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Soils

Dig a bit deeper

Soils are the life support system of the crops farmers produce, but to unlock their potential they require cover, roots, oxygen and porosity all working in unison. *CPM* digs into the matter.

By Melanie Jenkins

The emphasis placed on improving soil health has become integrated with many aspects of modern agriculture, but as Canadian agricultural engineer Odette Ménard pointed out at Groundswell in July, there's so much more that can be done to achieve truly healthy soils.

Regen agriculture has appeared in many guises for Odette. "Around 30 years ago we were talking about soil conservation, then it became sustainable agriculture, followed by agro-ecology, eco-agronomy and now we call it regen agriculture. But for me, it's always been soil health."

Before the prevalence of agriculture, forests created an equilibrium in soils through the diversity of roots not just from the various types of plant, but the range in the size of their roots, she explains. "But with the introduction of farmed perennials and then annuals, it's decreased the level of organic matter in the soil.

"We now focus on the organic matter in the top 15cm which is turning over every 5-10 years, but it's the really high-quality organic matter in the soil below this that's been depleting at a much slower rate and could take 100 years to cycle. So even though we're moving towards healthier practices we could still be losing organic matter from this lower layer."

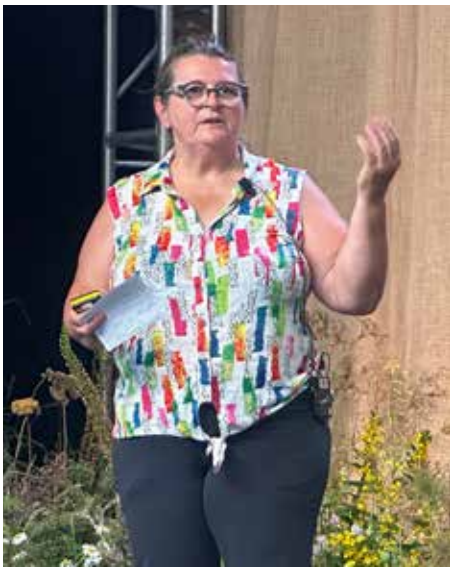
Odette points out that a lot of effort goes into managing the top 15-20cm (6-8inches) of soil, which she calls the direct intervention zone. "This is where we're ploughing, discing, disturbing the soil, planting and harvesting. But all of this work we're doing, despite our intentions to do good, causes collateral damage in the form of compaction, soil surface pulverisation and erosion."

Soil profile

When it comes to assessing soil health, although it's easy to visually analyse a field above ground and determine if what's growing looks to be a good crop, she points out that when digging deeper, it can become apparent that the soil profile isn't always allowing roots to grow to their full potential. "This is the very first step we should be taking and you should soil profile in good and bad parts of the field and when there are active roots in the system.

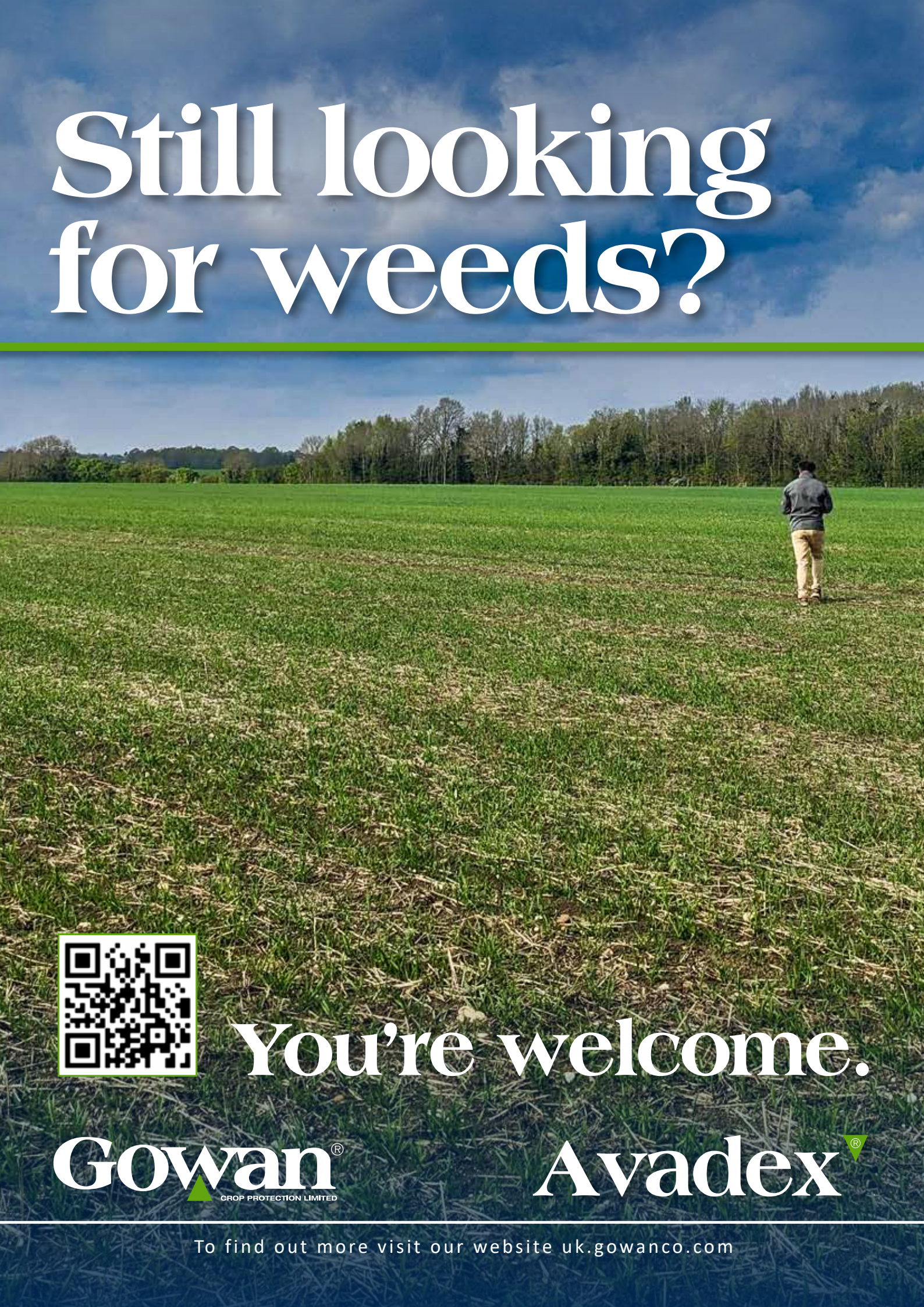
"The real soil potential is what's happening up to 76-102cm (30-40inches) deep and we want there to still be root activity here. Something we don't do enough is pull our shovels out to dig at least 90cm deep into the soil profile to find out what's going on.

"And once you've dug into the ground you can determine horizons to work on based on colour, structure and root system. But it's not just about the aesthetic of the soil, it's also about the smell and whether this is bad or not. Another test is to run a knife through the soil to determine where there's resistance and therefore compaction that will require actioning." ▶



Agricultural engineer, Odette Ménard points out that a lot of effort goes into managing the top 15-20cm (6-8inches) of soil, which she calls the direct intervention zone.

Still looking for weeds?



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Although more costly forms of management, such as subsoiling, drainage and levelling can be utilised to assist soil health, she flags that this still won't reach the entire soil profile. This is where her 'CROP concept' comes into play. According to Odette, this consists of four main principles which have to work together for soils to thrive and be healthy: these are cover, roots, oxygen and porosity.

"We often look at these elements separately but they each have an impact on one another. Cover will lead to less crusting, better germination and more sun protection, which leads to more root growth. The root system impacts the cover itself and the porosity by supporting more microbial life, creating deeper explorations and further glomalin production. If there's high porosity in the soil there'll be a better root system because there's more space and greater access to nutrients and water. And the better this system is, the less compaction there's likely to be.

"No-till was meant to be the answer, but it didn't work because we didn't have porosity in the soil, so we have to work all of this together in order to have a truly healthy soil that won't see yield losses. If one element is missing, we put a lot of energy into changing a system that still won't work."

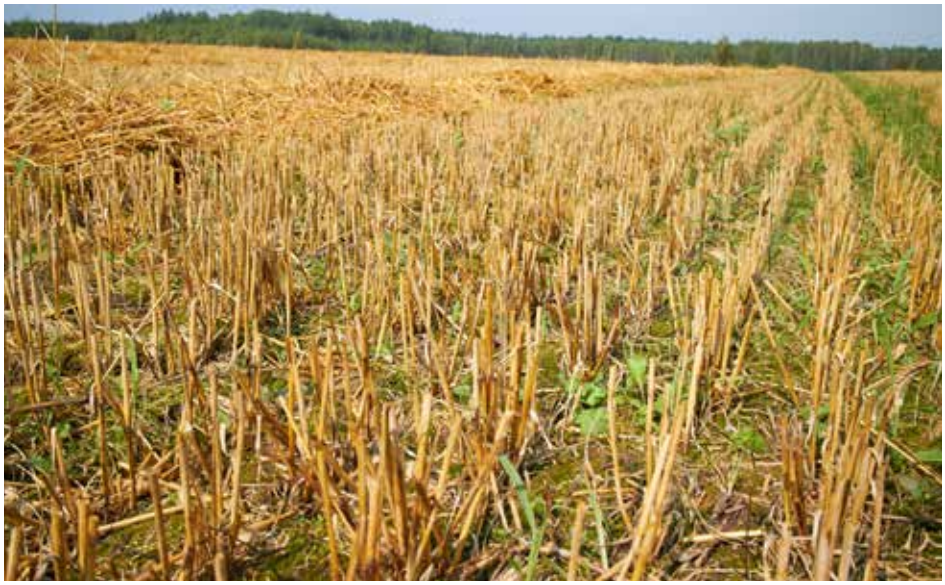
Cover crops provide both a way of alleviating the issues caused by compaction and improving the root system and soil porosity, she says. "Although we can take all of these steps, we won't be able to go back to the levels of organic matter found in the original forest systems. In addition to this, the climate is going to have an influence on replenishing organic matter."

When digging deeper, it can become apparent that the soil profile isn't always allowing roots to grow to their full potential.

Odette flags that organic matter is built by residue but that only 8% of the carbon in residues will end up in soil organic matter in no-till systems. "But with cover crops and organic manures this is 12-23%, and from the root system, 45% of the carbon will become organic matter, so it's important to get more roots into our systems to feed it."

Before any steps are taken, Odette again stresses the importance of digging into the soil profile to find out what the issues are. "We spend hundreds of hours a year on machines and I wish we'd spend as much time soil profiling. If we're soil profiling and we see a compacted layer at a certain depth, then it's possible to determine that subsoiling should be done 10cm below this – if we subsoil above or too far below the area of compaction then we aren't tackling the issue, but without soil profiling we wouldn't know."

However, subsoiling also has to be done when soil is at the right humidity at the depth that's going to be worked, she says. "Ahead of subsoiling, you should plant cover crops a week to 10 days before to allow the roots to work into the cracks produced through subsoiling – and then don't go back into your field for at least a month. But it's important to note that subsoiling is like chemotherapy, in that it's a practice you only ever want to have to do once – you don't want it to have to be a repeat solution." ■



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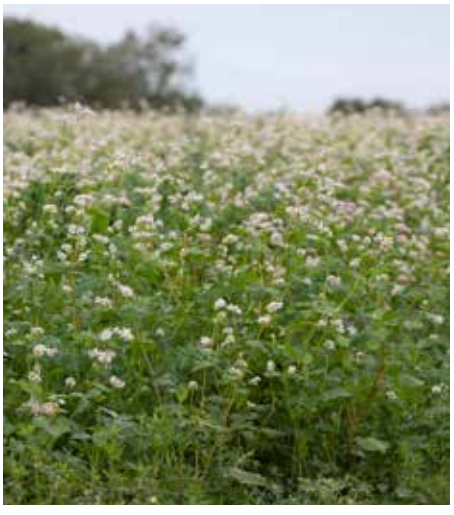

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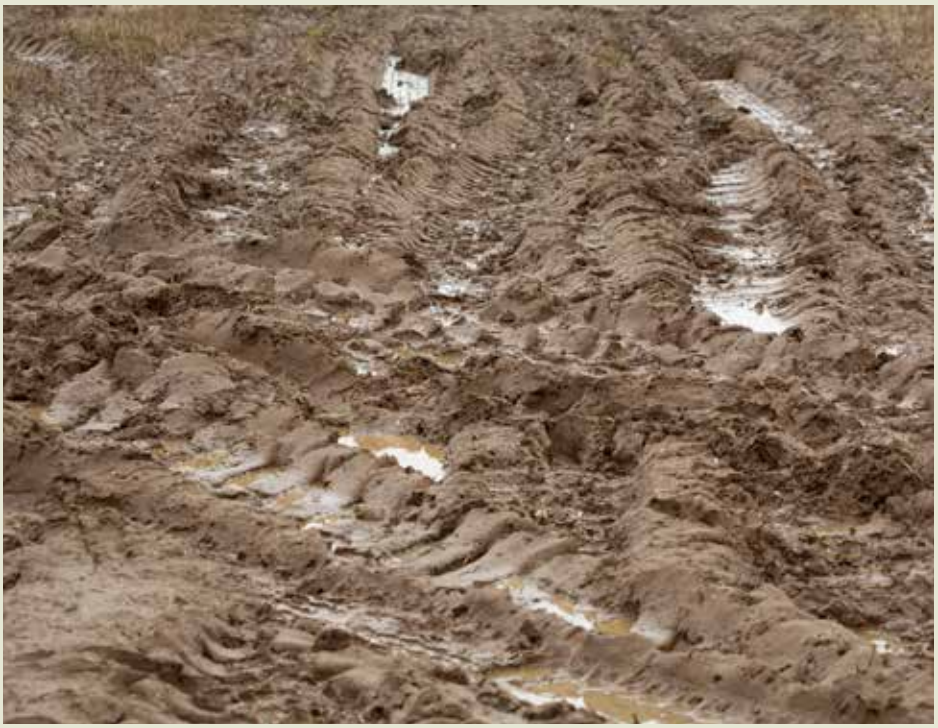
It's vital to avoid exceeding 3.5t in weight per wheel and by adding another set of wheels this halves the weight per wheel, and greatly reduces the impact on compaction.

According to Odette, soil compaction throws into relief what type of impact farming has had on the soil. The diffusion of nutrients is severely impacted by the level of compaction, she says. "NO_2 (nitrogen dioxide) can diffuse at a rate of 0.9-2.99mm per day, depending on how compacted a soil is. This ranges from 0.009-0.29mm per day with H_2PO_4 (dihydrogen phosphate) and 0.29-0.9mm per day with potassium. If we want a better diffusion rate in our soils, we should be avoiding compaction."

Compaction also impacts the main root system, the absorption hairs and the mycorrhiza, she explains. "We have to look at minimising compaction to help maximise root growth as their ability to grow all depends on the health of your soil."

She also points out that compacted soils can potentially only have an infiltration rate of 0.05m per day, whereas in healthy, well-structured soils this is as much as 1m per day. "This'll have a big impact on the water management of soil. In very healthy soils the water holding capacity is far greater, but when soil is compacted water has nowhere to go and this is where we get run-off.

"It's also important to understand that porosity has to have continuity and this leads to capillarity – in poor soils there's very little space for water to actually get to your plants. The impacts of this are multiple, ranging from a smaller zone of root growth to poor aeration and infiltration, to lower yields and high production costs."



The first, and arguably the most significant elements causing compaction, are tractors and machinery.

The first, and arguably the most significant

element causing compaction, is the tractor, she highlights. “Soils can have surface and sub-surface compaction with the former being affected by the air pressure in tyres.”

When air pressure is lower the effect at the soil surface is reduced, she says. “This is because the tyre sinks less due to its larger surface area, and because less soil is compressed, this reduces the slope of soil the tyre pushes against – something we can’t see by eye – resulting in more economical fuel consumption, cutting usage by about 15%. Further to this, lower air pressure will allow the soil surface to retain more of its porosity.”

The difference between a tyre set at pressures ideally suited for road travel and for movement across soil are significant, says Odette. “For example, an identical tyre at 23psi will have a contact area 37.5% larger than if the pressure was set at 9psi,” she explains. “Tyre pressure is often set for road conditions and therefore at the higher level, but tractors are more often than not spending the majority of their time working in fields and not traveling on roads.”

To indicate how much pressure further impacts the surface, she points out that tyres set at 17psi will exert 24psi onto the soil surface, but if tyres are filled to 6psi, this will exert 13psi. “At 17psi we’re seeing way too much pressure applied on the soil surface which will cause compaction.”

So why is it so important to prevent soil surface compaction? “When compaction occurs at the surface, it pulverises the soil structure and we’ve seen instances of up to 95% fewer roots in the surface compaction layer. This is significant when you consider that a plant can have up to 80-90% of its total root system in the first 30cm of soil.”

However, about 5% of a plant’s roots can be found up to 1m deep and according to Odette, and these roots can provide up to 20% of the water a plant requires, making it incredibly important.

A few simple steps can be taken to help prevent compaction and protect soil porosity, the first of which is to aim for a maximum of 12.5psi in tyres, she stresses. “We have to lower the pressure to protect the soil surface and this is highly achievable.”

But to avoid sub-soil compaction, further steps are necessary, adds Odette. “It’s also vital to avoid exceeding 3.5t in weight per wheel – not per axel, per wheel – and so it might be worth looking to add another set of wheels because halving the weight per wheel will have a greatly reduced impact on compaction.”

Other steps that can help to avoid compaction include optimising the balance of the tractor, slowing down and working in optimal conditions. And conditions can play a large part in the impact machinery has on the bulk density of soils, says Odette.

“It’s generally understood that working in dry conditions will have less impact on soil because it has a better bearing capacity. But at the same time, all the weight of machinery still has to be supported by a certain volume of soil, so when it’s dry it’ll require less volume but the impact on bulk density will be greater.

“So it’s important to work in conditions that aren’t too dry or too wet but which sit in the middle. When the bulk density of the soil increases, so too does the mineral content in the volume of soil, meaning less space for roots and water holding capacity.”