry soil conditions to prevent drill bits stalling and snapping in the soil.

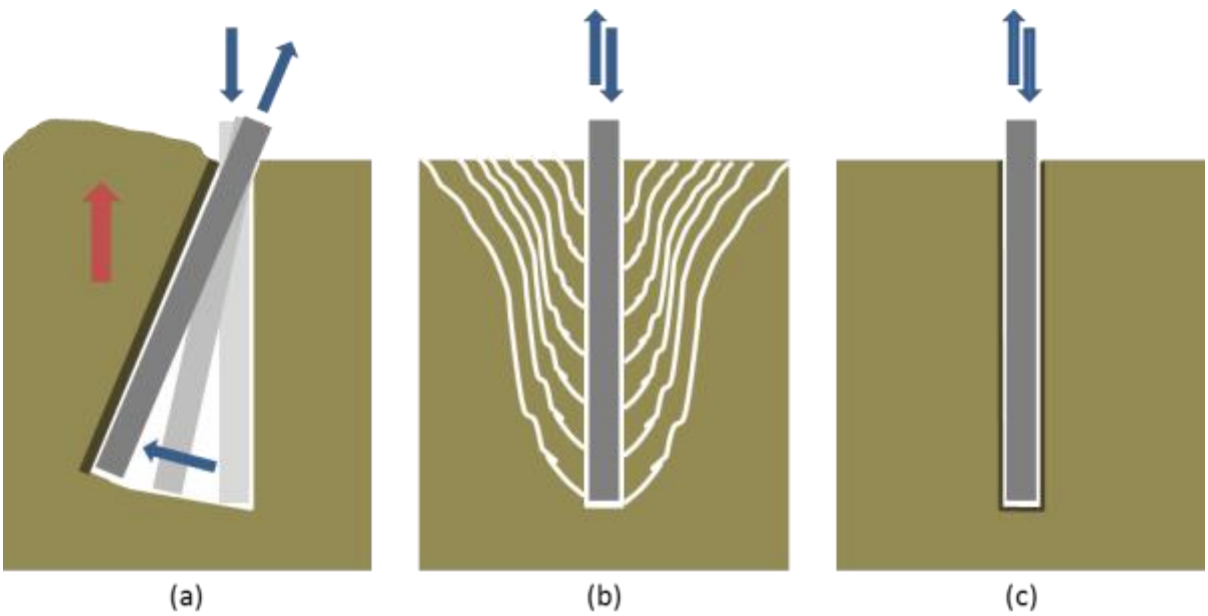

Figure 9 Solid tine effects on cricket pitches. It is essential to ensure that the tine enters and exits the soil on the same axis and that this axis is vertical. If the tine is rotated in the soil as shown in (a) then surface disruption will occur – machines should be set up to ensure that heave is avoided and that tines enter and exit the soil vertically. (b) shows an ideal creation of fractures as a result of using a vertical solid tine. Commonly, this does not take place because in order to create these fissures the soil needs to be dry enough to achieve brittle failure but in this condition it is too hard to achieve tine penetration to full working depth. The situation in (c) is more common where the soil is wetter to achieve penetration but then fails plastically – with localised compaction around the tine hole. This compaction must breakdown through shrink and swell action before the tine hole is fully functional.

It is essential to ensure that tines enter and exit the soil vertically and that there is no upward lift of the surface as this could lead to an uneven playing surface and the formation of root breaks. Careful machinery set up and operation is essential to ensure that forward movement is matched to cam speed in a way that reduces horizontal and upward soil movements.

A new strategy for aerating soils in a more brittle state is to use narrower diameter tines (5-7 mm) which increase the stress applied on the soil by the aeration equipment, meaning that more consistent, deeper penetration depths can be achieved. Reducing tine diameter increases the penetration stress but reduces the strength of the tine making it more liable to snap so care must be taken to ensure that the tines are acting vertically and not subject to bending forces from non-vertical entry/exit. By matching tine diameter to soil strength, this aeration technique has been used for in-season vertical solid tining in first class cricket. For the majority of community clubs, who do not own a solid tine aerator, availability of suitable equipment is limited to end of season renovations using a single tine diameter of around 10 mm, which requires softer ground conditions to penetrate without damaging the surface. The degree of penetration is also about the size of machine, with larger tractor-mounted machinery generally achieving a greater working depth.

Figure 10 The Deep Drill in use on a cricket square (side view). Picture courtesy of Chris Wood © ECB 2012.

The tine or drill holes produced allow grass roots to penetrate deeper into the profile but root growth is down the tine holes rather than through the rest of the soil which remains very dense and structure-less. The deeper the hole, the deeper the roots grow, Figure 11a and Figure 11b show roots penetrating through a 200 mm profile down a deep drill hole but Figure 11c shows that roots only exploit the shallower 90 mm deep vertical solid tine holes. The use of solid tines or the deep drill results in deeper roots down the channels but is not the same as deep rooting throughout the profile (Figure 12). Grass plants not located near tine/drill holes will remain shallow rooting. Repeat applications will increase the number of tine holes. Our research determined that each solid tine treatment affects 0.6-1.8% of the soil volume – so repeated applications over five years might affect 10% of the soil, depending on the soil type, tine diameter, tine spacing and the shrink swell behaviour of the soil.

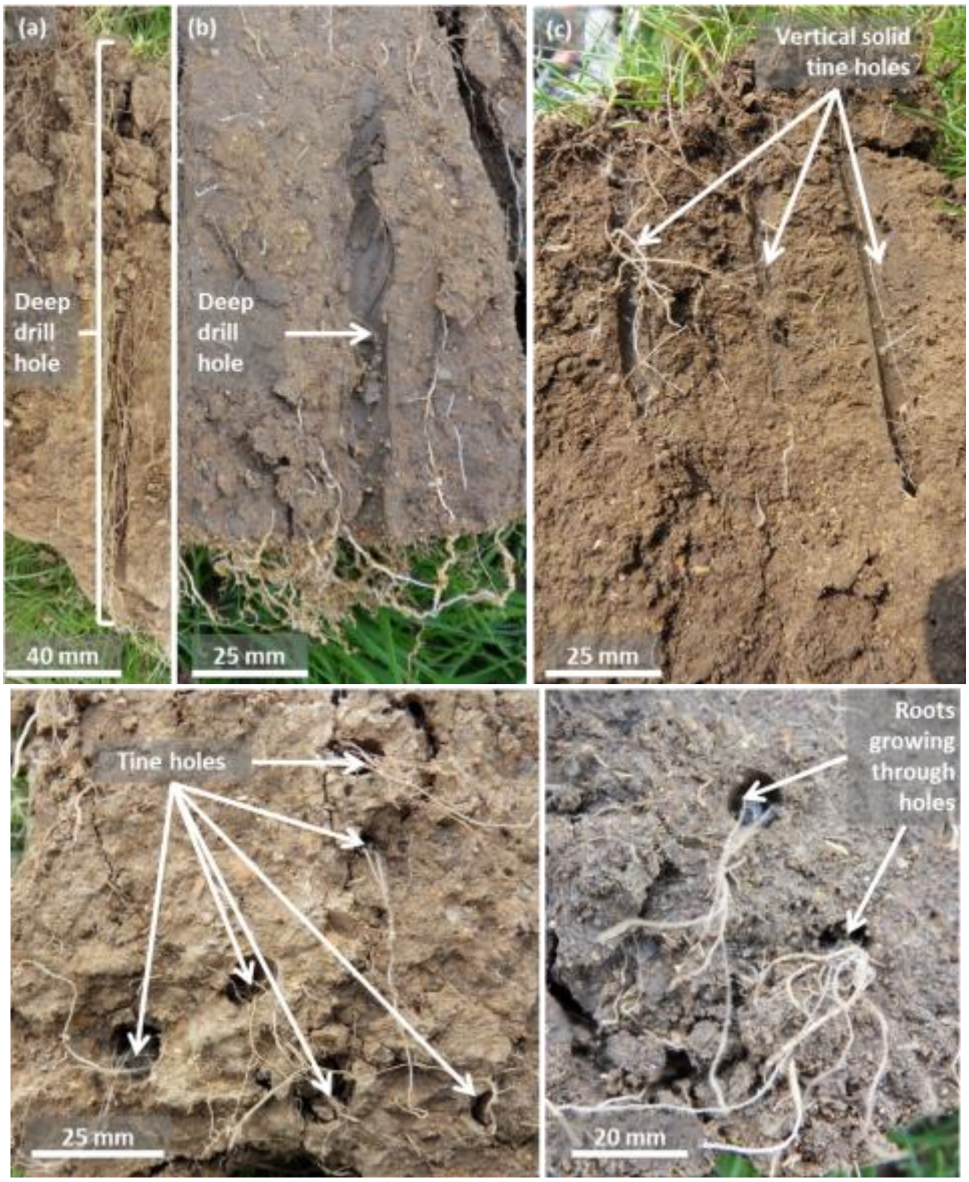

Figure 11 Photographs from the aeration trial plots at Cranfield University: (a) a deep drill hole extending 200 mm through the profile. (b) a deep drill hole at 100-200 mm deep showing smeared sidewall. (c) vertical solid tine holes showing smeared side walls and shallower penetration than the deep drill. (d-e) 50 mm deep horizontal cross sections of the profile showing preferential root growth in solid tine holes. There is evidence of some root growth through the massive, tight structure of the clay profile but the majority of deep root growth is through the solid tine holes.

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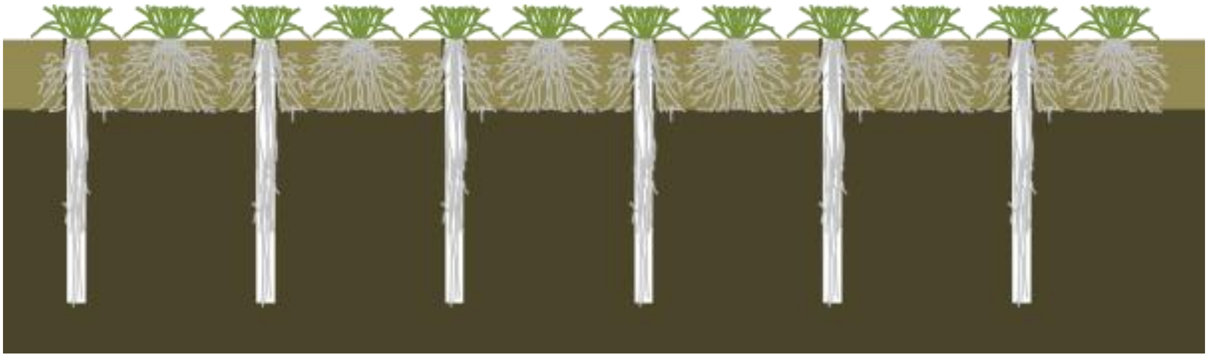

Figure 12 Illustration of the effect of deep drill /vertical solid tine on grass rooting in a soil that is dense at depth. Roots exploit the channels created by the drill /tines, surrounding plants unable to access these channels remain rooted in the less dense upper layers.

4.3 Dealing with root breaks

Where a root break has been identified and it is causing low or variable bounce then action should be taken to remove the root break – as with dealing with thatch layers, routine solid tine aeration is unlikely to be an effective solution. There are three strategies available and the most appropriate depends upon the depth and severity of the root break, the money and resources available and the amount of fixture disruption that is tolerable.

1. **Removal of relatively shallow root breaks using a surface planing machine** (e.g. a Koro Fieldtop Maker). This technique removes near surface layers and root breaks using a tractor mounted planing machine that cuts surface layers off down to 50-75 mm, removes that material and then replaces it with new compatible cricket loam.

   It is essential that the core is examined carefully to identify the layers to be removed and that the remaining soil type is identified and a compatible replacement loam is used. If in doubt speak to your County Pitch Adviser. The new loam must be keyed into the existing soil to ensure a new root break isn't formed and constructed in well keyed layers to a level that is slightly proud of the outfield and in conformance with ECB/IOG pitch construction performance standards regarding slope, and surface levels to ensure that water is shed from the square and does not pond in low spots. Grades should be matched across the square.

   Whilst planing equipment is available to hire (ca. £1500-£2000 /day + removal of material), this work is best carried out by experienced, suitably equipped contractors with experience in the construction and renovation of cricket squares. When conducted immediately post-season, shallow renovations such as this can allow cricket to be played on the new surface in the following season. Whether the whole square is treated at once is a question of risk management for the club – by renovating 50% of the pitches one season and 50% the next, some of the risk is reduced but the cost is increased because the contractor has to come out twice.

The cost of hiring contractors to treat 5-10 pitches in this way is £5000-£8000 depending on site specific details and the quantity of materials removed/re-supplied.

2. **Reconstruction to 75 to 100 mm to remove root breaks**
   Deeper profile reconstruction will help remove deeper root breaks, mixed layers and address the problems presented in the left hand core in Figure 4. The top 75-100 mm is removed using an excavator or similar. The profile is then reconstructed in keyed layers to an appropriate depth and grade that marries with the rest of the square and the outfield to ensure a smooth run up for the bowlers and that water does not pond on the surface.

   Again, careful consideration of surface levels and compatible loam types is essential. Speak to your County Pitch Adviser for more information. This work is best carried out by experienced cricket contractors with suitable equipment.

   Typical costs for reconstruction to 100 mm depth is £2000-£3000 /pitch – but costs vary with site factors, the price of loam, whether soil has to be disposed of and the depth of reconstruction.

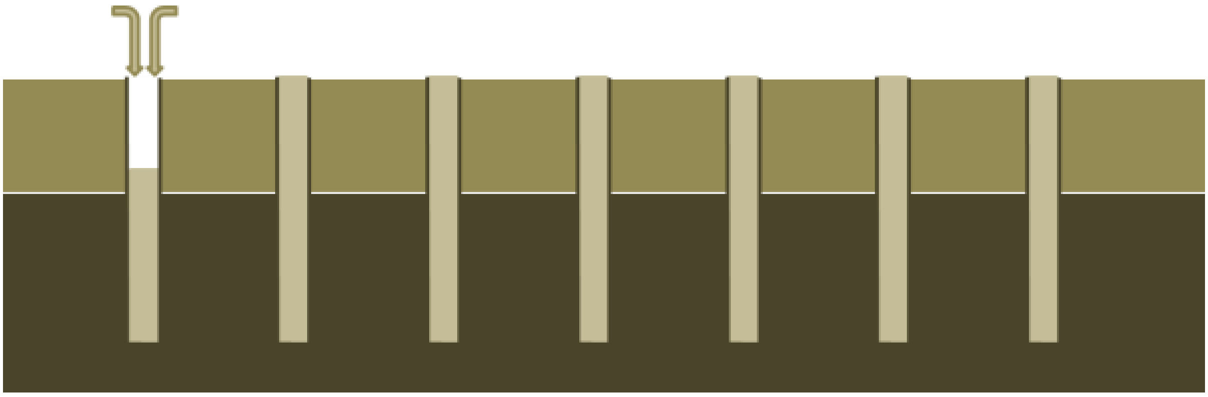

Figure 13 The process of reinforcing a cricket pitch using the 'Drill and Fill' technique (sometimes called 'nailing' a pitch). Larger diameter holes are drilled through the root break and loam is manually compacted into each hole using a piece of doweling or similar. This is a time consuming process but is lower cost than surface reconstruction.

3. **Drill-and-fill to provide root stabilisation of near-surface layers to lower layers.**
   This is a relatively lower cost technique that does not physically remove the break but attempts to anchor less stable near-surface layers to lower layers by using the deep drill to create holes that are then back filled with compatible loam to form small 'pilings' to reinforce the profile (Figure 13). Eventually grass roots follow these channels to help reinforce the anchoring.

The cost of hiring a deep drill contractor is in the region of £1000-1200 /day in which 10-12 pitches can be treated (exact costs will depend on location and timing). There is little reduction in treating fewer pitches because getting the equipment to site is a fixed cost.

This machine only creates the holes however – it cannot fill with cricket loam – this has to be done manually using a gang of people to compact loam into each hole (spaced on a 100-120 mm grid) right across the treated pitches. This is extremely time-consuming and hence the cost savings are relative – if the time to fill the holes is included and fully costed then it can be an extremely expensive process.

Once a root-break has been removed it is essential to ensure that it doesn't reappear. This can be difficult but the use of the correct compatible loam during reconstruction and ensuring that all construction layers are keyed into each other is the starting point. Staying on top of thatch management, keeping a regular eye on profile cores and avoiding rolling the pitch when it is too wet or using shallow aeration devices in the wrong soil conditions will help avoid the formation of new root breaks.

5 Measuring the benefit

Having identified a need for aeration using profile cores and investing the time and resources in carrying out aeration procedures, it is essential to continue to monitor the profile by taking cores over the following seasons to ensure that the aeration treatments are effective and the problems are not reoccurring.

The reason for this is that in our four years of research we found that the benefits of certain aeration treatments in certain cricket loams were not always consistent and it was only occasionally that they provided any benefit over and above routine scarification and the natural effects of shrink and swell and over-winter frost heave. We have outlined above the situations where aeration treatments are beneficial but it is essential to monitor this benefit. Aeration costs in terms of machinery purchase/hire, machinery wear, fuel and time/labour – it is essential for club sustainability that this investment provides a return for the club/facility. To assess this requires routine monitoring of the pitch. We would encourage you to become familiar with the third dimension of cricket pitches – depth. Keep an eye on your cricket pitch below the surface.

6 Aerating outfields

Aerating outfields is different from aerating squares. This is for two reasons:

1. A small amount of surface heave is desirable to loosen and decompacts the surface without disturbing levels
2. The soil might not be clay (although in England and Wales 70% of cricket facilities are located on clay soils and only 30% on more freely draining sandy soils.

Outfields often show signs of compaction including broad leaf weeds such as plantains and shallow root growth – use a corer or a spade to investigate the outfield profile inexactly the same way as on the square.

Compaction is usually near-surface and comes from the use of mowers, from winter use for sports such as football and rugby and for non-sport use such as events and concerts. Routine pre-season and post-season spiking with a tractor mounted solid tine spiker with a small amount of heave to loosen the profile will help maintain a healthy outfield sward. Pay particular attention to traffic routes from the grounds shed to the square where rollers and mowers can cause significant compaction. Use of a light roller, such as is found on a mower can help restore minor disruption of outfield levels.

In certain soils a rotary knife decompactor (such as an Earthquake) can also help to loosen outfield soils but care should be taken in shrink-swell clay soils as the slits created by this machine can expand significantly in certain soils and it can cause vertical heave when used too shallow in the wrong soil conditions (too dry) which can result in ridges that will affect ball roll unless they are re-levelled by a light-medium weight roller.

Again, routine monitoring of soil profiles with a spade, auger or corer is recommended, particularly where localised drainage problems such as ponding are evident. In areas where water does pond, dig a hole to determine whether it is surface impedance to drainage or a deeper problem such as a shallow groundwater table / perched water table where drainage might be necessary. If in doubt, contact your County Pitch Adviser.

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7 What aeration equipment should we buy?

Every club should invest in scarification equipment for routine post-match renovation of pitches and to help lift and thin grasses when preparing pitches. This could be traditional hand towed rakes or motorised scarifiers designed for use in cricket pitches. Because this equipment is used frequently and is essential for slowing the rate of thatch accumulation, clubs are encouraged to invest in such equipment. We would also recommend that clubs invest in the equipment to extract cores from pitches as this will allow the grounds manager to stay on top of thatch and other sub0surface problems

Investment in larger machinery such as cam-action solid tine spikers or deep scarification equipment will depend on the finances of the club/facility and the frequency with which the equipment will be used. For first class grounds, large schools with a number of squares and some premier league clubs, investment in a cam-action solid tine spiker might be justified if clay and silt contents are high and use is frequent. If purchasing we would recommend a range of tine sizes for different soil conditions on the squares and outfields. For the majority of facilities, where budgets are limited hiring machinery or contracting in machinery and experienced operators is recommended. The capital cost of owning a machine that is used infrequently and is sitting in the grounds shed depreciating is difficult to justify. When using contractors –get references from other local clubs and inspect their work – look for contractors with experience in the specialist grounds management requirements of cricket pitches and grounds.

When it comes to operations such as fraise mowing, surface renovation and reconstruction – experienced contractors are invaluable. A lot of damage can be caused to a cricket square in a very short time with the wrong machinery in the wrong hands. What may seem like a cost saving opportunity will often cause extra costs. Use a contractor experienced in cricket work of this type and that has appropriate machinery including laser-levelling /surveying equipment to ensure the correct grades are constructed.

8 Summary

These guidelines are based on a four year research programme at Cranfield University, funded by the Institute of Groundsmanship and the England and Wales Cricket Board. This research has taken a scientific and practical view on the many challenges of aeration in cricket.
The approach we recommend is to take a problem-led approach to aeration. This is because we found the effects of aeration to be inconsistent across loam types and different seasons. Start any aeration process by analysing pitch performance, how the pitch looks and by taking a core to examine the profile in cross section. Look for signs of anaerobic conditions, water logging, thatch. Soil layers and root breaks. Then select your treatment accordingly. Carry

out this treatment using the best available equipment in the right soil conditions. Finally continue to monitor pitch performance, how the pitch looks on the surface and how it looks in profile cores to measure the effectiveness of your treatments and to ensure that further damage does not occur.

Our research found that:

1. Aeration in cricket is not a single process – most grounds managers have multiple expectations of outcomes that include gas exchange, decompaction and improved grass rooting. A wide range of techniques and equipment are used and views vary from 'never aerate' to 'aerate all year round including through the season'. Aeration is justified in certain situations.

2. Spiking does not decompact the soil, it can increase oxygen and drying rates of higher clay/silt loam soils used in cricket. Therefore routine spiking is not recommended in all soils – it is important to see whether there is a problem and whether spiking can help with that problem.

3. Spiking must be vertical – heave will ruin surface levels and achieve excessive decompaction.

4. Spiking and drilling will not remove thatch layers. Deep scarification, fraise mowing and surface renovation are more effective.

5. Shrink and swell, and frost heave do decompact the soil – these are natural processes and should be encouraged over winter but managed by pre-season rolling.

6. Spiking and drilling a square can help deeper rooting in the profile – the extent to which deeper roots venture from the tine holes into the surrounding compacted soil is dependent upon shrink and swell processes to break down compacted tine hole walls.

7. The majority of outfields will benefit from aeration and in particular decompaction at some point as they are frequently compacted.

These guidelines are based on a four step process: identify the problem – identify the best solution – carry out that operation in the best conditions – evaluate its effectiveness and act accordingly. By following this approach you should be able to maintain pitch performance whilst avoiding wasted time, money and fuel.