David White - practical ways of assessing structural demage and how to remove it

Practical ways of assessing structural damage and how to remove it

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Options for compaction reduction

Controlled traffic

After: Tullberg et al. 2003 *Source: CTF Europe*

Reduced pressure/axle weight and central tyre inflation pressure control systems

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Outline

Traction

Tillage

Planting a crop this year

Concluding remarks

Wheels

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Tracks

Our ancestors knew something - keep off the soil.

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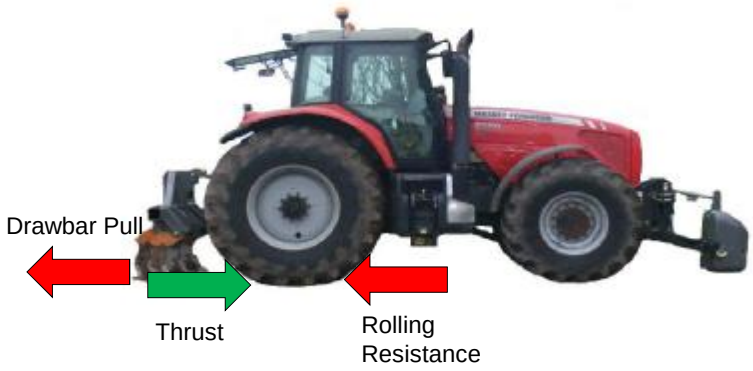
Traction

- Thrust is a force which arises from the interaction between a track or wheel and the soil.



The bigger the drawbar pull, the bigger the wheel/track thrust needed.

Thrust depends on:

- The weight on the wheel or track
- Soil cohesion
- Soil friction
- Tyre track contact area
- Slip

Most agricultural soils in the UK have both cohesion and soil/soil friction and, therefore, benefits can be gained in traction terms from increasing both weight and contact area

Ways of increasing tyre contact area

- Tracks
- Dual tyres
- Wide tyres
- Large diameter tyres
- Extra axle
- Lower tyre pressure
- Radial tyres

Ballast

- Wheel weights
- Front end weights
- Partly fill tyres with water
- Dynamic weight transfer – attach the implement to the tractor as per the instruction manual.

Note

- You can over ballast tractors.
- Aim for correct wheel slip i.e. between 8 and 15 %.

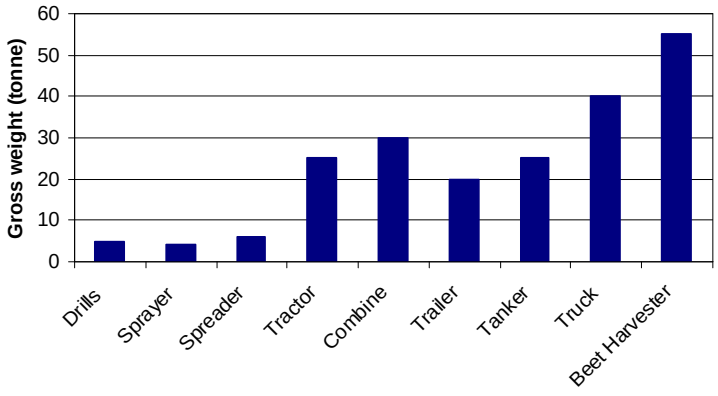
Drawbar Power = Pull X Speed

Conclusion

- Slow and high drawbar force (very wide implement) requires large wheel thrusts.

Heavy loads

Maximum gross weight of vehicles:



After: Erickson et al 1974
Updated by Godwin 2007

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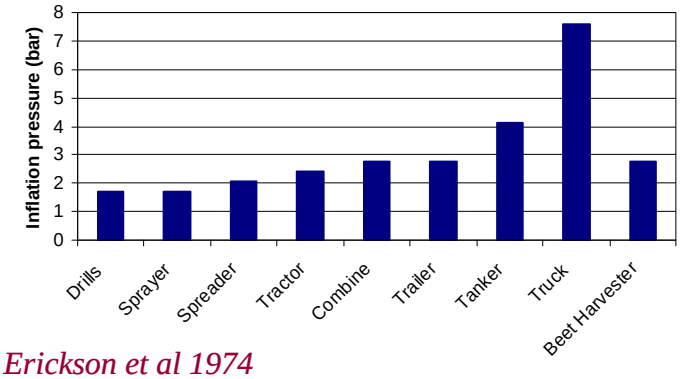
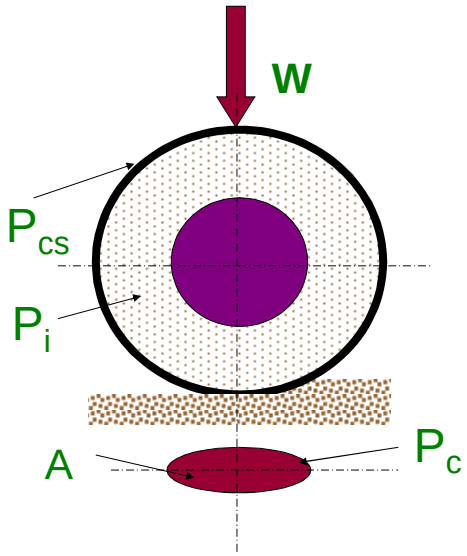
Maximum tyre inflation pressure of vehicles:



After: Erickson et al 1974
Updated by Godwin 2007

Tyre load and inflation pressure



$P_c = W / A$

P_c – contact pressure
W – tyre load
A – tyre contact area

$P_c = P_i + P_{cs}$

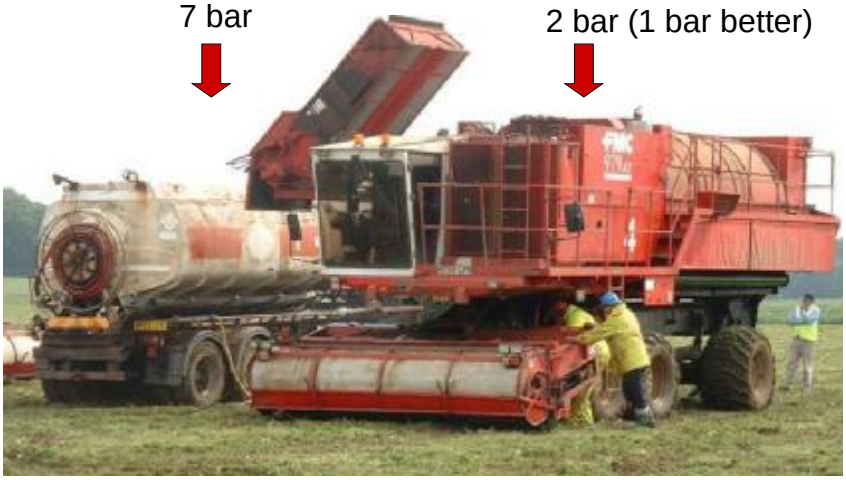
P_i – inflation pressure
P_{cs} – tyre carcass stiffness

- Large contact area
- Low load
- Low tyre stiffness
- Low contact pressure
- Uniform contact pressure

Compaction issues

20 + tonnes
7 bar

25 tonnes
2 bar (1 bar better)



Conclusion

Do not allow vehicles with high inflation pressure tyres in the field

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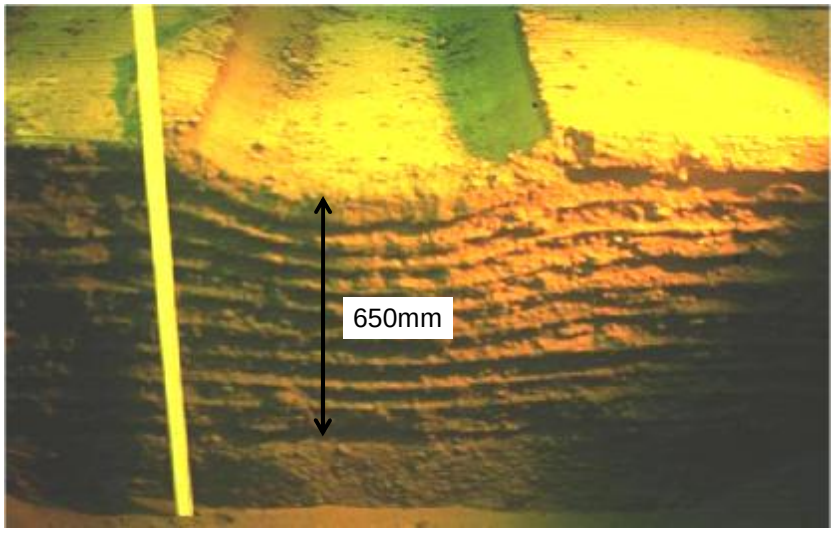
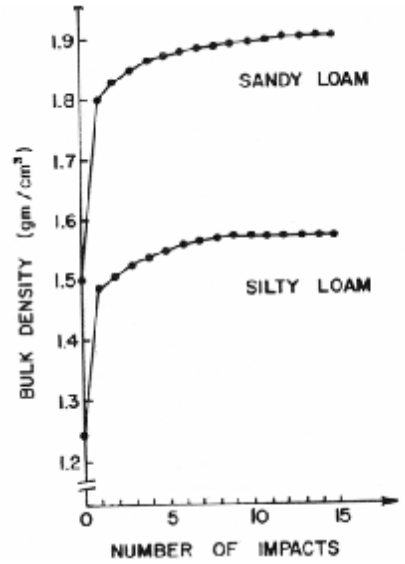
Deeper compaction



Conclusion

Compaction at this depth is difficult to remove, avoid putting it there in the first place.

Compaction of soil by repetitive loads



First pass causes the most compaction. Controlled wheeling is better than random wheeling.

Conclusion

- The first pass of a wheel, or track, does the most damage. Further passes only add a bit more compaction.
- Make as few passes over the field as possible.

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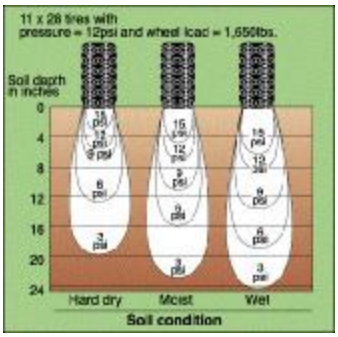
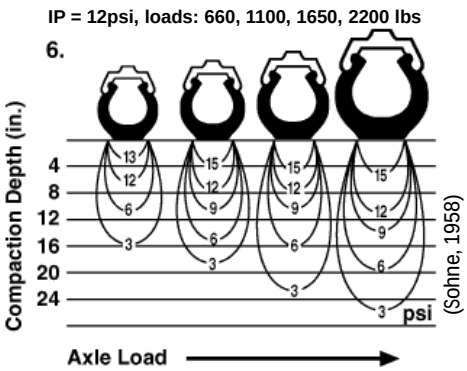
Contact pressure below tyres



(Sohne, 1958)



(Sohne, 1958)

- Large contact area
- Low load
- Low contact pressure
- Uniform contact pressure

Conclusion

- Reduce tyre pressures to lowest recommended by manufacture for given load.

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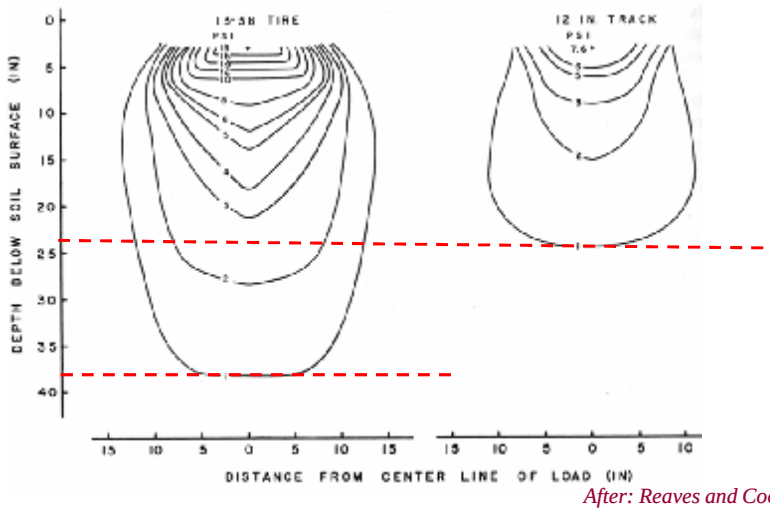
Normal stress under a track & tyre



After: Reaves and Cooper 1960

Tillage

- If a tillage operation is not going to be of benefit do not do it.

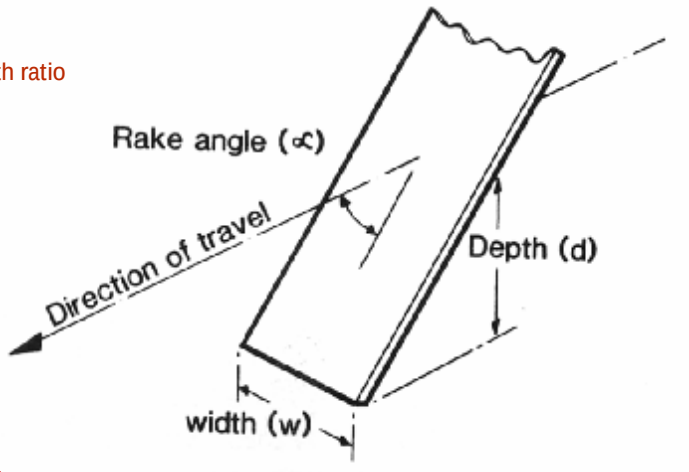
Aims Of Tillage

- Prepare a suitable growing medium for a crop (Germination, emergence, action of herbicides)
- Bury/incorporate surface residues/fym
- Remove local or general soil compaction problems (promote drainage).
- Provide adequate soil strength to support surface traffic.

Tine geometry and soil disturbance

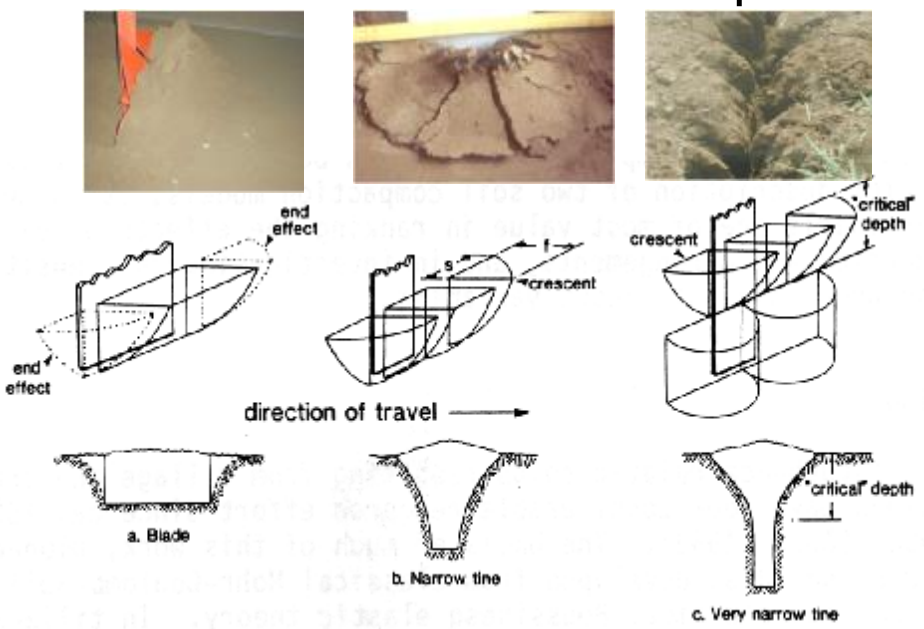
2 key factors:

1.Rake angle
2.Depth/width ratio



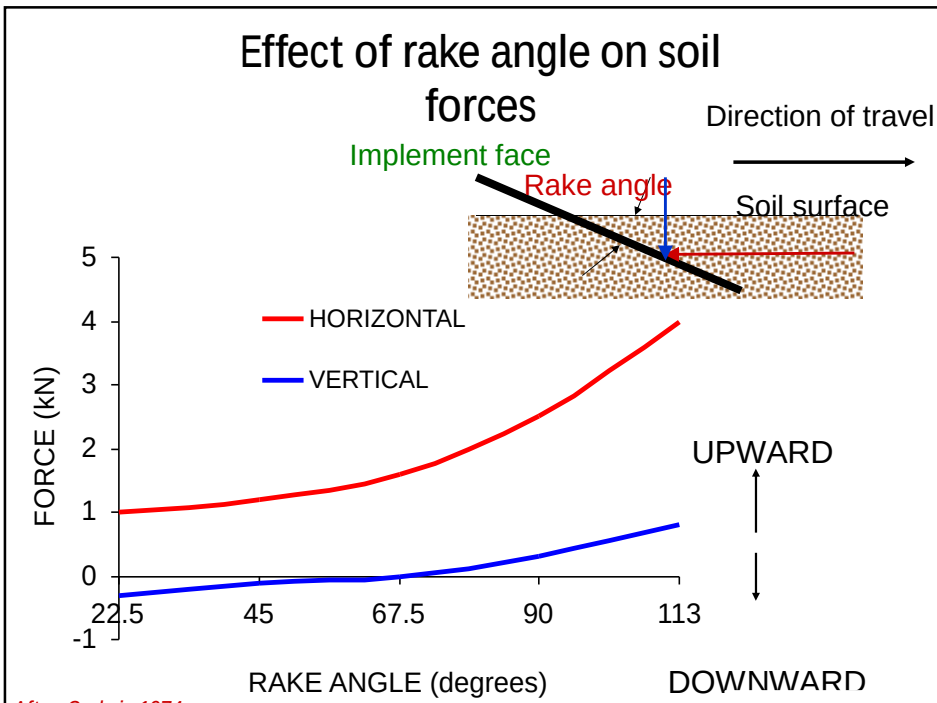
After: Godwin, 1974

Soil failure patterns



Depth/width = < 0.5 > 1 to < 6 >6

Effect of rake angle on soil forces

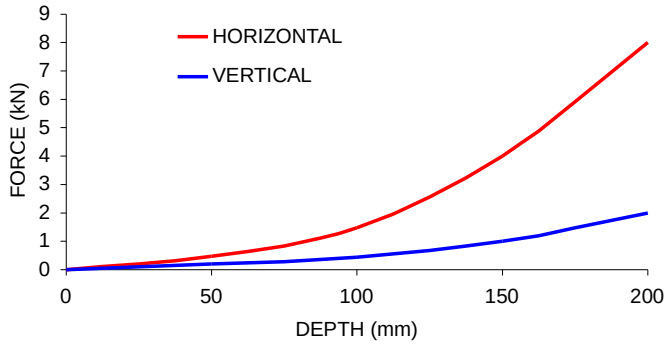


After: Godwin 1974

Conclusion

- Backward inclined tines need more force to pull them than forward inclined tines at the same depth (therefore, more wheel thrust, more ballast).
- Consider lifting out backward inclined tines on drills, tillage trains, etc. under adverse soil conditions

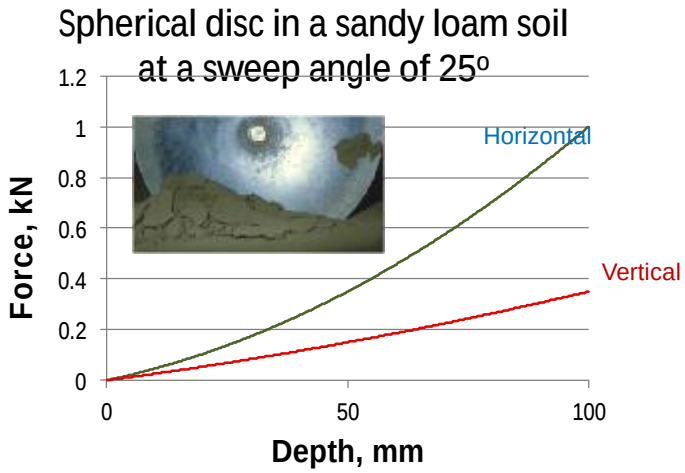
Effect of depth of tine on soil forces



Rule of thumb: double depth, quadruple draft

After: Godwin 1974

Effect of depth of work on disc forces

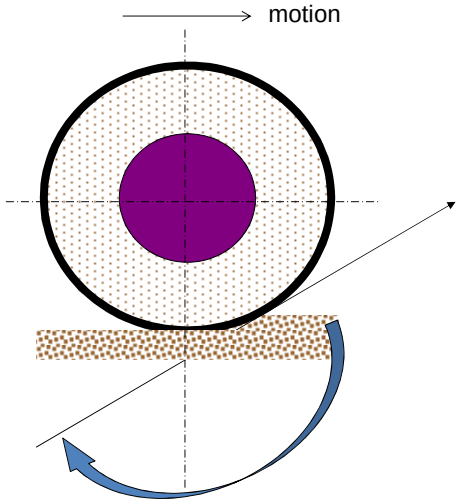


From: Godwin et al,1987

Conclusion

- Doubling the working depth, approximately quadruples the drawbar force.

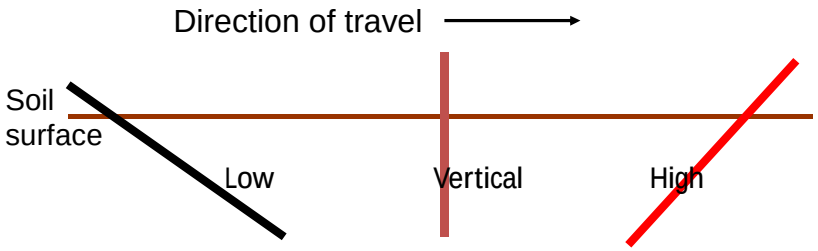
A wheel is a backward inclined tine



Conclusion

- Wheels cause compaction.

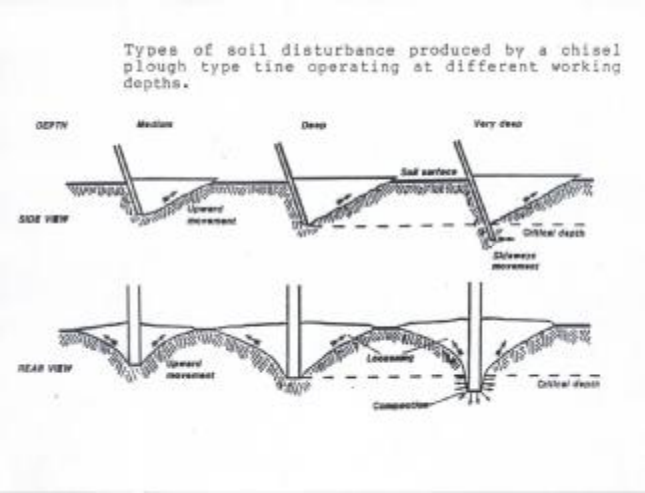
Selection of implement rake angle for tillage operations



Operation:	Loosening Cutting Inverting Smoothing	Sorting Disintegrating Rearranging Consolidating	Compacting Disintegrating
e.g.:	Chisel tines Plough shares Bulldozer blades	Harrows - drag - power	Rollers Scrubber boards Pneumatic tyres

After: Spoor, 1968

Critical depth



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As a general rule of thumb, critical depth occurs at approximately six times the individual loosening tine's width for friable soils; for example, a tine foot that is 8 cm in width, will have a critical depth of around 48 cm.

For plastic soils this can almost come to the soil surface.

(Godwin, 1975)

Conclusion

- Check what the implement is actually doing.

Worn components

Conclusion

- Using worn components is false economy.
- They will produce a poor job and possibly need a higher drawbar pull.

Subsoiling

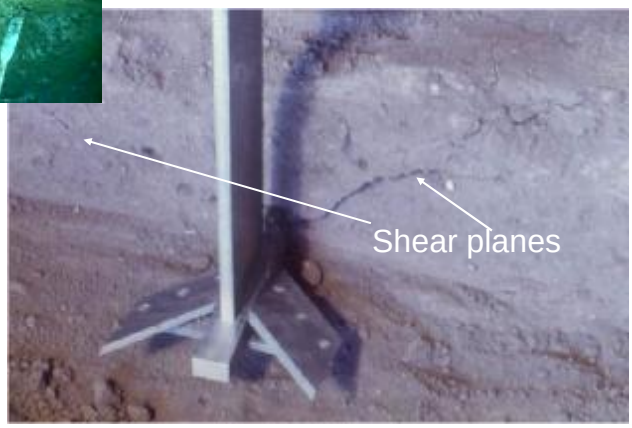
Plain tine

Wide point, high lift wing

Narrow point, low lift wing

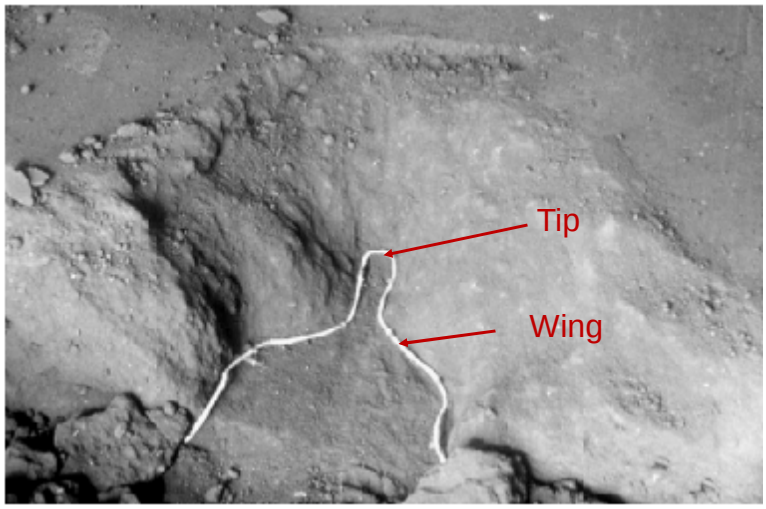
After: Spoor and Godwin, 1978

Effects of winged tines



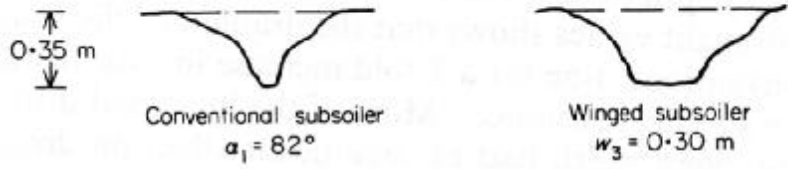
After: Spoor and Godwin, 1978

Total soil disturbance



After: Spoor and Godwin, 1978

Effect of wings



Draught	20.43 kN	26.58 kN
Disturbed area	0.098 m^2	0.184 m^2
Specific resistance	208 kN/m^2	144 kN/m^2

After: Spoor and Godwin, 1978

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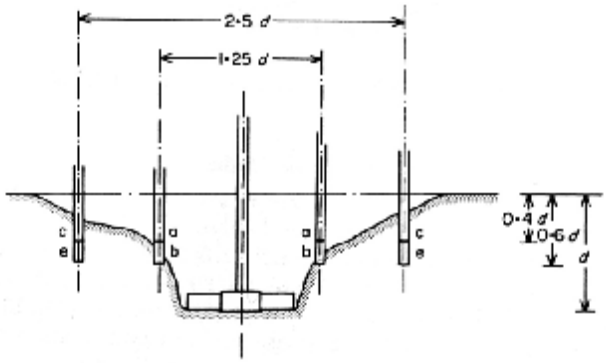
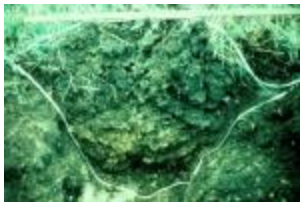
Leading shallow tines



After: Spoor & Godwin, 1978

Soil disturbance



Wings only

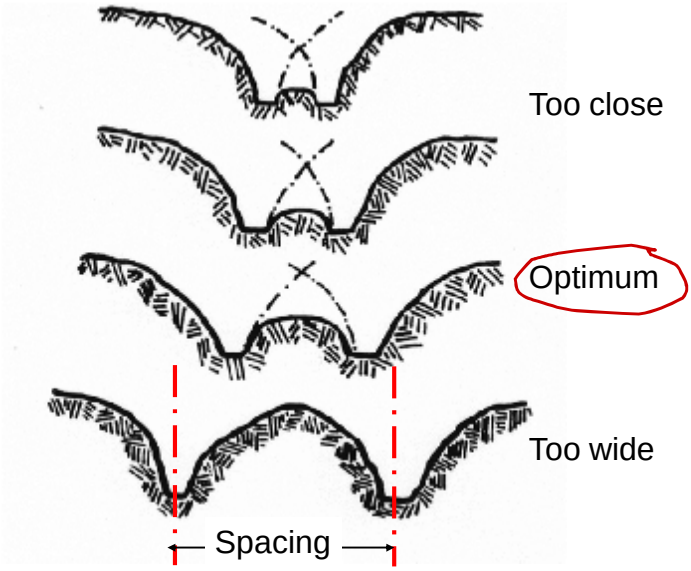
Plus shallow leading tines

Draught Force (tonnes)	Area of disturbance (m^2)	Specific resistance (tonnes/m^2)
2.39	0.24	9.6
2.35	0.42	5.4

Similar: Almost double: 45% reduction

After: Spoor & Godwin 1978

Effects of tine spacing



After: Godwin, Spoor and Soomro, 1984

Multiple tine spacing

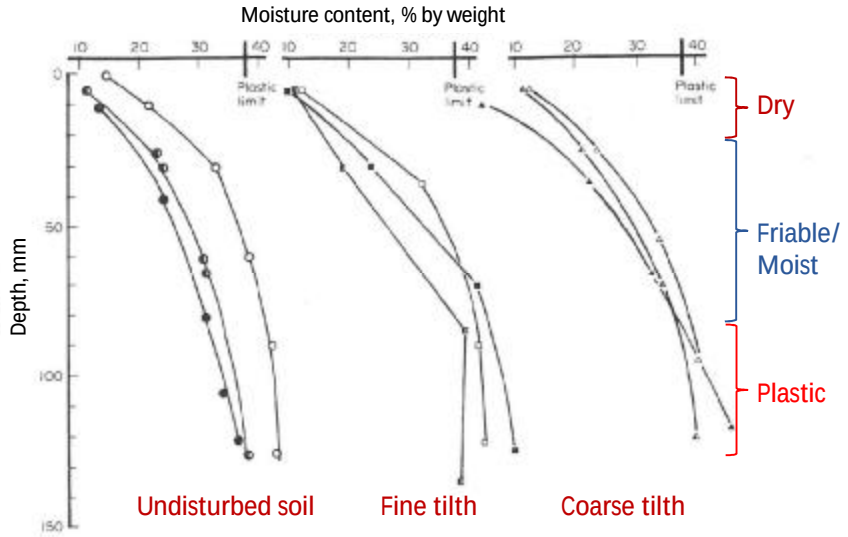
- Simple tines = 1.5 x depth of work
- Winged tines = 2.0 x depth of work
- Winged tines + leading tines = 2. 5 x depth of work (of shallow deeper tine)

After: Spoor & Godwin, 1978

Note

- If you subsoil plastic soil you will simply make “square moles” i.e. waste of time

Moisture profiles after 7 days of drying



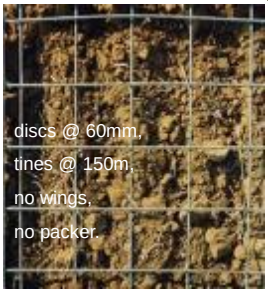
After: Spoor and Godwin, 1984

Conclusion

Avoid bringing up wet soil e.g. deep tillage

Implement adjustment –

clod size distribution and residue levels



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Conclusion

Make sure no component is “getting a free ride”

Machinery manufactures recommendations

General working recommendations :-

1. Make as few passes over the field as possible. (although a field that has been laid wet over winter may benefit from a once over with a tined cultivator to get some air in)
2. Work headlands last (or not at all)

(Vaderstad 2012)

Machinery manufactures recommendations

Machine set up :-

1. Read instruction books carefully (none of us ever look at them!)
2. Get the basics right
3. Pay attention to detail
4. Inflate tyre pressures as recommended
5. Soil engaging parts should be replaced or in good condition ...scalloped discs work and drive better if they are not worn down
6. Set wheel scrapers as recommended
7. Set front tools (on cultivator drills) to minimum depth (or out of work) to minimise draft requirement
8. Don't fill seed hopper completely to minimise overall weight

(Vaderstad 2012)

Agronomy views

- Do not be in too much of a hurry – resist the temptation to fill up the drill.
- Do not force seed into poor soil conditions – it might lead to a costly re-drill.
- Allow green material to remain there as long as possible. Consider killing with glyphosate as late as possible
- Dig a hole with a spade to check cultivation work for smearing

(Blake et al 2012)

Spring 2013 strategies

- Cultivate to minimum depth
- Lightest tractor
- Lowest tyre pressure or tracks
- Consider reducing machine width
- Broadcast and harrow
- Leave it in a cover crop

(Blake et al)

Overall conclusions/recommendations

- We do not have a “magic solution”
- Assess your own fields
- Monitor what your machinery is doing to the soil
- Read instruction manuals
- It will take time to repair your soils
- Speak to your agronomist

Any questions?

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