PROTECT YOUR SOIL

Types of soil
Soil compaction
The tyre's impact
MICHELIN Ultraflex Technologies
Summary

MICHELIN
A better way forward

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Soil compaction

The tyre's impact

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Preface

Agriculture in the 21st century is characterised by larger and larger farms, using increasingly powerful and sophisticated machinery.

Larger farms and greater technical demands call for tractors and combine-harvesters that are ever more capable and powerful. Inevitably these machines are becoming heavier and this trend appears set to increase.

Heavier axle loads can translate into greater ground pressure, which compacts the soil and reduces soil aeration and water absorption. Compaction disrupts crop growth, thus reducing yield.

Machinery is indispensable, yet soil compaction has an adverse effect on crops. This booklet seeks to offer a number of solutions to this problem. In the pages that follow, you will find recommendations for analysing soil and advice for preventing soil degradation caused by compaction. You will learn how the appropriate tyre technology and tyre inflation pressures can protect your soil while reducing costs.

Types of soil

Each type of soil has its own particular features.
This chapter explains ways of characterising soil structure to better understand and protect the soil when working in the field.

Determining the type of soil

The key characteristics of soil are texture and humus content which then determine the soil type. Soil texture can be assessed by touch or by laboratory analysis, and is dependent on the relative weight of three minerals: sand, silt and clay.

To check soil characteristics yourself, take a small amount of moist earth, rub it between your fingers, roll it into a ball and then crush it. Using sense of touch and the table opposite soil type can be classified as light, medium or heavy depending on the ease with which it can be worked.

In addition the balance of air and water circulation in the soil (permeability, aeration, retention capacity) and the structural stability of the soil's structure (risk of siltation and compaction) can be determined. Finally, colour provides information about a soil's organic material content.

1. Rub between your fingers to test the stickiness

3. Test the plasticity

Finger test for mineral soil

1. Rub between your fingers and test the stickiness	2. Test the malleability	3. Test the plasticity	Type of soil
Very granular, does not stick	Difficult to shape	Diameter of the cylinder: >7 mm	**Light**
Somewhat granular, not very sticky	Possible or easy to shape	Diameter of the cylinder: 2-7 mm	**Medium**
Smooth, shiny, very sticky	Easy or very easy to shape	Diameter of the cylinder: <2 mm	**Heavy**

Determining soil characteristics

With a small clod of earth it is relatively easy to assess the humidity, smell and colour of soil.

1. Moisture

Using farm machinery on ground that is too wet often causes the structure of the soil to deteriorate. It is therefore important to check the moisture content of the soil before beginning work in the field. Take several clods of earth and crush them between your fingers. Based on your observations and the table opposite, you can assess the measures needed to ensure proper soil care.

Special case: Harvesting sugarbeet and soil humidity

Sugarbeet is often harvested during rainy periods when there is little soil drainage. As a result, the average soil humidity is well above levels recorded during the harvest season or when, for example, potatoes are dug. Soil humidity is often low enough only at midday. This is the ideal moment for harvesting as the soil is at its most workable.

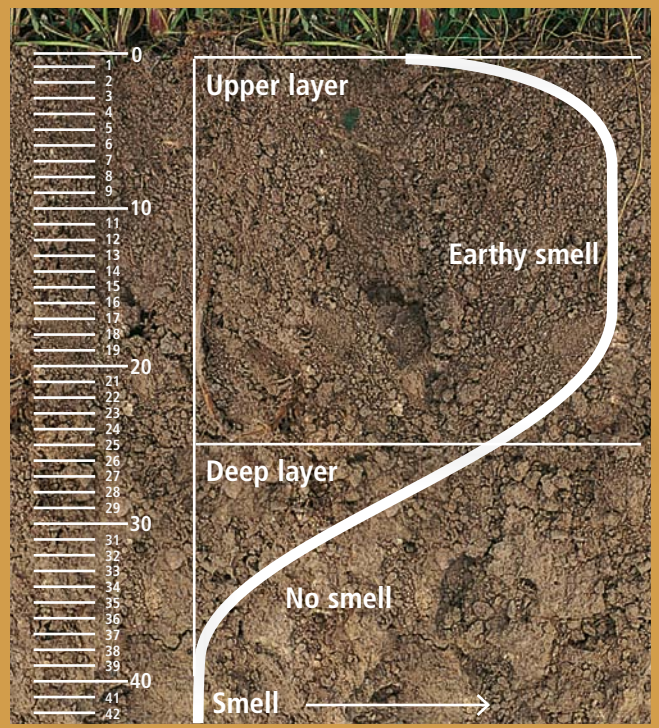
Determining soil humidity

Nature of the soil	Consequence
1. Hard The earth is hard to break with your fingers.	**Do not work the soil:** Too much energy is required and the tools may cause mechanical damage to the soil. **Ideal working conditions:** Excellent load bearing capacity.
2. Fragile The earth crumbles under pressure from your fingers.	**Ideal period for working the soil:** The soil is loose and opens up naturally. **Acceptable working conditions:** Average load bearing capacity. Risk of compacting when using heavy machines or inappropriate tyres not inflated to the right pressure.
3. Plastic The earth is pliable or can be deformed, but does not break.	**Do not work the soil:** The soil is malleable and easily deformed. Compaction causes rutting and damage. **Unacceptable working conditions:** The soil is likely to be damaged by compaction.

Determining soil characteristics

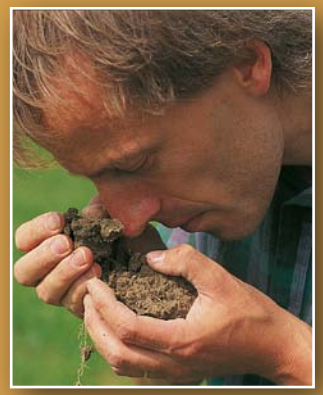
2. Smell

Smell a small amount of freshly crumbled earth. The smell makes it possible to draw conclusions about the circulation of air and the decomposition of organic matter in the soil. A pleasant earthy smell is the sign of proper soil aeration: organic material is decomposing and the structure of the soil is intact. On the other hand, a mouldy smell is a sign of insufficient aeration: the organic matter is rotting. This is a sign of soil compaction.



Determining the smell of the soil

The smell of the soil is much more pronounced in the upper layers than in the deeper layers. The smell is especially strong when the soil is warm and damp and when it contains organic matter that decomposes easily.



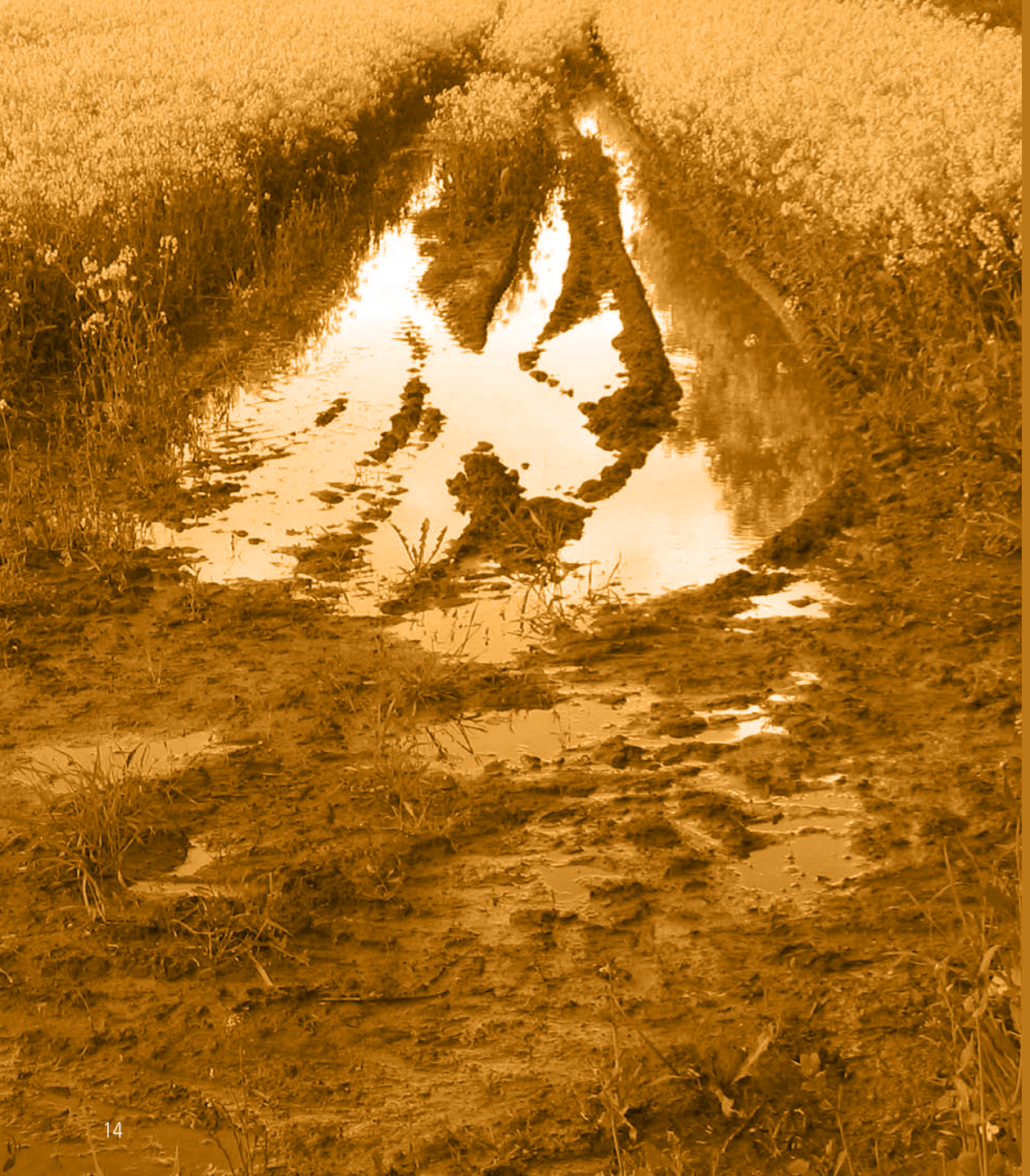
3. Colour

Colour provides information about air exchange and the soil's moisture content.

Yellow, brown and red hues indicate the presence of iron compound in well-aerated soil.

Rust-coloured streaks and dark-brown manganese sediments are seen in soil alternating between wet and dry periods.

Blue-grey colours develop in damp soil containing iron compound. The presence of humus adds grey-to-black tones to the original colour of the soil's minerals. Areas of soil displaying this colouring hinder the growth of plants.



Soil compaction

Soil is compacted by the passage of farm equipment. In the worst cases, water and air cannot reach the roots in sufficient quantities.
This section explains how compaction causes damage and the impact this can have on soil and on crop yield.

How soil is compacted

Compaction occurs when the downward pressure of the tyre is greater than the ground's ability to resist. As a result, the soil loses porosity. Water blocked in the pores of the soil causes compaction because it creates a slippery film between the solid particles. That is why damp soil is more susceptible to compacting than dry soil.

Compaction is inevitable but does not automatically result in soil deterioration. Natural processes also have an impact:

- Repeated swelling and shrinking (due to alternating dry and wet periods).
- Freezing and thawing: this forms finely structured cracks and as a result new aggregates.
- Earthworms and plant roots "bore" holes into the soil, creating air and water discharge routes. Earthworms also ingest compacted humus aggregates and secrete loose aggregates stabilised by mucus.

However, these processes progress slowly and they have less impact at greater soil depths.

Soil damage due to compaction

Soil damaged by compaction is due to a number of factors:

1. **Too many passes in the same tracks**
2. **Excessive wheel slippage**
3. **High pressure in the contact patch, which is especially damaging to the structure of underground layers of soil**
4. **Heavy loads per wheel, which primarily damage the deep layers of soil.**

When these factors occur simultaneously, the risk of deterioration through compaction is considerably higher. The type of soil also plays a key role, with damp soil more at risk than dry soil.

Characteristics of soil damaged by compaction

Soil that has deteriorated through compaction is less porous, which reduces irrigation and disrupts both flora (plant roots) and fauna (earthworms).

Impact on moisture content

Compacted soil reduces water penetration and leads to surface run-off, with a major risk of erosion. In dry conditions, significant compaction also reduces the rise of water through capillary action.

Impact on air circulation

Significant compaction hinders the exchange of gases between the humus and the deep layers of soil, which slows down the decomposition in the surface layer. The lack of oxygen makes it more difficult for roots to breathe and grow.

A negative long-term impact on crop yield

In the event of serious compaction, the soil must be decompacted, resulting in lost time and additional costs.

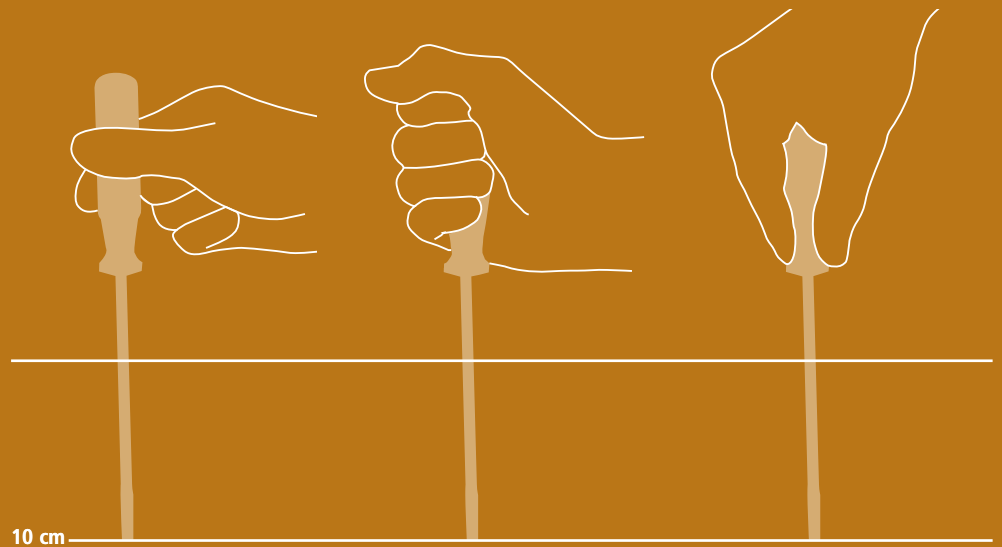
Five tips for preventing soil damage by compaction

A few simple tests can help to reduce the risk of compaction:

1. Test the soil's load bearing capacity.

Fertile soil needs to be aerated. Before working the fields with heavy tractors and farm equipment, it is best to check the soil's load bearing capacity. The screwdriver test is a simple but effective way of testing this.

Screwdriver test



When held between the thumb and index finger, the screwdriver can be effortlessly inserted 10 cm into the earth:

⇓

Loose soil that is highly susceptible to compaction

When held by the whole hand, the screwdriver can be effortlessly inserted 10 cm into the earth:

⇓

Semi-hard soil, susceptible to compaction under heavy loads

With slight pressure applied from the palm of the hand, the screwdriver can be inserted 10 cm into the soil:

⇓

Hard soil that resists crushing and is not very susceptible to compaction

Five tips for preventing soil damage by compaction

2. Avoid driving on soil that is too wet.

Whenever possible, concentrate field work when weather conditions are more favourable and, when the soil remains dry.

3. Reduce the number of passes.

The fewer the number of passes, the less the soil is compacted.

Repeated passes can be avoided by:

- Combining farm equipment to do 2 or more jobs in a single passage across the field.
- Taking advantage of the previous crop cycle, which sometimes makes it possible to avoid tilling the soil for the next crop.
- Using paths.

4. Choose a wide work area.

Cover a wide work area and so reduce the combine-harvester or tractor's contact patch.

5. Use modern work methods.

Tilling without turning the soil, for example, protects the soil since no hardpan (i.e. dense layer of soil below the uppermost topsoil layer) is created.

In addition, decompacting or otherwise working the soil also helps to eliminate possible compaction of the surface layer.

The impact of the tyre

As the link between farm equipment and the soil, tyres play a decisive role in preventing compaction. In this chapter, we will illustrate the advantages of choosing the appropriate tyre and maintaining the right tyre pressure – to protect the soil and to increase profitability.

Demands in the field and on the road

Tyres are the interface between farm machinery and the soil. They must satisfy widely differing requirements, depending on how they are used.

In the field

- Good traction
- High load capacity
- Soil protection

On the road

- Comfort
- Low rolling resistance
- Steering precision, stability when cornering and safety when braking

In the field: loss of drive because of deep ruts

On the road: loss of drive due to rolling resistance

The right tyre pressure

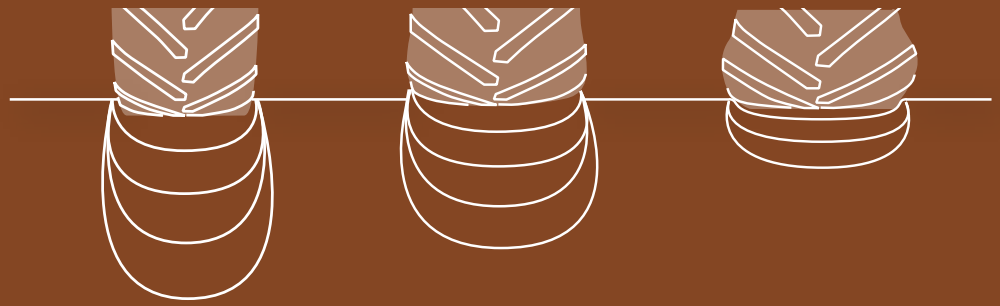
Tyre pressure is generally higher when equipment is used on roads, paths and other hard surfaces, than when it is used in the field. This is because on loose soil the same laws of physics do not apply and user expectations are not the same.

Impact on the soil

For a tyre used both in the field and on the road, 1.6 bar of pressure is generally recommended. However, this pressure is often too high in the field. Because high pressure reduces the tyre's contact patch, it leads to wheel slippage and soil damage due to compaction.

Using twin tyres or wide tyres provides a bigger contact patch, improves traction and reduces pressure on the soil.

Contact patch and soil compaction



Standard tyre with 1.6 bar of pressure

Wide tyre with 1.6 bar of pressure

Wide tyre with 0.8 bar of pressure

Lower tyre pressure means less compaction

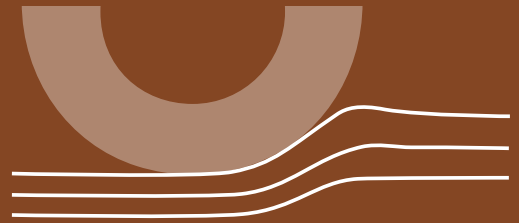
Using a wider tyre may not be enough to increase the contact patch sufficiently: inflation pressure must also be adjusted. When the load and the pressure on the ground are spread over a wider surface, soil compaction decreases.

Impact on fuel consumption

Overinflated tyres result in:

1. The so-called bulldozer effect. The tyre "digs" a rut, pushes the earth forward and creates a mound, which increases fuel consumption.
2. A smaller footprint and fewer lugs in contact with the soil, leads to a loss of traction increasing wheel slippage and fuel consumption.

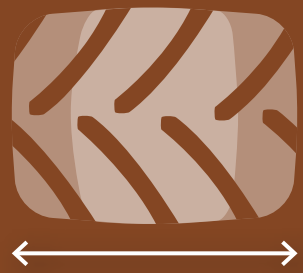
The bulldozer effect



For greater efficiency, the inflation pressure of towed machinery should also be adjusted.

The tyre contact patch elongates

In principle and when tyres are designed for such use, when pressures are adjusted for use in the field the size of the contact patch increases. A larger number of lugs are in contact with the ground, which improves traction and results in reduced fuel consumption.



Test results show fuel savings of up to 20%*

During field studies, Michelin and the South Westphalia University of Applied Sciences demonstrated the connection between tyre pressure and fuel consumption.

* Source: South Westphalia University of Applied Sciences, Soest, Germany

Impact on working time

Slippage results in lost time for farmers, because when the wheels spin, the tractor moves forward more slowly.

Lower tyre pressure means less lost time

Tyre pressure that is adjusted to working conditions in the field lengthens the ground/tyre contact patch. With more lugs to grip the ground, traction is delivered more effectively.

Test results show time savings of up to 20%*

A 50% decrease in tyre inflation pressure – from 1.6 to 0.8 bar – results in a 20% increase in driving speed and a corresponding reduction in work time.

Therefore, if:

- A tractor's operating costs are €50 / hour
- and the time to till 1 hectare is 1 hour
- a saving of €10 per hectare is possible

➔ Giving a total of €2,000 with just one pass over a 200 hectares area

* Source: South Westphalia University of Applied Sciences, Soest, Germany

MICHELIN Ultraflex Technologies

While low tyre pressure is beneficial for the soil, it is generally harmful for tyres made with conventional technology whose casing has not been designed for repeated flexing.

However, tyres made with MICHELIN Ultraflex Technologies have an especially robust, long-lasting casing that allows for more flexing and bending which can be used at lower inflation pressures. This section explains MICHELIN Ultraflex Technologies and outlines the range of tyres available.

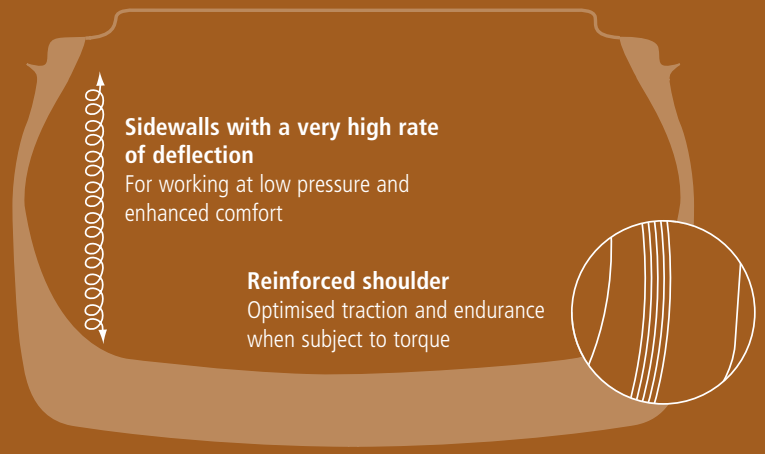
MICHELIN Ultraflex Technologies

To avoid soil damage by compaction, the inflation pressure of conventional tyres must be adjusted depending on the load and driving speed. This means the tyre pressure often needs to be changed, depending on whether the tyres are used in the field or on the road. Many farmers do not adjust tyre pressure and opt for a compromise between the two.

MICHELIN Ultraflex Technologies provide a solution that enables tyres to operate with the same pressure on the road and in the field. Thanks to its special casing, the tyre is more resistant to flexing in service and is able to carry loads on road at field imposed pressures.

The casing's flexibility increases the tyre footprint and the number of lugs in contact with the ground, which improves traction.

Tyre cross-section:



Benefits:

- Less soil compaction thanks to a larger ground/tyre contact patch and reduced slippage.
- Fuel savings when used in the field thanks to improved traction.
- Time savings in the field thanks to less slippage.
- Overall time saving as there is no need to adjust tyre pressure between the field and the road.
- Greater longevity, even at low pressure, thanks to a robust casing.

MICHELIN ULTRAFLEX TECHNOLOGIES Patented

Protecting soil throughout the year

In every phase of crop farming, the soil is severely tested by increasingly heavy machinery. Tyres made with MICHELIN Ultraflex Technologies are available for all types of farm equipment.

For more information, please contact your MICHELIN advisor or your tyre dealer.

For tractors from 80 to 220 hp: the MICHELIN XeoBib

The MICHELIN XeoBib is designed for tractors from 80 to 220 hp. MICHELIN Ultraflex Technologies **not only protect the soil** but also provides:

- **Fuel savings***, thanks to improved traction and reduced slippage
- Excellent **longevity**, even at low pressure*, thanks to a robust casing
- Up to **40% more load capacity** at identical inflation pressure*
- **Time savings***, thanks to a high level of traction and reduced slippage
- **Precision steering** and **safe braking***, even at low pressure
- Excellent driving **comfort**, even at low pressure*

* Compared with the MICHELIN MultiBib, which integrates conventional tyre technology

For tractors over 250 hp: the MICHELIN AxioBib

In addition to **protecting the soil** with its larger contact patch and **saving time** thanks to its superior traction the MICHELIN AxioBib also provides:

- Improved **fuel savings***, thanks to a high level of traction and reduced slippage
- Excellent **longevity**, even at low pressure*, thanks to a robust casing
- **20% more load capacity** at identical inflation pressure*
- **Precision steering** and **safe braking***, even at low pressure
- Excellent driving **comfort**, even at low pressure*

* Compared with the MICHELIN MachXBib, which integrates conventional tyre technology

For harvesters: the MICHELIN CerexBib

At harvest time, equipment must perform at very high levels in all types of weather. The MICHELIN CerexBib and MICHELIN Ultraflex Technologies deliver **outstanding safety** performance, even in difficult conditions, while **protecting the soil**. At the same time, they provide:

- Up to **40% more load capacity** at identical inflation pressure*
- **Improved fuel savings***, thanks to a high level of traction and reduced slippage
- Excellent **longevity**, even at low pressure*, thanks to a robust casing
- Improved **performance on slopes** thanks to a high level of traction
- Better **mobility on roads** thanks to narrower tyres that enable harvesters, at comparable load capacity, to comply with maximum width limits for road transport

* Compared with the MICHELIN MegaXBib, which integrates conventional tyre technology

For sprayers: the MICHELIN SprayBib

The MICHELIN SprayBib **reduces soil compaction** for self-propelled sprayers. MICHELIN Ultraflex Technologies enable machines to operate at constant lower pressure and greater **load capacity** while also providing:

- Enhanced **soil protection*** thanks to a footprint that is up to 16% larger*
- Up to **40% more load capacity** at identical inflation pressure*
- Excellent **longevity**, even at low pressure*, thanks to a robust casing
- **Time savings***, thanks to superior traction and reduced slippage
- **Precision steering** and **safe braking***, even at low pressure
- Excellent driving **comfort**, even at low pressure*

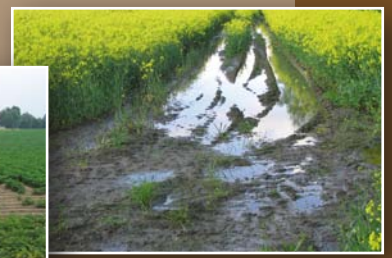
* Compared with the MICHELIN AgriBib Row Crop, which integrates conventional tyre technology

In summary:

Problem: Soil damage due to compaction

1. Soil compaction caused by the repeated passage of heavy farm machinery.
2. Compaction has a long-term negative impact on the circulation of air and water.
3. A weakened moisture system and reduced air exchange are harmful to crop growth.

Consequence: Productivity and crop yield are reduced over the long term.



Solution: Optimise machine working and tyre choice and adjust tyre pressure

1. Before using heavy machinery, check the load bearing capacity of the soil.
2. Drive on dry soil whenever possible.
3. Minimise the number of passes and use a wide work area when harvesting, labouring and tilling the soil.
4. Use modern work methods, such as tilling without turning the soil.
5. Key recommendation: use the right tyre pressure when working in the field.

Low tyre pressure not only protects the soil; it also guarantees superior traction and consequently improved profitability.

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