Åtgärder mot markpackning
Reducing the risk of soil compaction

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How can we reduce the risk of soil compaction?

Soil stress

Soil strength

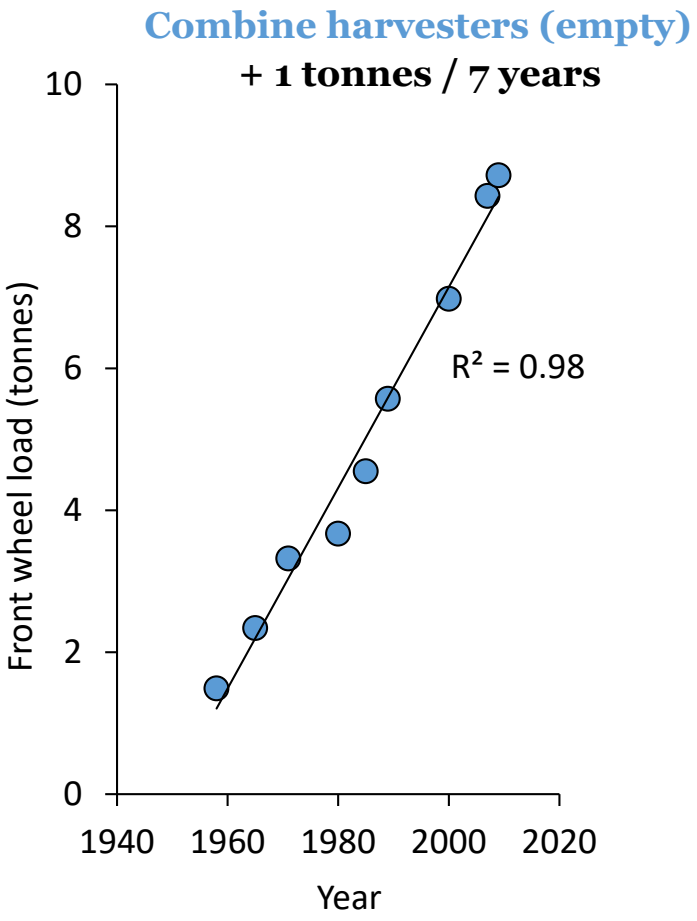
Reduce soil stress

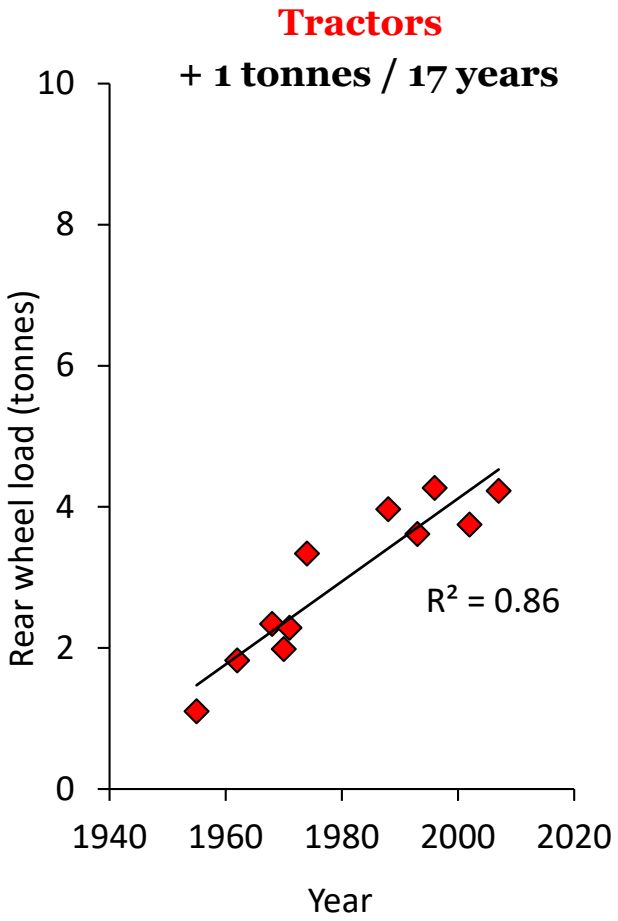
Increase soil strength

Stress > strength → Residual deformation = ***Compaction***

Stress ≤ strength → At most, only elastic deformation

Wheel-loads have been increasing over time

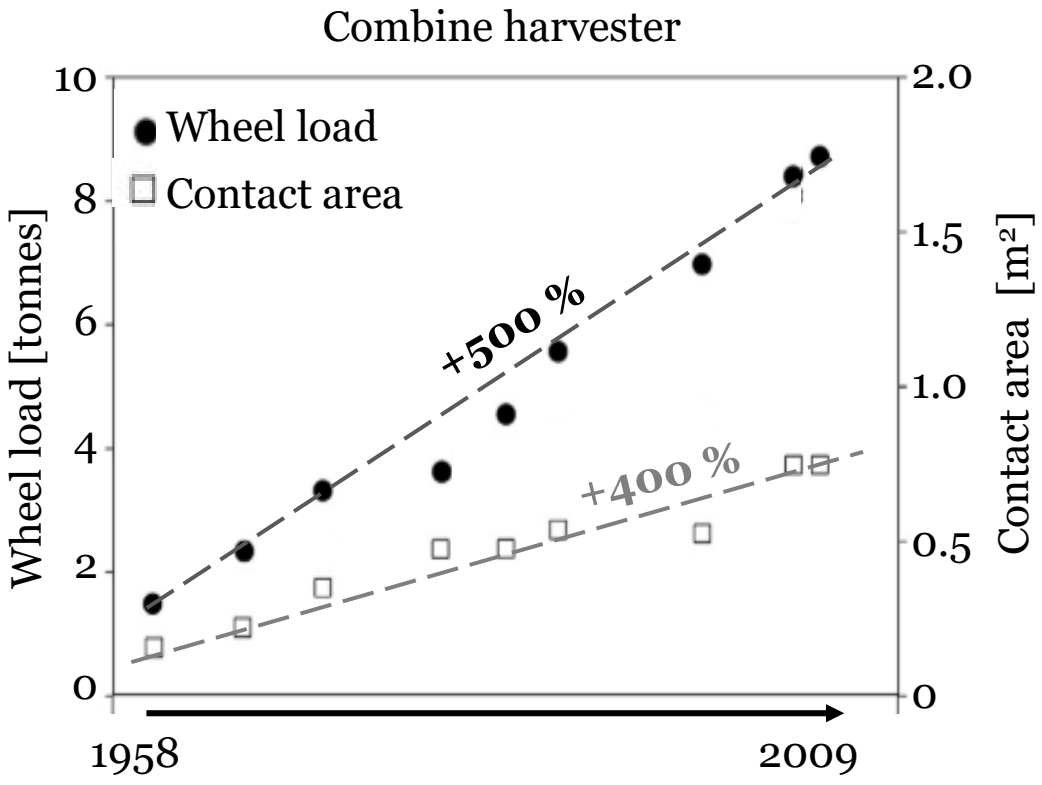




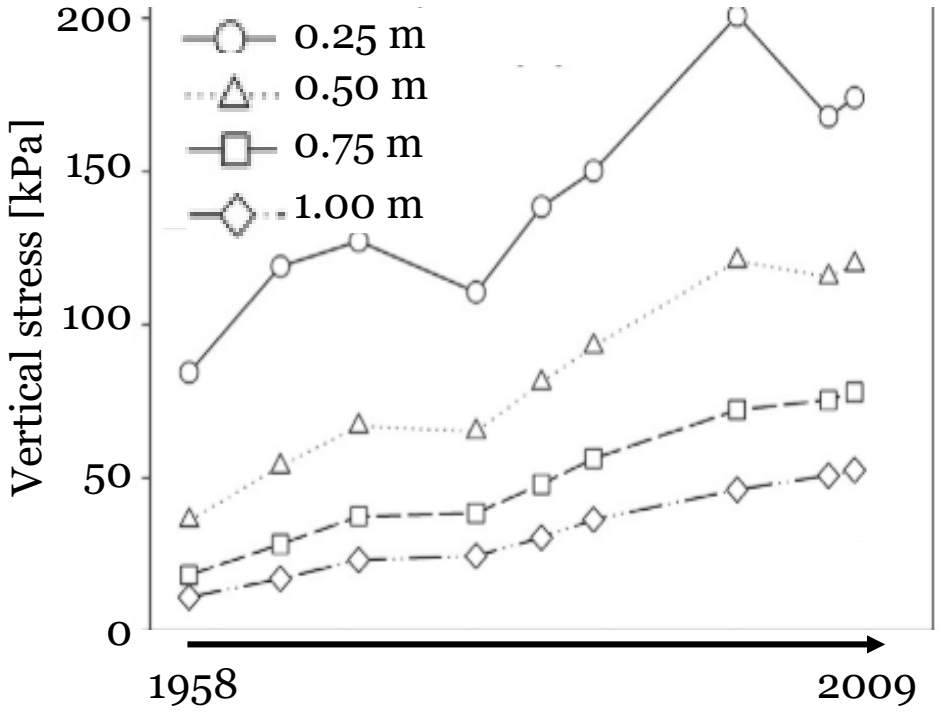
Landbrugsavisen 3rd September 2019

Keller et al. (2019), STILL 194

Higher wheel loads increase the risk of subsoil (*alv*) compaction



Schjønning et al., 2015



Schjønning et al., 2015

Decision on loading characteristics influences risk of soil compaction

Tyres

Tracks

Nr. wheels

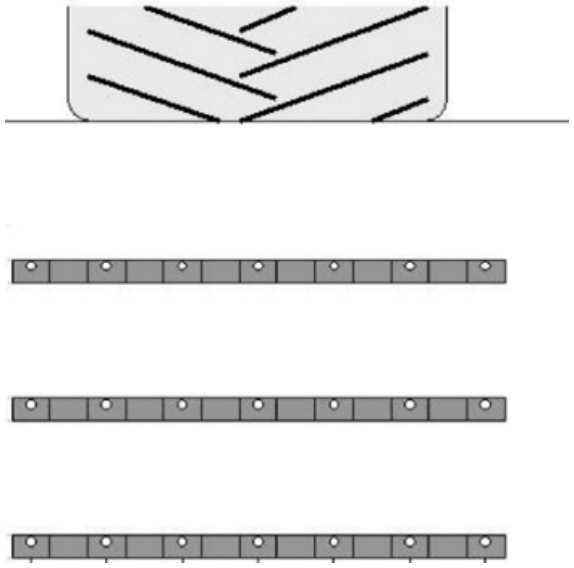
How?

Effect of tyre developments

Dimensions, inflation pressure and construction

SCIENCE AND EDUCATION FOR SUSTAINABLE LIFE

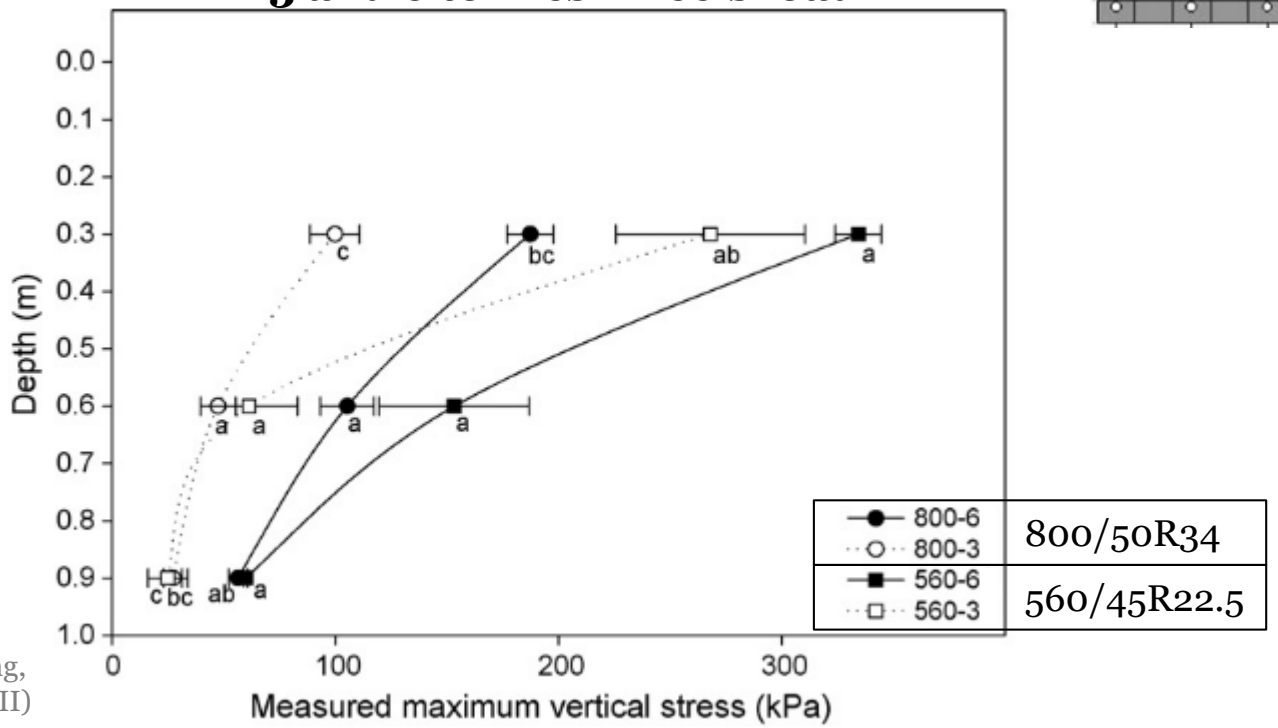
Wider tyres reduce vertical stress



A larger tyre means:

1. Larger tyre-soil contact area
2. Lower peak stresses in contact area
3. Lower stresses in the soil
4. Limited effect at depth

3 and 6 tonnes wheels load



Lamandé & Schjønning, 2011, STILL 114 (part II)

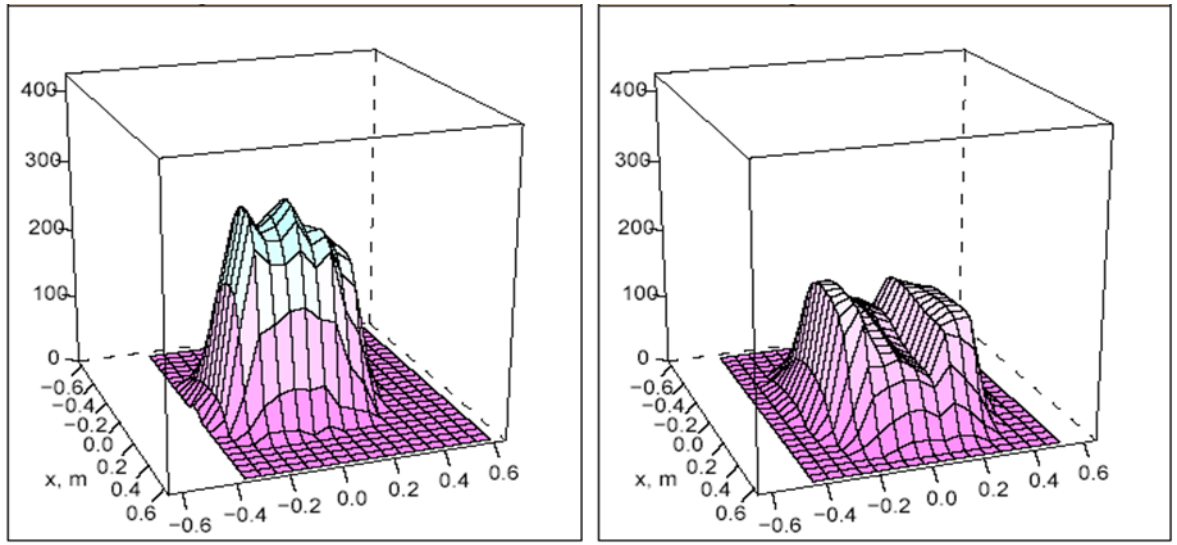
Lower inflation pressure reduce vertical stress

Lower tyre inflation pressure means:

1. Larger contact area
2. Lower peak stresses in contact area
3. Lower stresses in the soil
4. Limited affect at depth

650/65R30.5, 6 tonnes wheels load

2.4 bar **1.0 bar**



Schjønning et al., 2008, Bios. Eng., 99

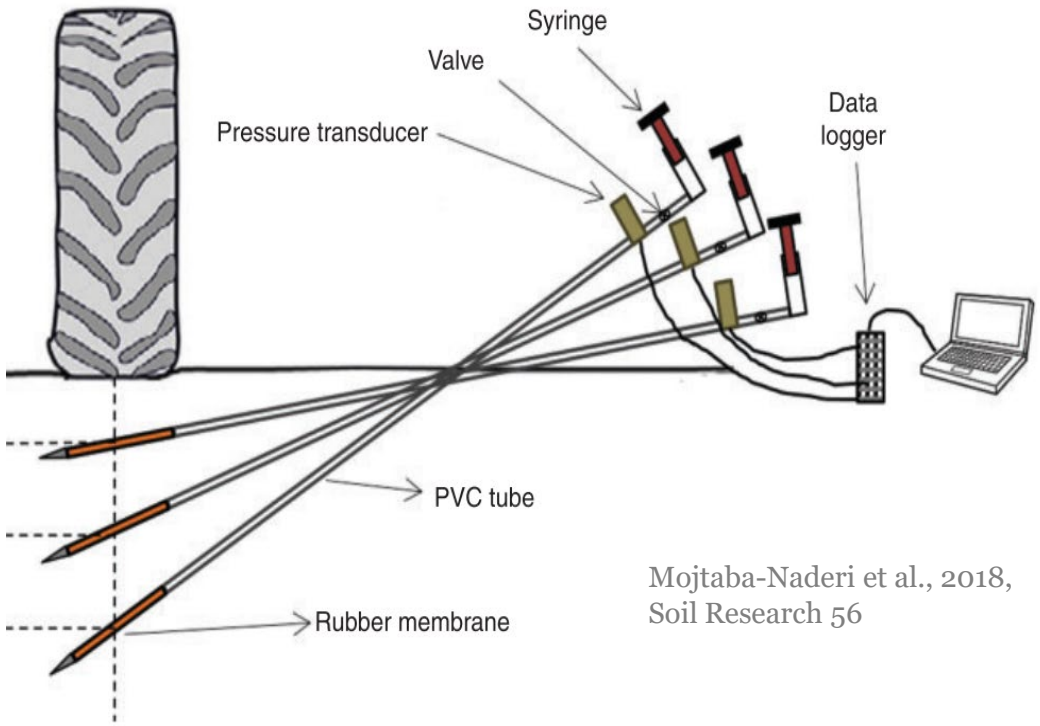
Tyre construction – effect on contact and soil stress?

Differences in construction, e.g.:

1. Tyre type: orientation of the plies (diagonal/bias or radial)
2. Flexion technologies: e.g. standard, IV, VF
3. Workload: steel belted

Stress measurements

1. Five generations tractor tyres (< 1970s – 2018)
2. At similar wheel loads: 4.3 tonnes (rear)
3. At inflation pressures: 2.4 – 0.6 bar



Mojtaba-Naderi et al., 2018, Soil Research 56

Newer (designed) tyres reduce soil stress

Mean normal stress, σ_m , under centreline rear tyres

1. Reduced for newer tyres

Not tyre construction *per se*

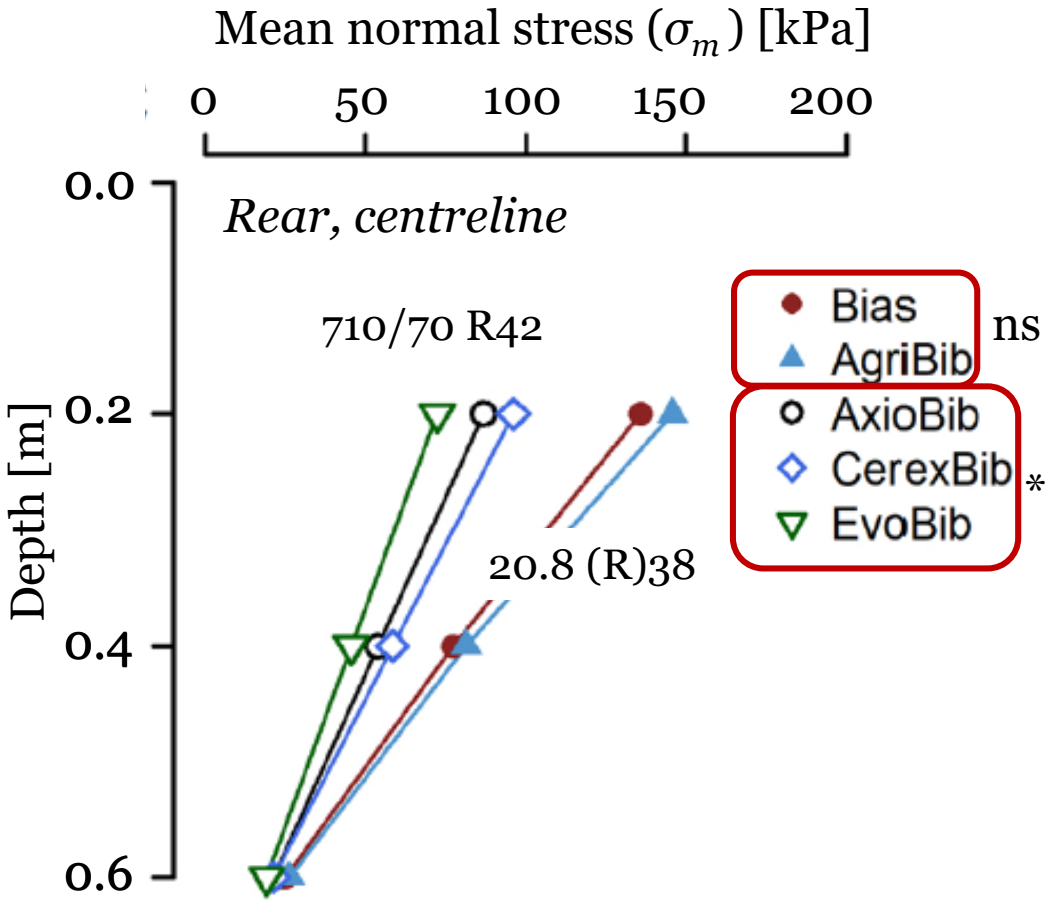
1. No differences in stress at similar inflation pressure

   Small, standard (at 2.4 bar)

   Wide, low-inflation pressure (at 0.8 bar)

Different tyre construction meant:

1. Not much, unless:
2. Improved better stress distribution;
   1. Lower inflation pressure;
   2. Larger tyre-soil contact area



Ten Damme et al., 2020, STILL 204

More wheels

At the same axles (dual/twin),
or at more axles (tandem)

Benefit of more wheels: lower wheel load

Lower wheel load allows for lower inflation pressure, but …

1. Act multiple tyres as one very large and heavy tyre?
    1. Measurements showed: as multiple, more or less similar tyres
2. What about the ‘multipass effect’ (tandem)?

Dual/twin wheels

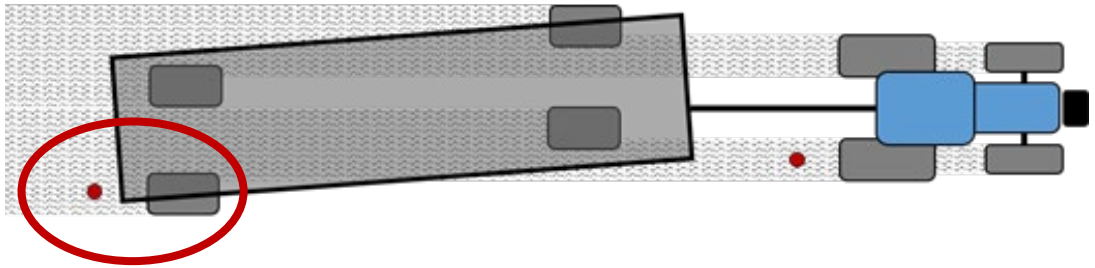
Tandem wheels

Multipass effect can increase soil compaction

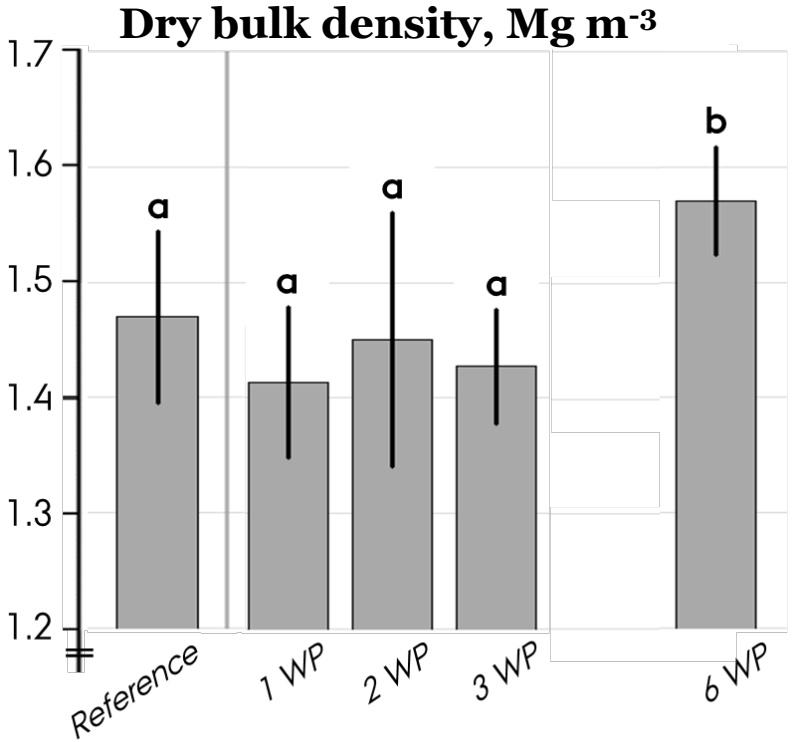
Repeated wheeling of one trailer wheel

(0), 1, 2, 3 and 6 passes

Wheel load = (N*) 5.5 tonnes



More studies to understand the effect of repeated loading are carried out.



Ten Damme et al., 2021, STILL 213

Ways to reduce number of wheel passes

1. No trailer
2. Self-propelled three wheelers
3. Dogwalk/crabwalk/offset steering


desamenwerkingbv.nl

Schjønning et al. (2016)


vredo.com

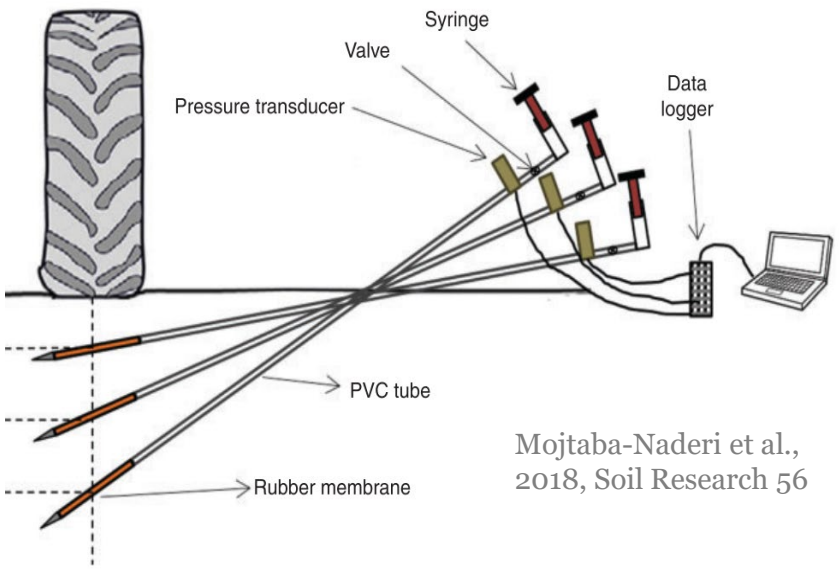
Tracks

Versus tyres

The effect of track versus tyre on soil stress

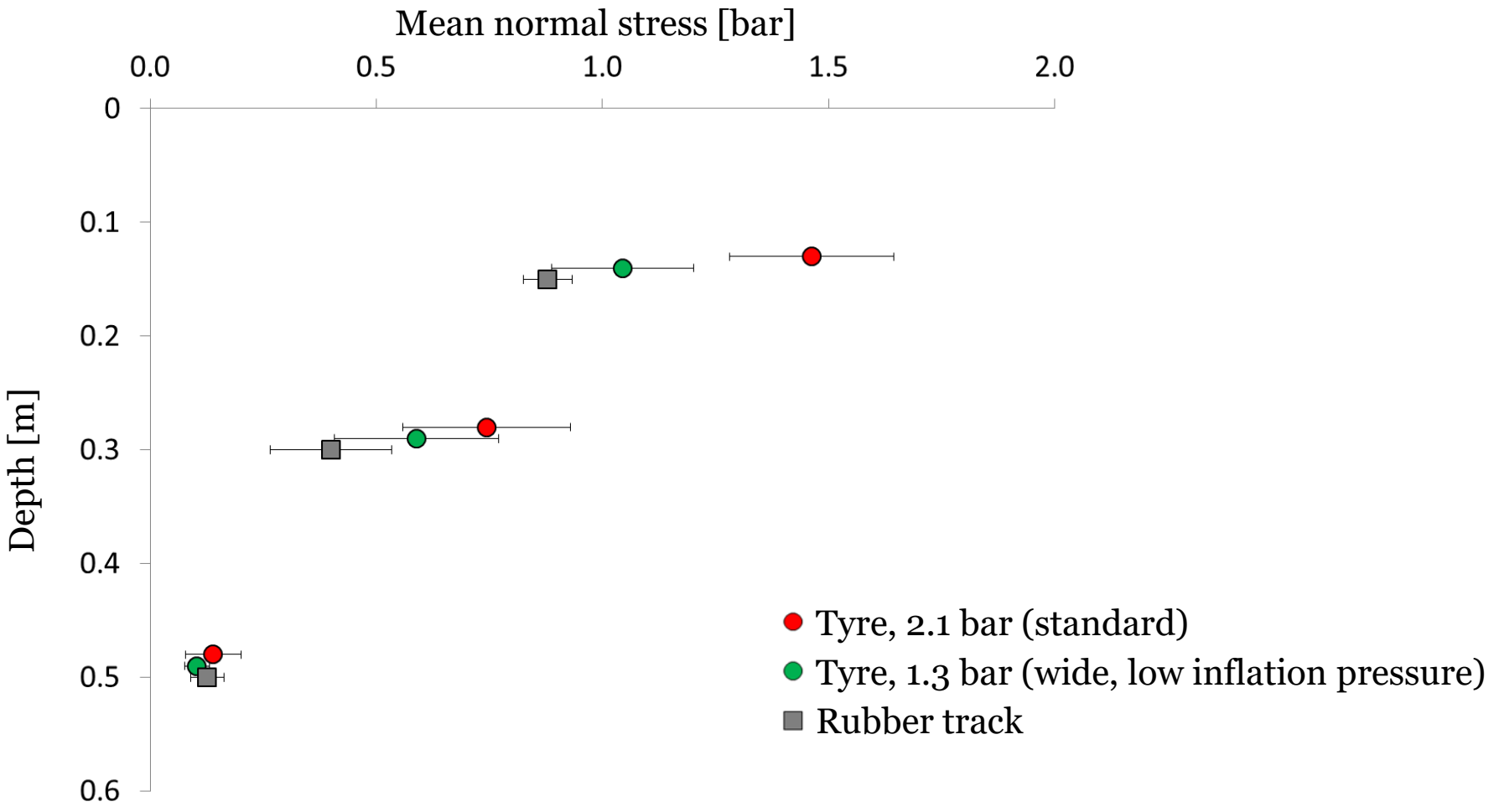
1. Rubber track: 1.93 m long, 0.65 m wide
2. Tyre: 900/60 R32 at 2.1 bar (standard tyre)
3. Tyre: 900/60 R32 at 1.3 bar (wide, low inflation pressure tyre)

Wheel load = 6 tonnes



Mojtaba-Naderi et al., 2018, Soil Research 56

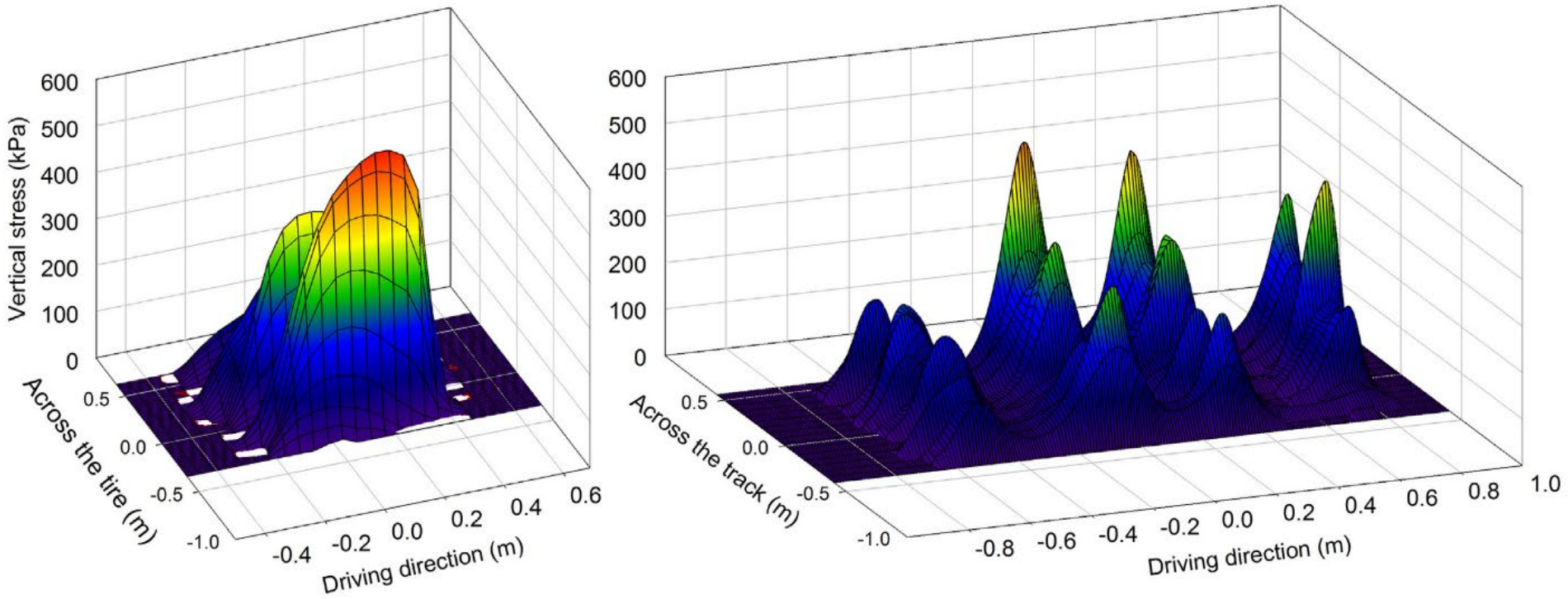
Choice of ‘rolling gear’ matters, especially in upper part soil profile



Vertical contact stress distribution for tyre and rubber track

Tyre
10.5 tonnes, 0.61 m²
Max. stress: 653 kPa

Rubber track
12 tonnes, 1.27 m²
Max. Stress: 529 kPa



Lamandé et al. (2018), Catena 167

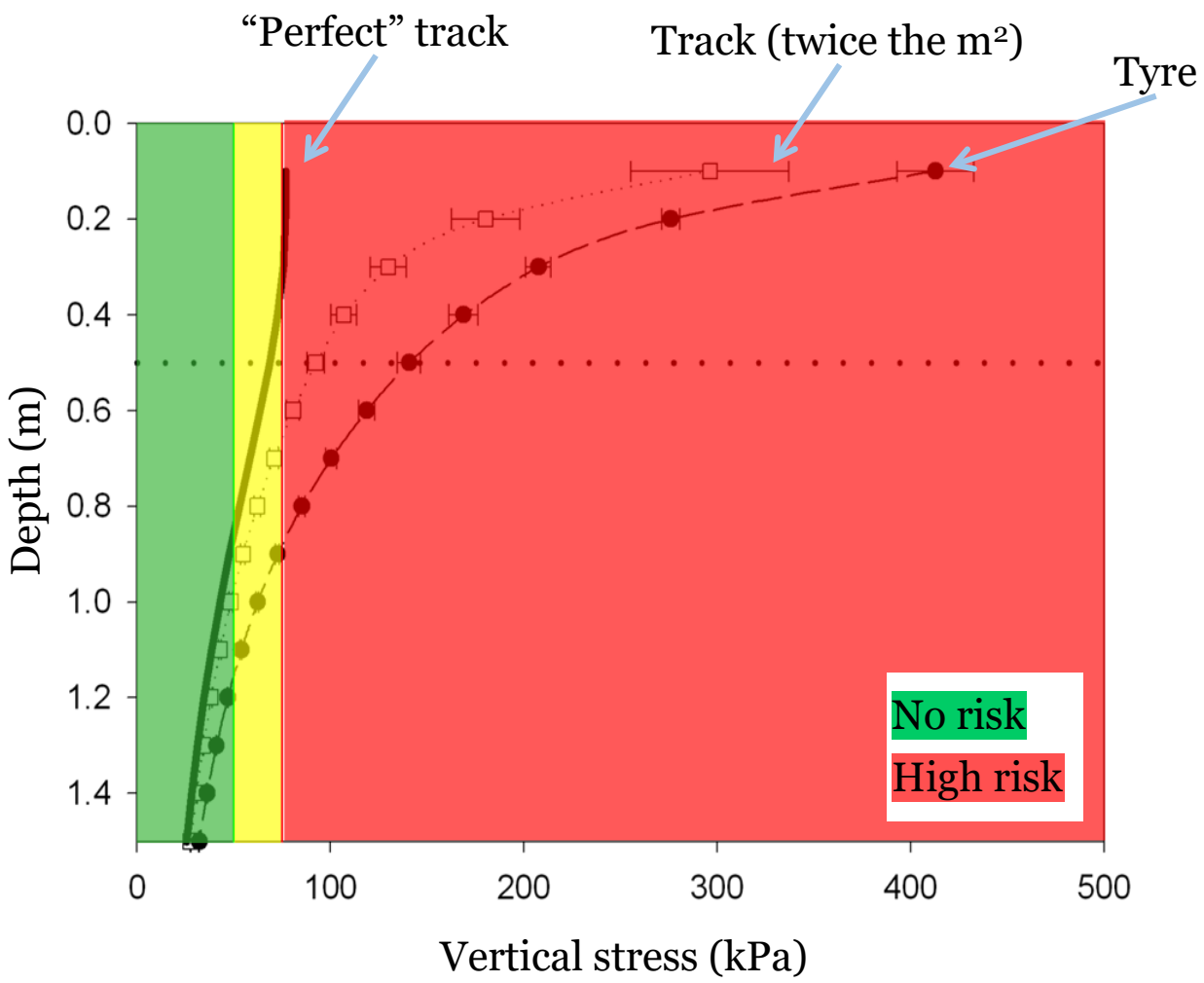
Tracks are not yet optimal

Tracks can be good, but are not yet perfect.

1. Need the distribute load *well* over large contact area
2. Stress versus soil response
    1. Effects of traction / loading time?

Depth		ρ_b	k_a
m		g cm^{-3}	μm^2
0.13–0.17	Tire	1.44	9.21
	Rubber track	1.45	5.49
		P = 0.954	*P = 0.273*
0.33–0.37	Tire	1.56	20.3
	Rubber track	1.55	7.92
		P = 0.742	*P = 0.041*

Lamandé et al. (2018), Catena 167



What else can we do?

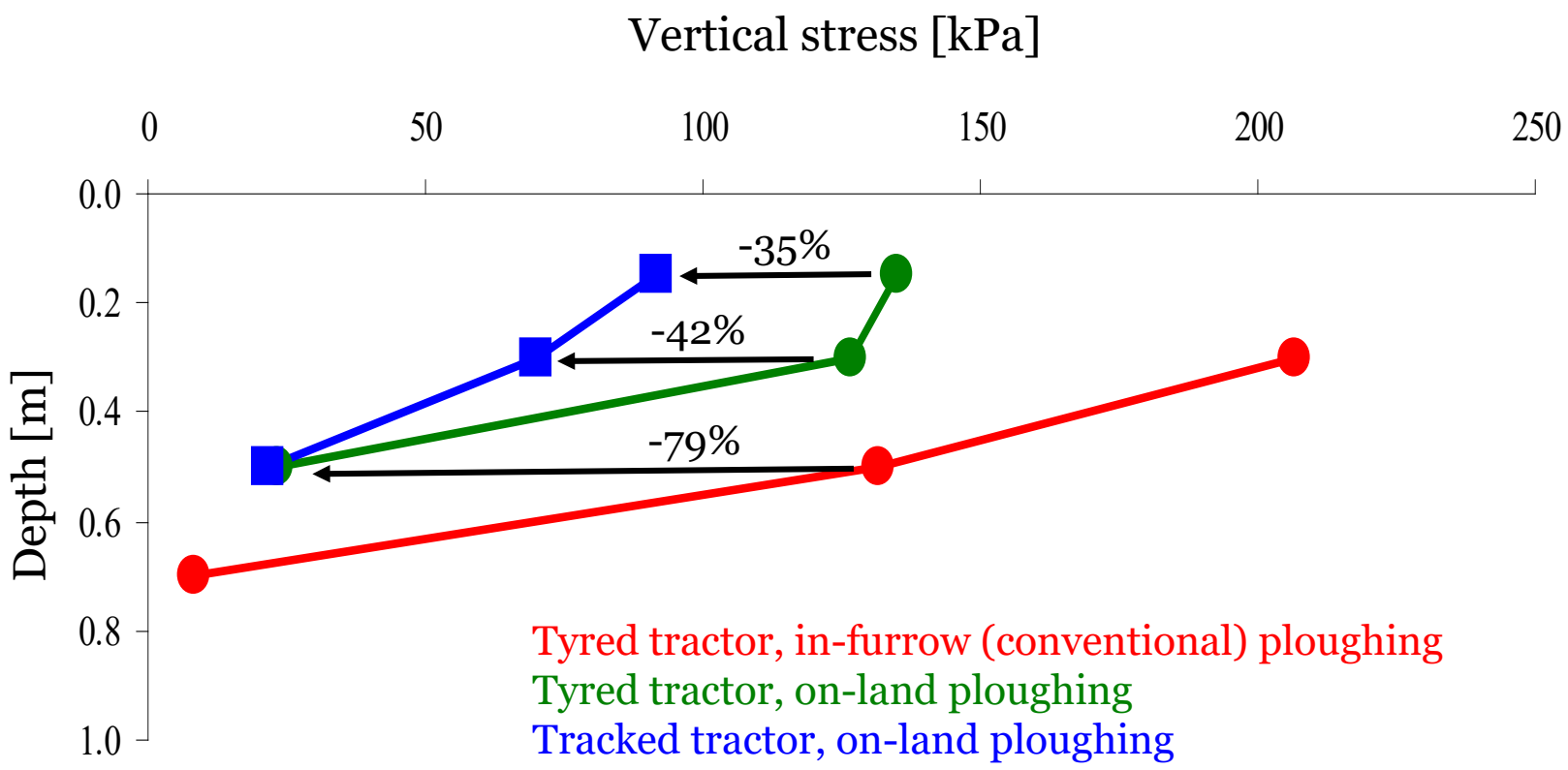
What can we do when ploughing?

Tyred: in-furrow ploughing
(conventional, one side in the furrow)

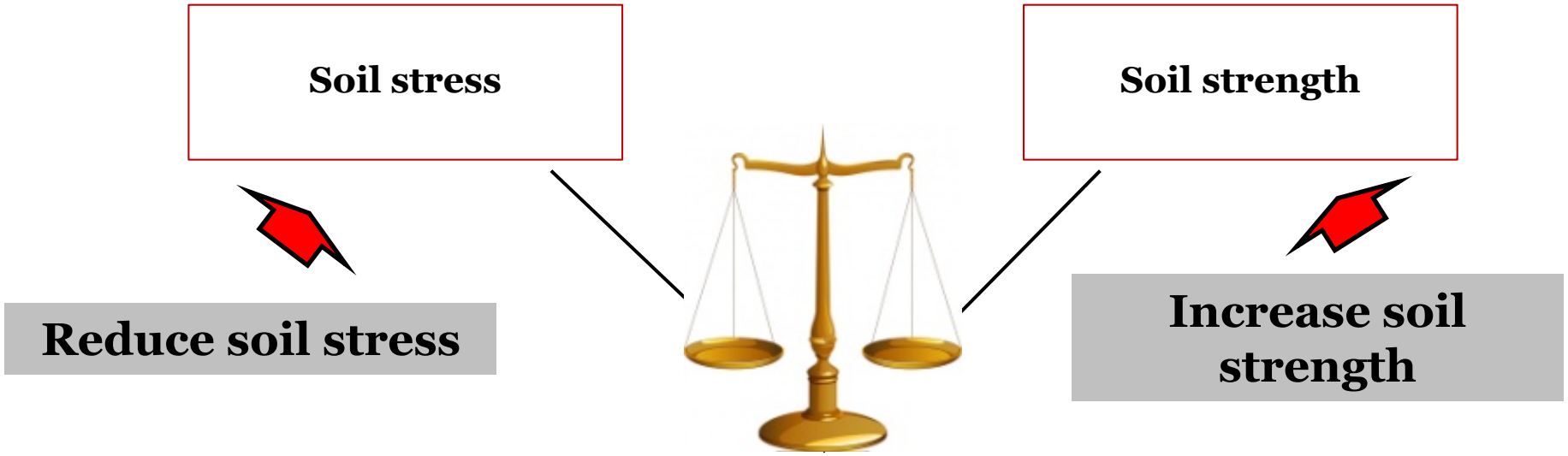
Tyred: on-land ploughing

Tracked: on-land plouging

Soil stress during ploughing

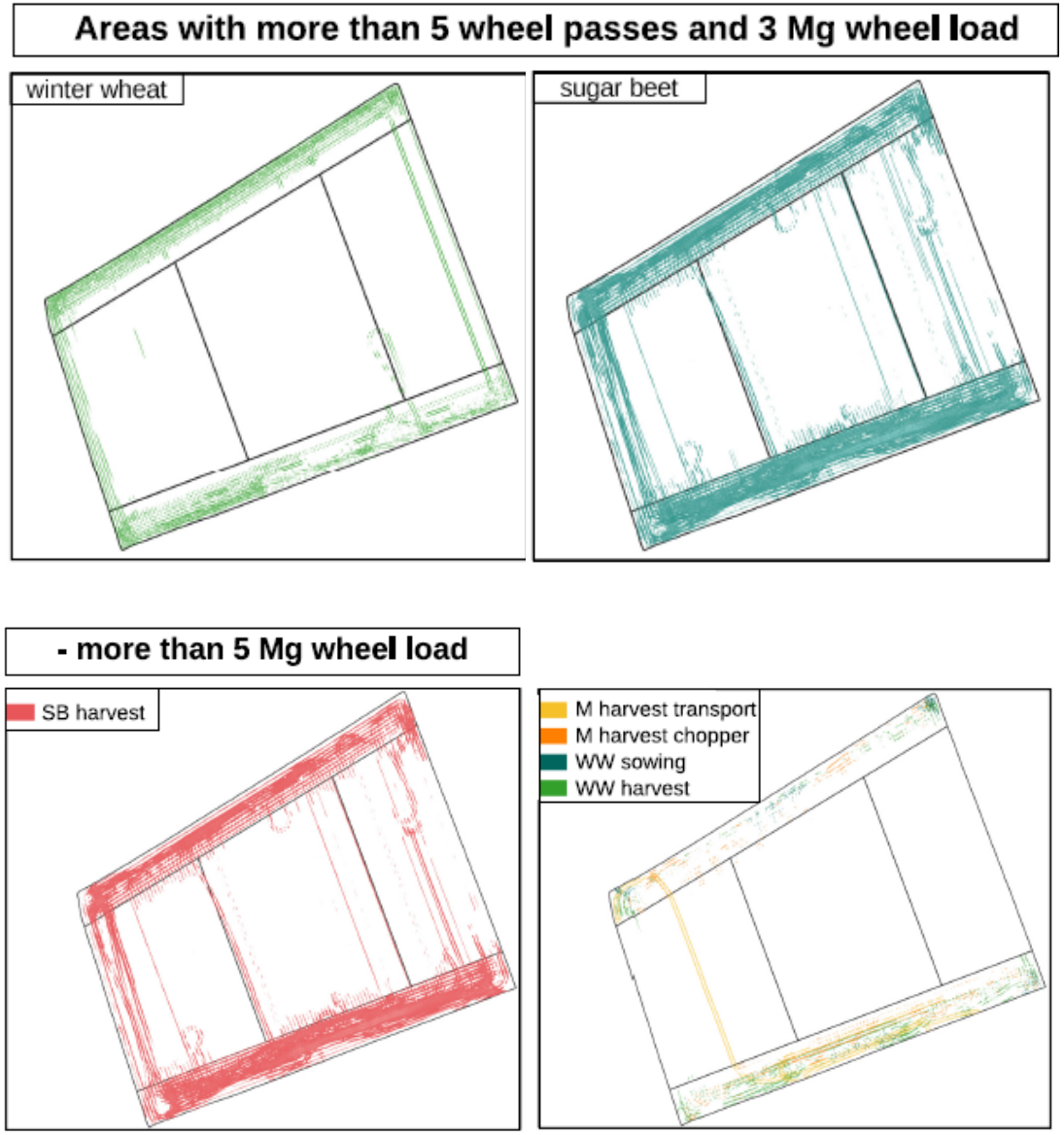


How can we reduce the risk of soil compaction?



Consider field traffic

1. How many and which field operations per year?
2. How much of the field is driven on?
3. With what wheel load?
4. At which field conditions?



Augustin 2020, Geosciences 10

Åtgärder mot markpackning

Given the current, common high wheel loads…

(Tracked) on-land plouging

Distribution not yet optimal, unknown effect loading time / traction

Large tyres, regulate inflation pressure

Always:

1. Limit wheel loads
2. Avoid driving in too wet conditions (reconsider crop rotation?)

Multipass effect?

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