Soil&Water Management Centre

Harper Adams University

Presentation1

Tillage Machine Principles

Dick Godwin

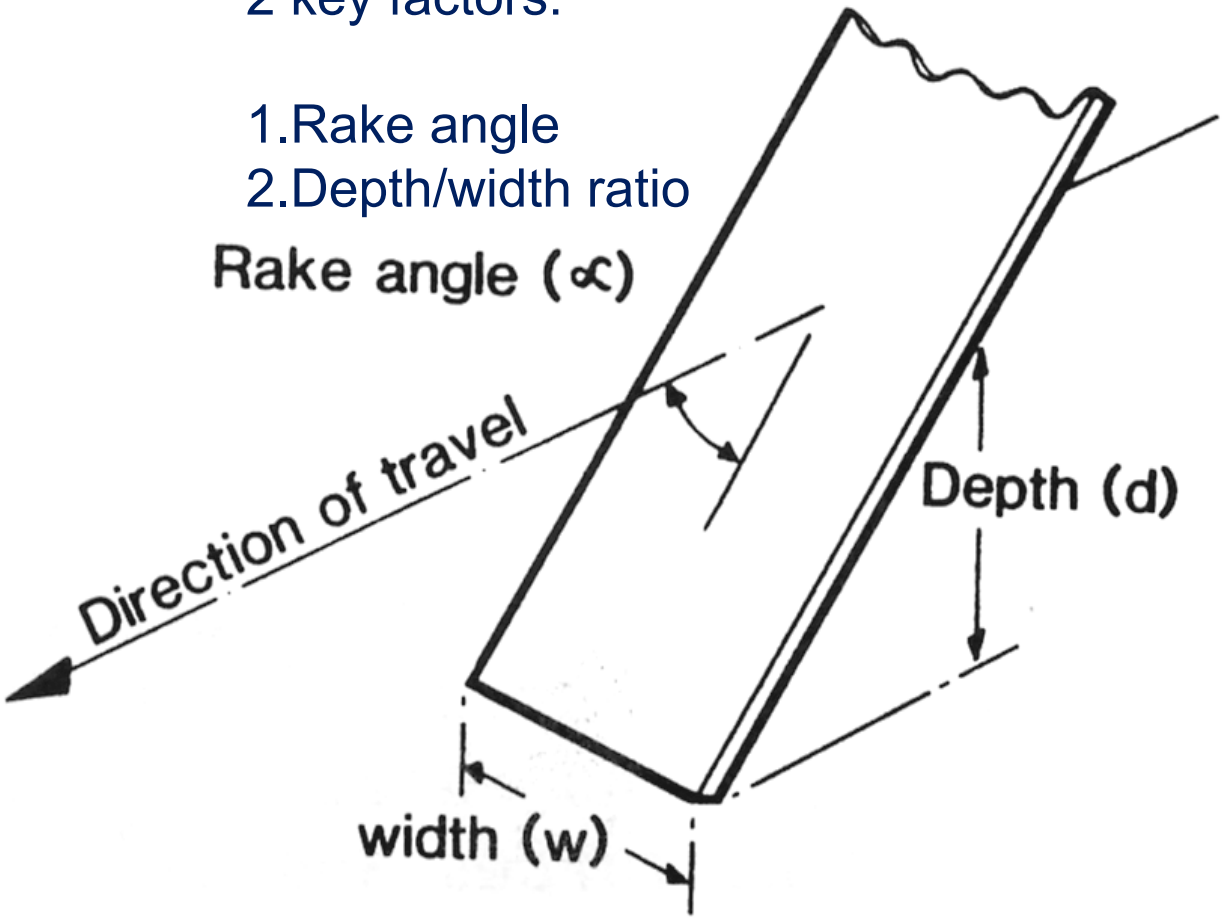
Outline

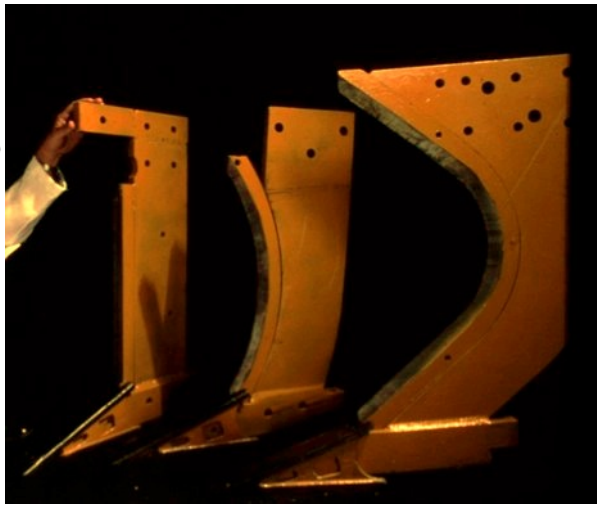
- Effect of implement shape
  Depth/Width
- Rake Angle
- Speed
- Wings
- Shallower tines
- Spacing
- Discs
- Mouldboard Ploughs
- Concluding comments

Implement geometry and soil disturbance

2 key factors:

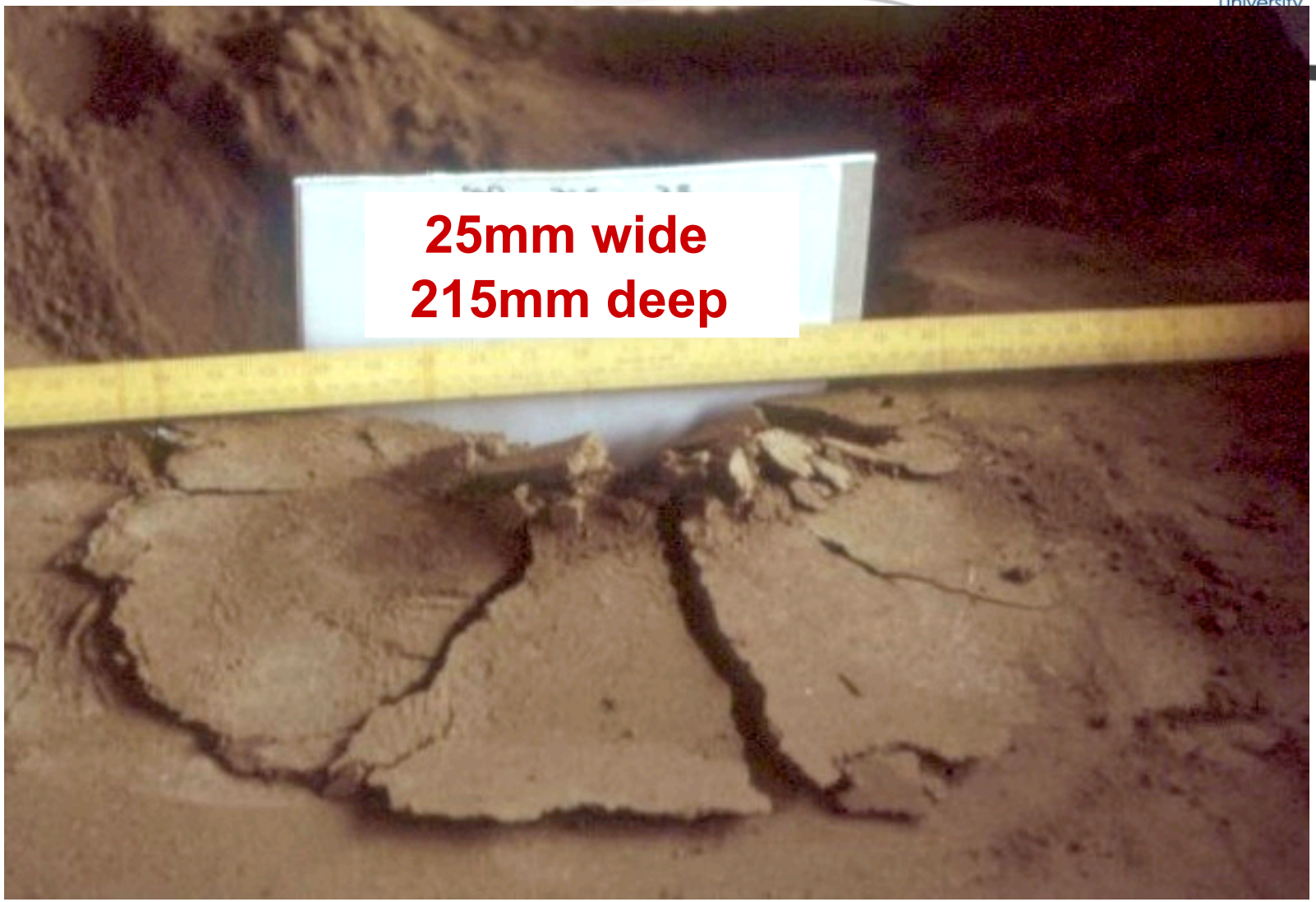
1.Rake angle
2.Depth/width ratio





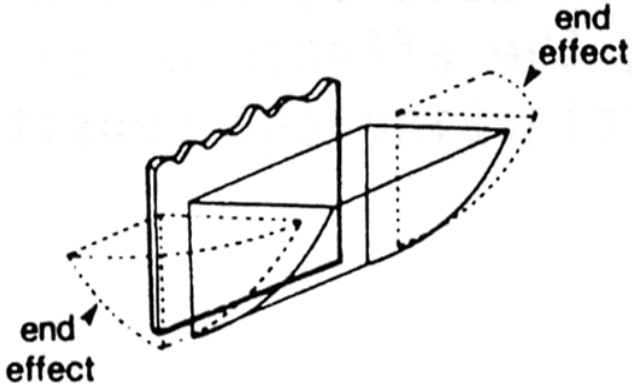
After: Godwin, 1974

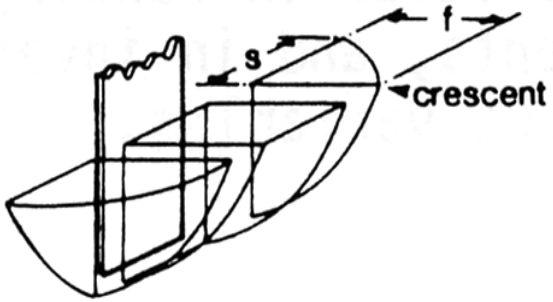
Soil disturbance by a vertical tine

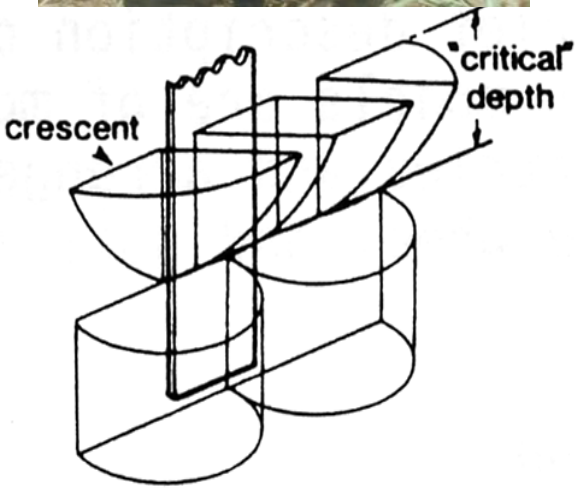


After: Godwin, 1974

Soil failure patterns

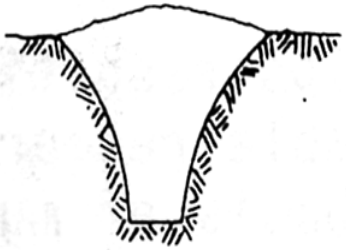




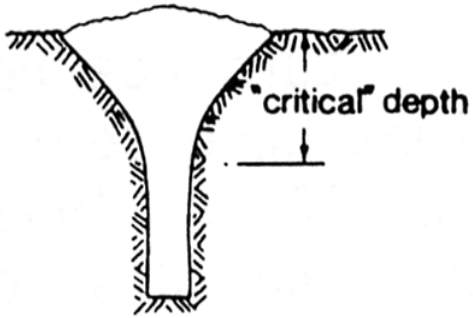


direction of travel →

a. Blade



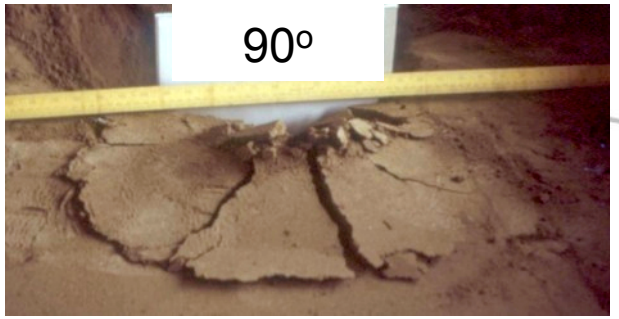
b. Narrow tine

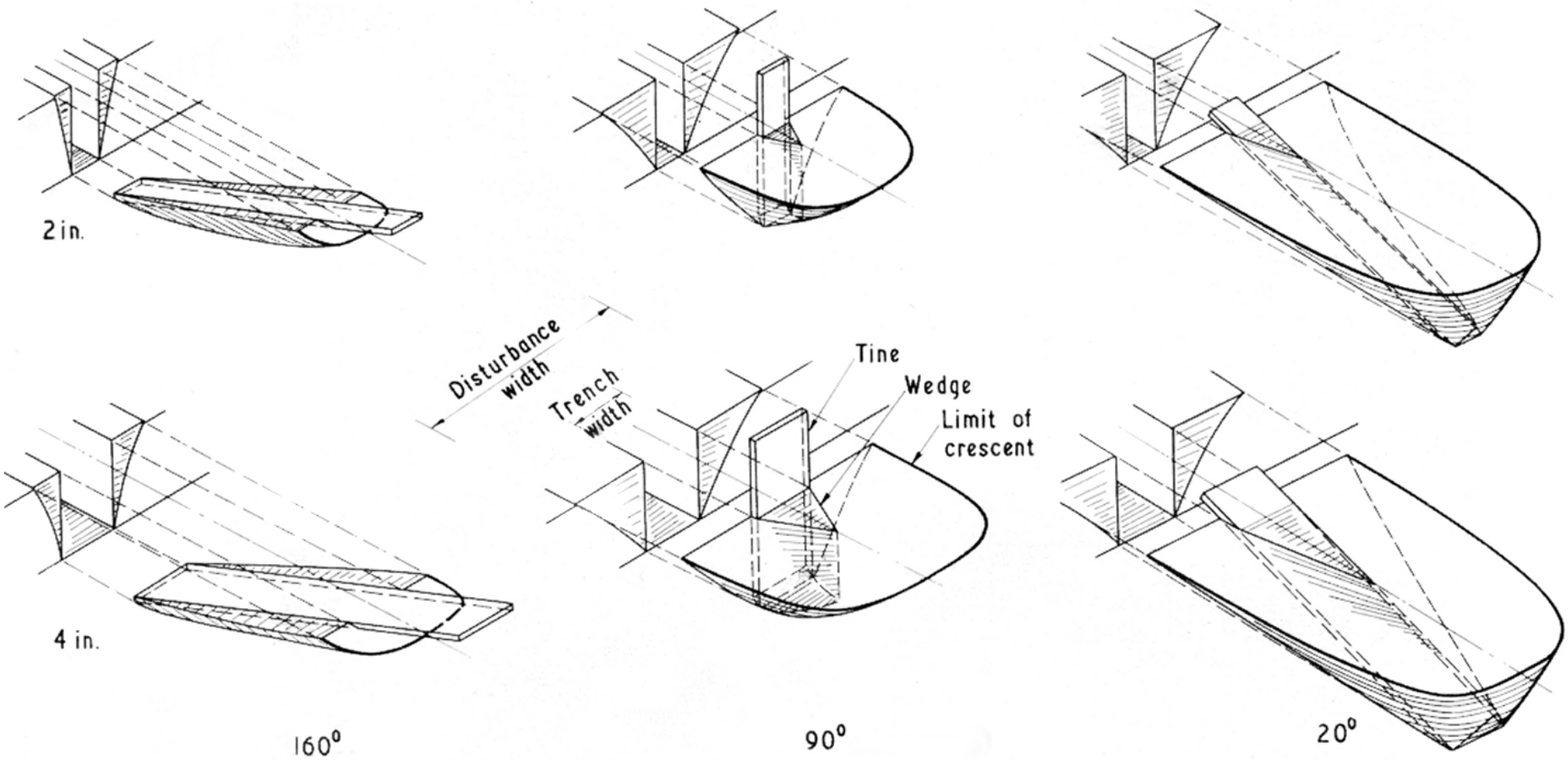


c. Very narrow tine

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

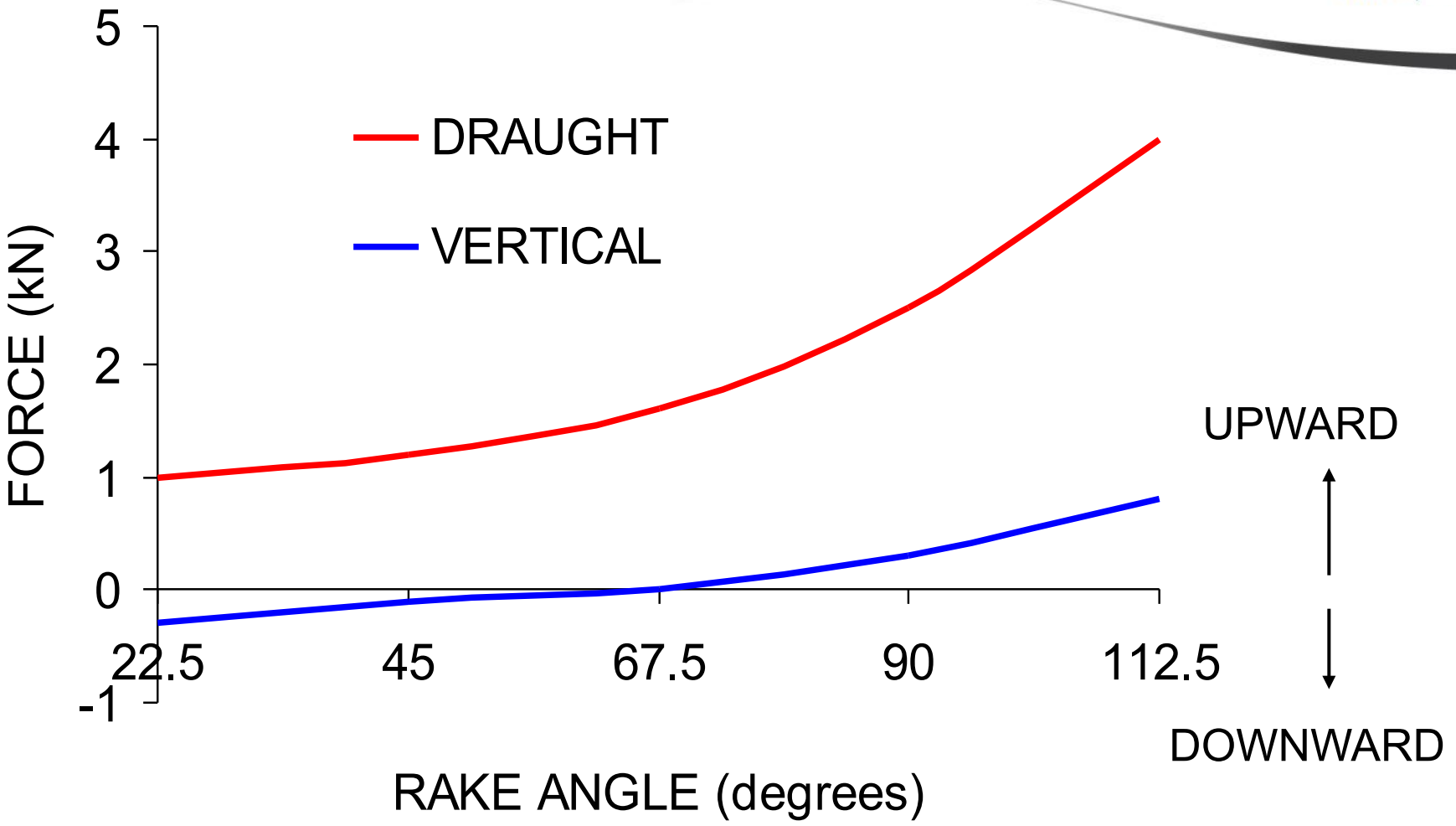
Effects of rake angle on crescent geometry





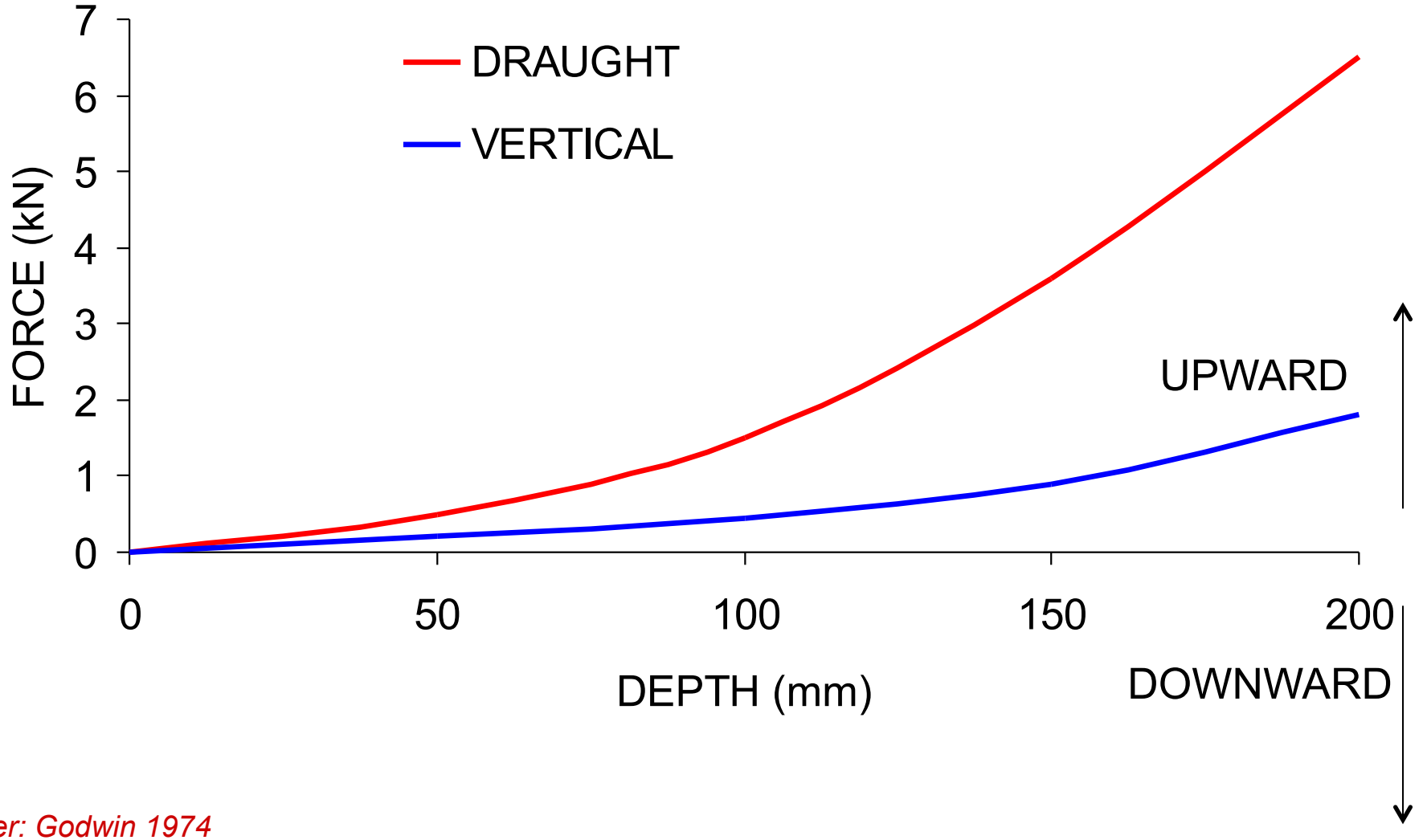
After: Payne and Tanner, 1959

Effect of rake angle on soil forces



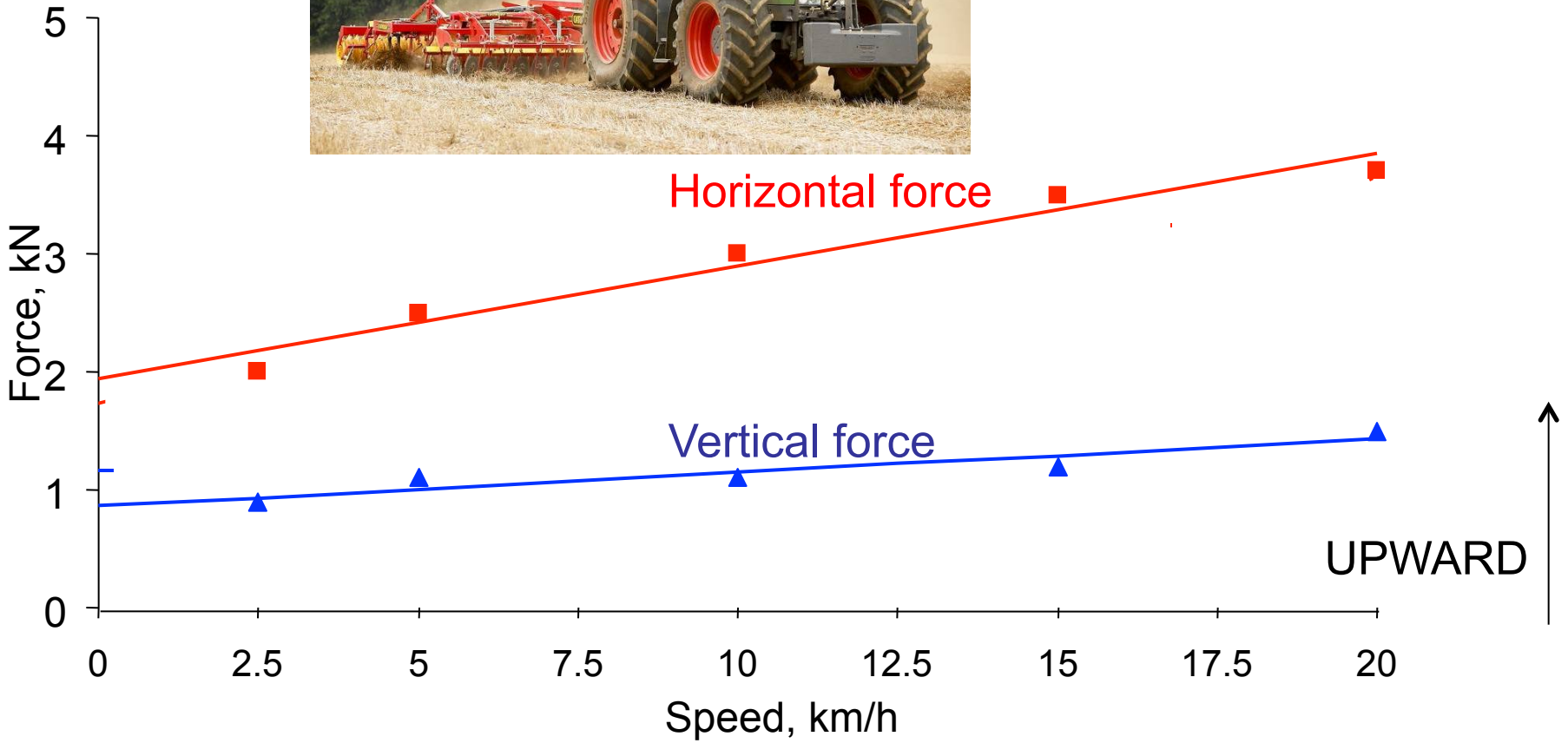
After: Godwin 1974

Effect of depth on soil forces



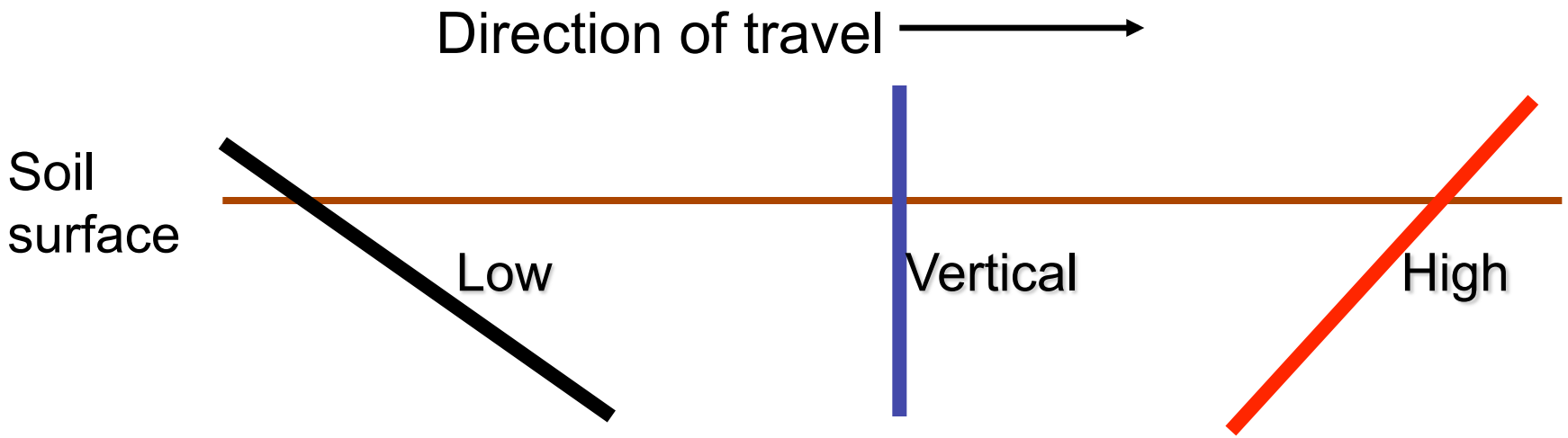
After: Godwin 1974

Effect of speed



After: Wheeler and Godwin, 1996

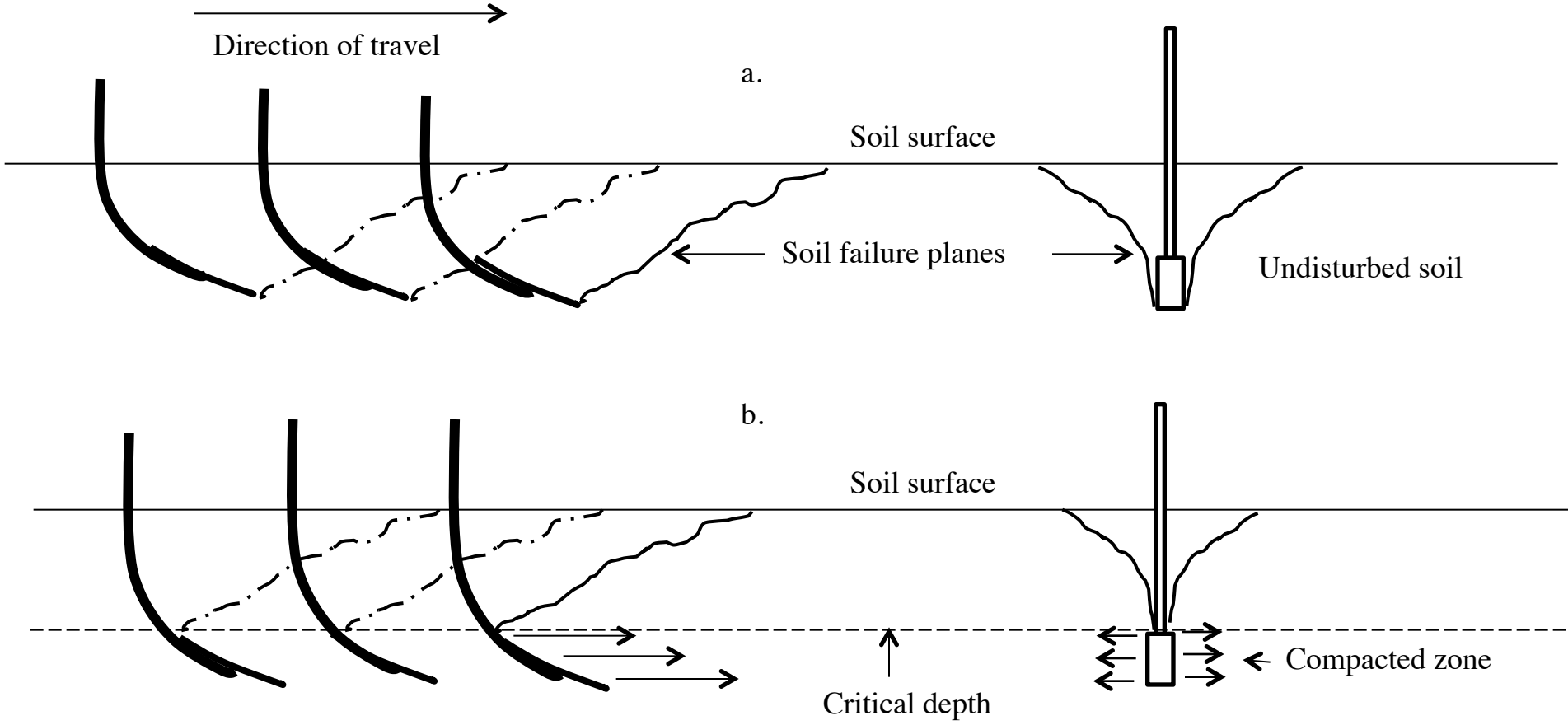
Selection of implement rake angle for tillage operations



	Low	Vertical	High
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

Soil failure and critical depth



Side view

Cross section

Mole ploughs

Mole drains connect clay soils with perched water tables to gravel backfill over existing tile/plastic drains

Soil failure

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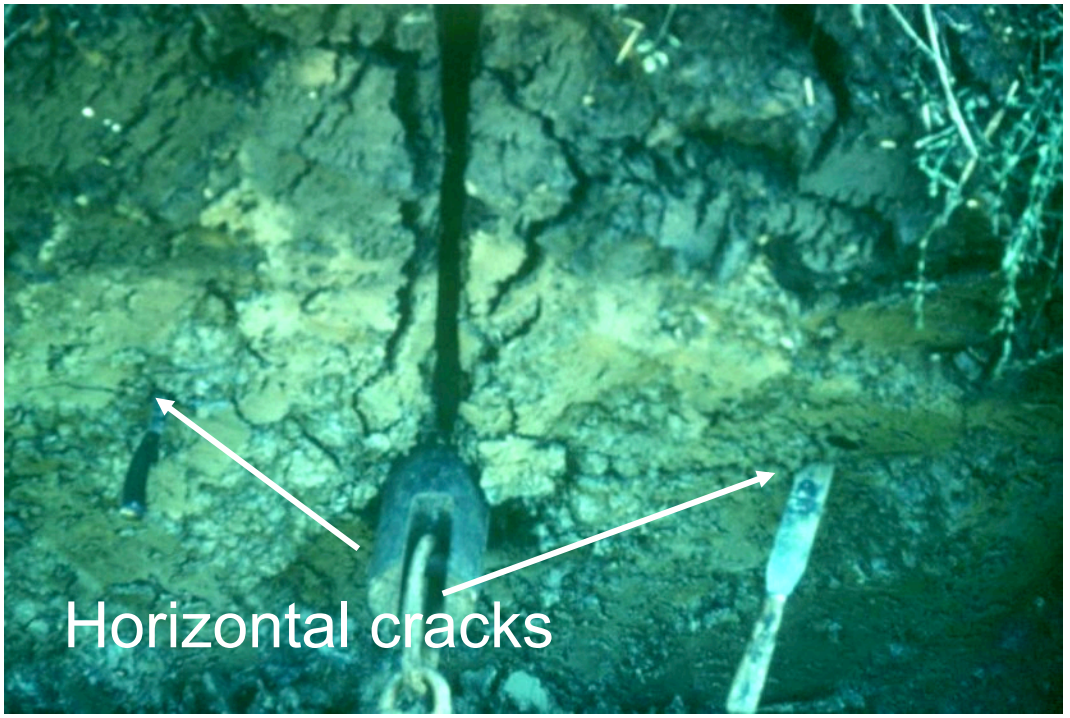
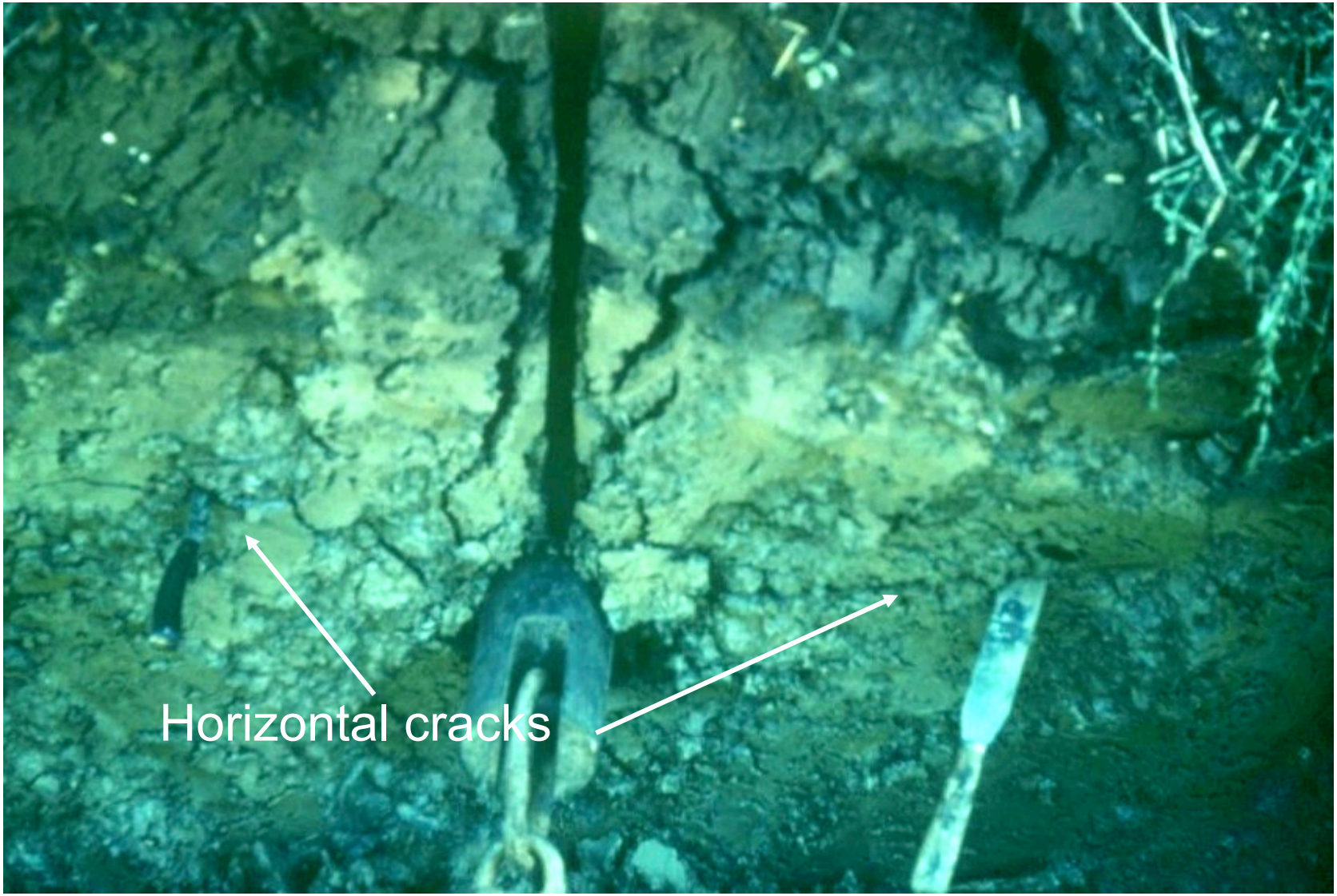
Herringbone cracks



After: Spoor and Godwin, 1978

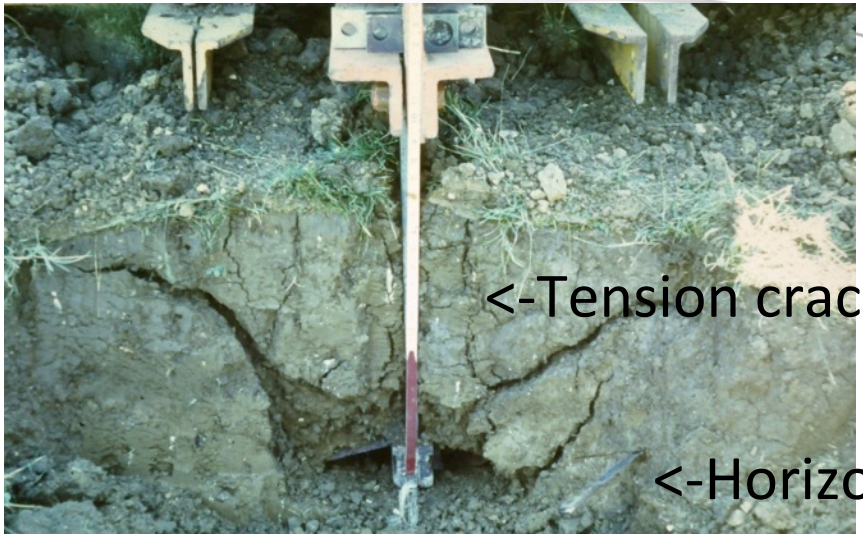
Deep tine - 45^{o} leg cracks

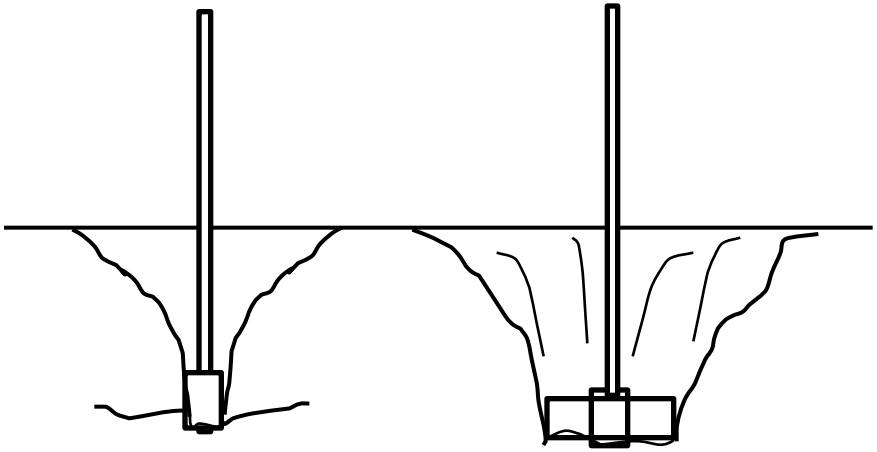
Lateral failure - Mole plough

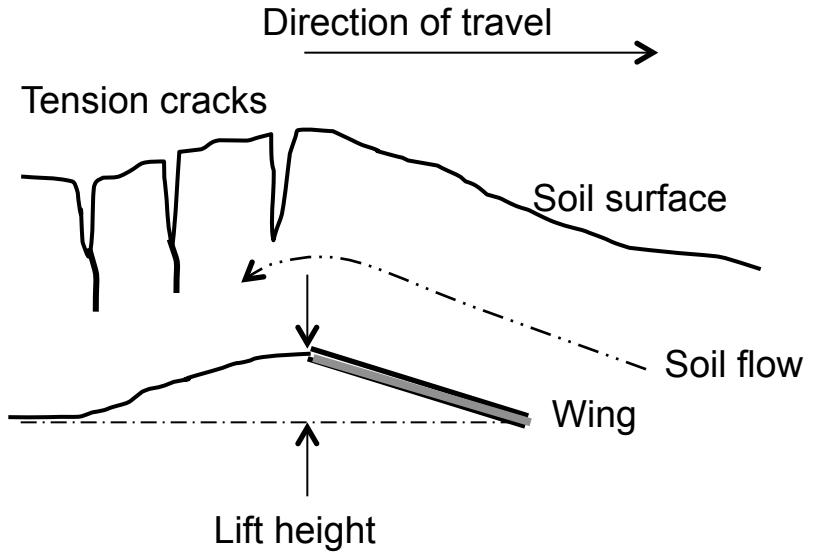


After: Spoor and Godwin, 1978

Addition of Wings

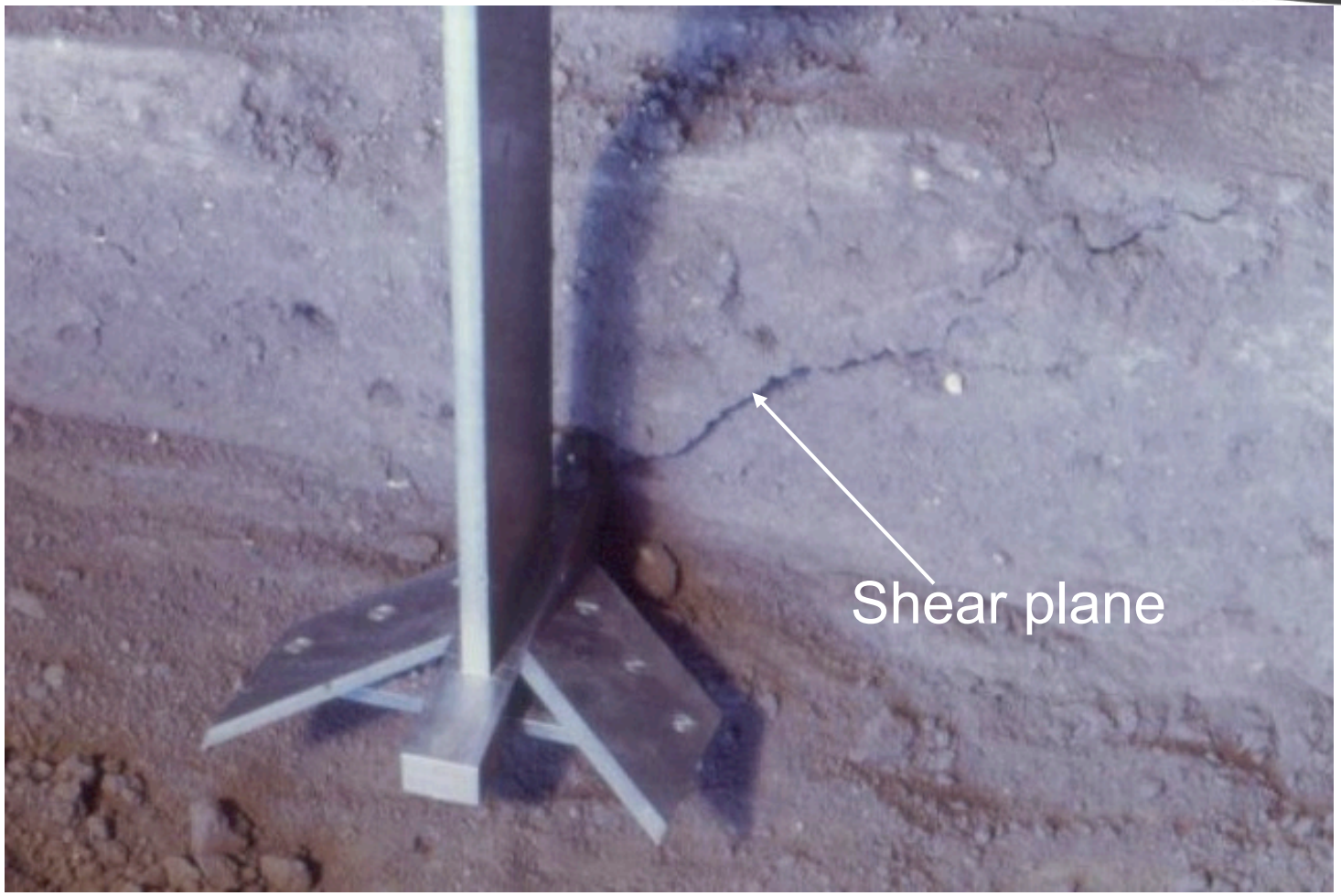




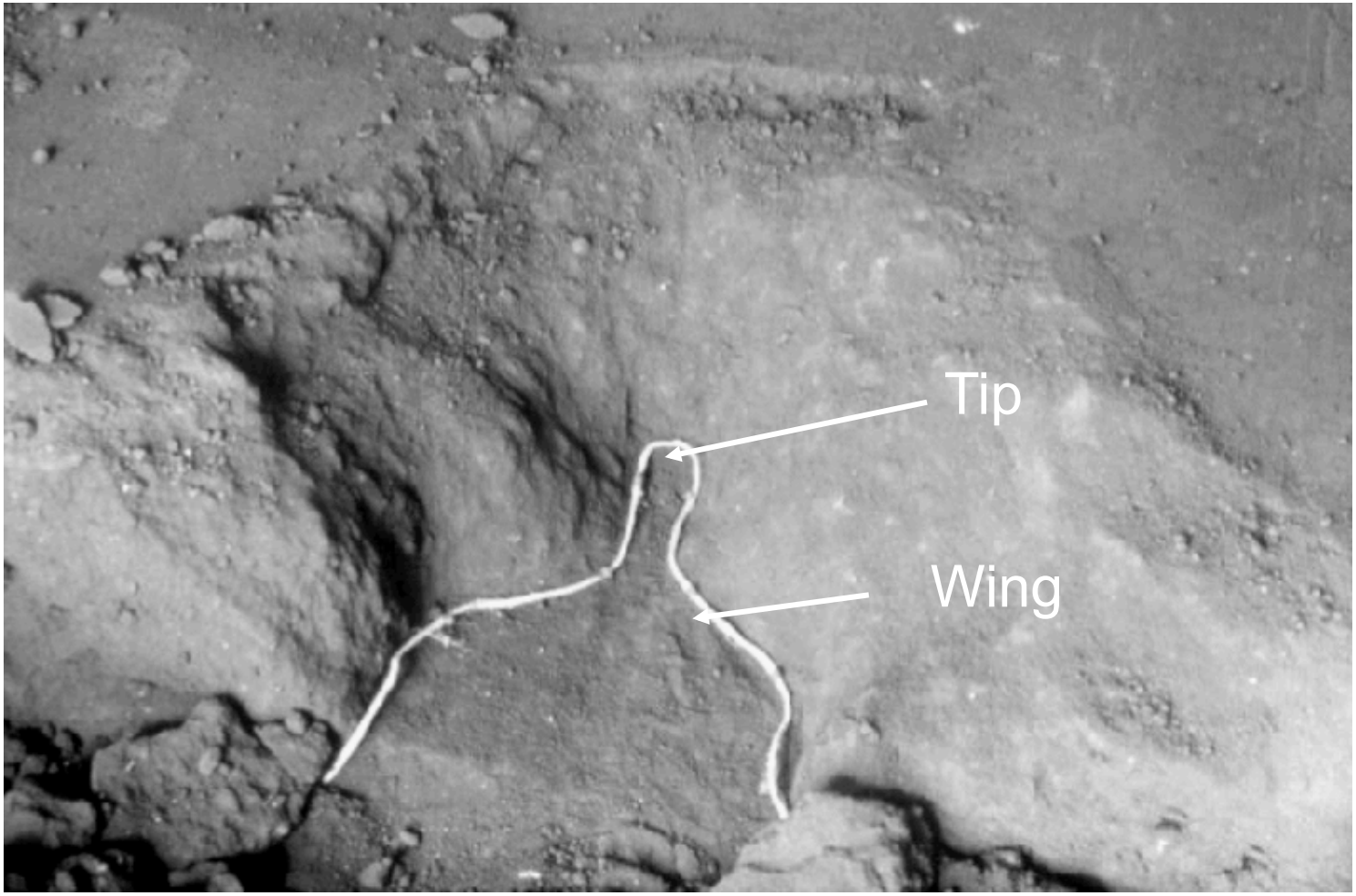


Godwin and Spoor, 2015

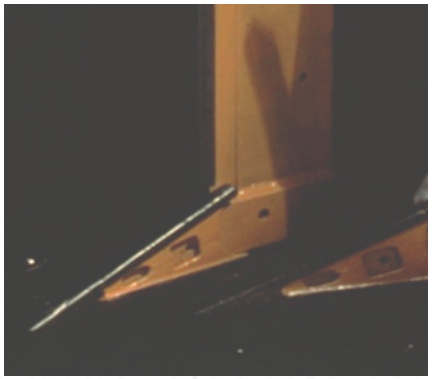
Effects of winged tines

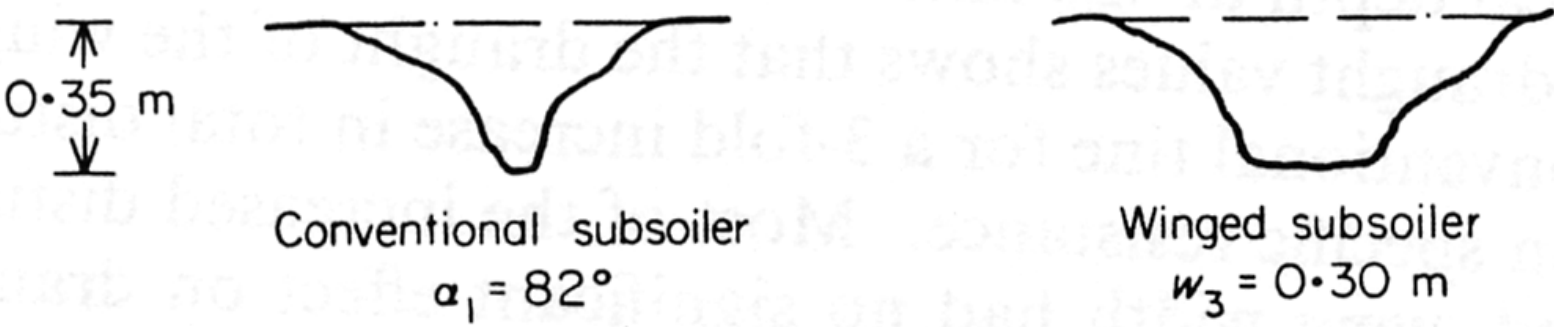


Total soil disturbance



Effect of wings

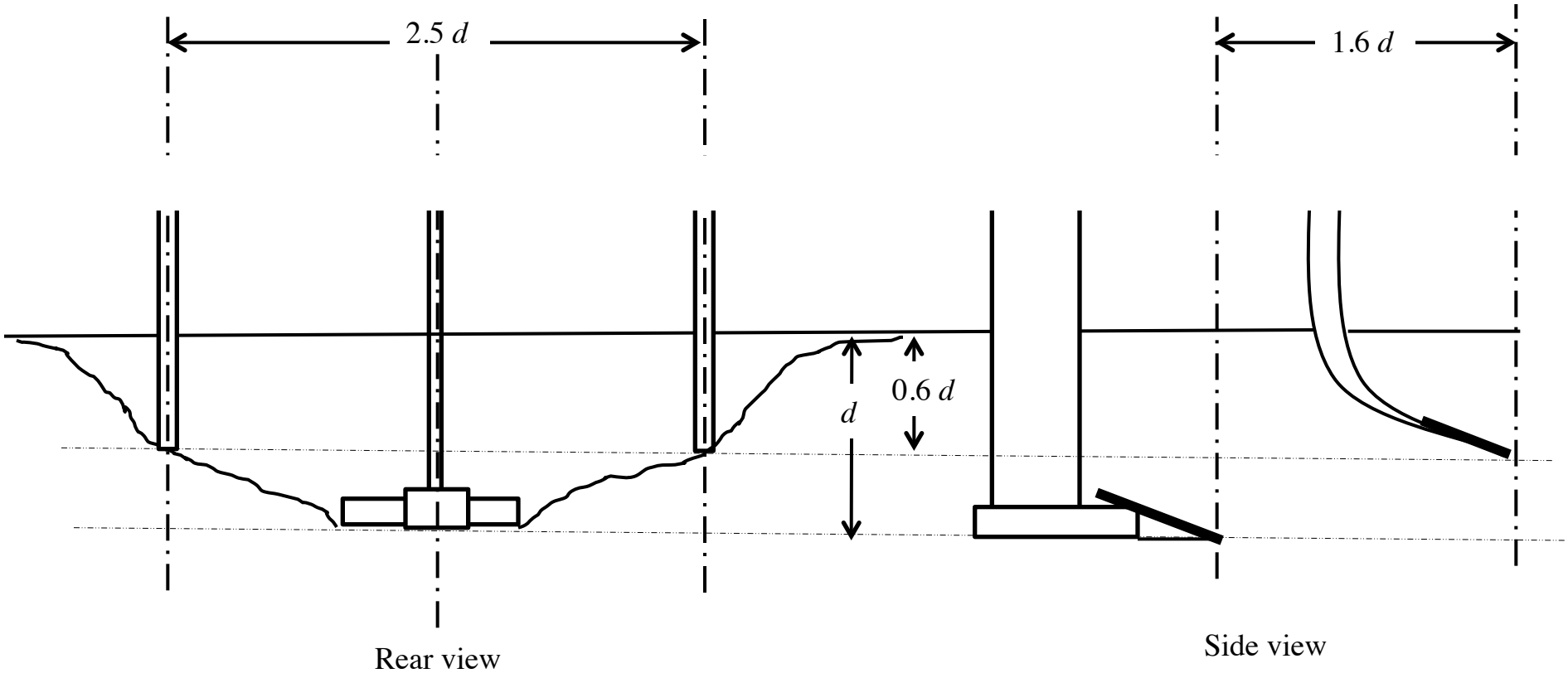




Draught	20.43 kN	26.58 kN
Disturbed area	0.098 m^2	0.184 m^2
Specific resistance	208 kN/m^2	144 kN/m^2

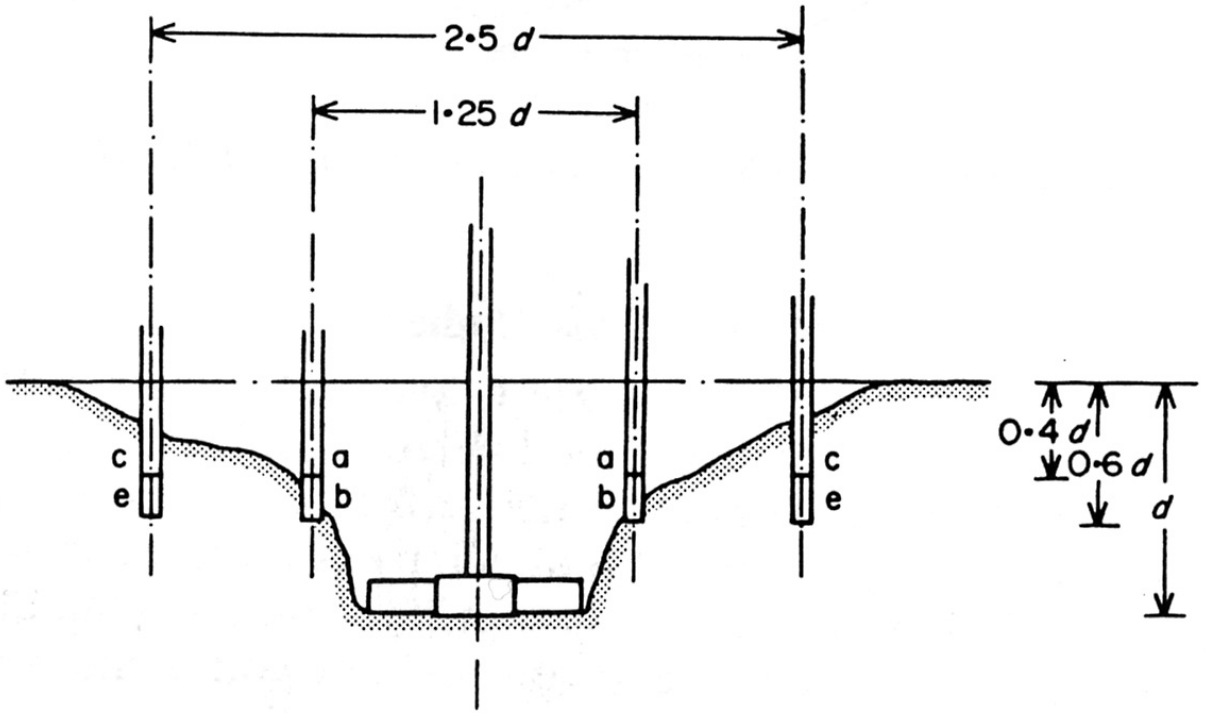
After: Spoor & Godwin, 1978

Leading shallow tines



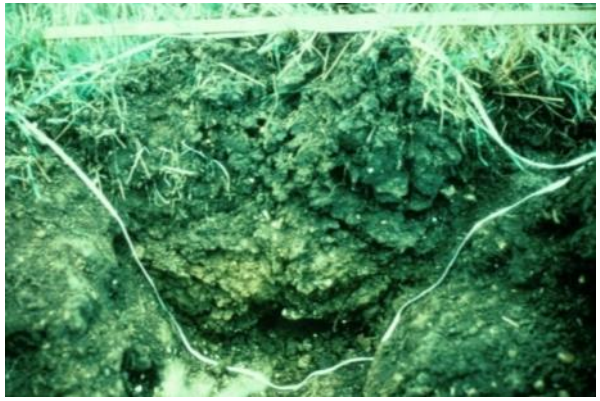
Godwin and Spoor, 2015

Leading shallow tines



After: Spoor & Godwin, 1978

Soil disturbance



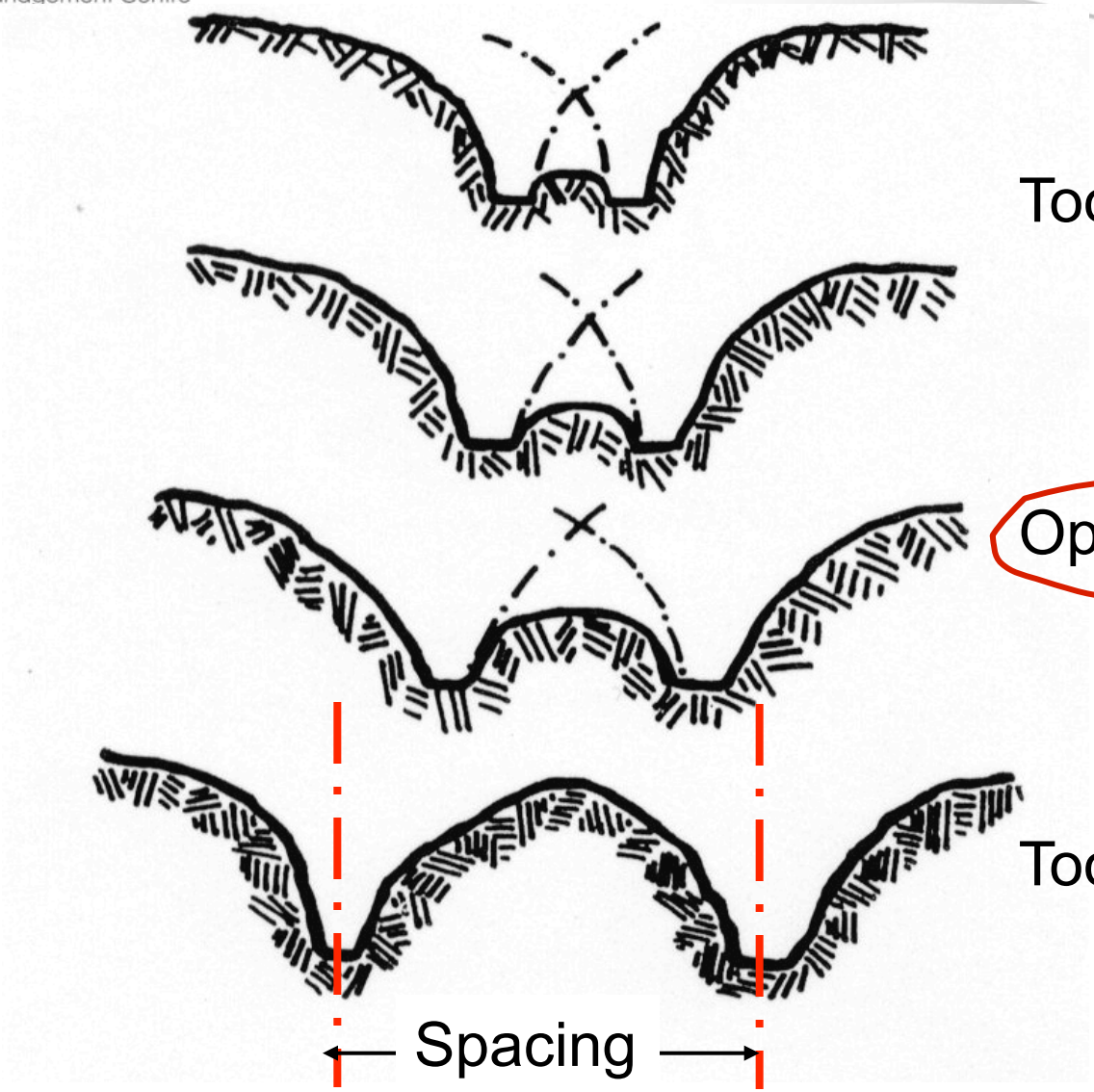
Wings only

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



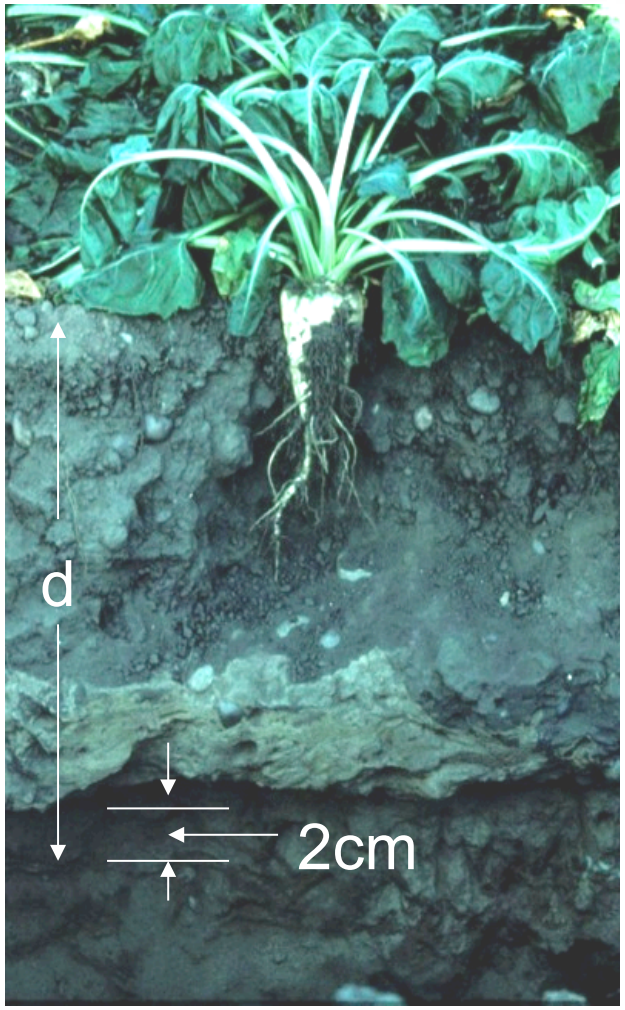
After: Godwin, Spoor and Soomro, 1984

Multiple tine spacing

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

After: Spoor & Godwin, 1978

Effects of depth



Subsoiler – Draught forces

Subsoiling after tracks at 350mm 88hp

Subsoiling after tyres at 450mm 240 hp

63% Reduction

Draft force (kN)

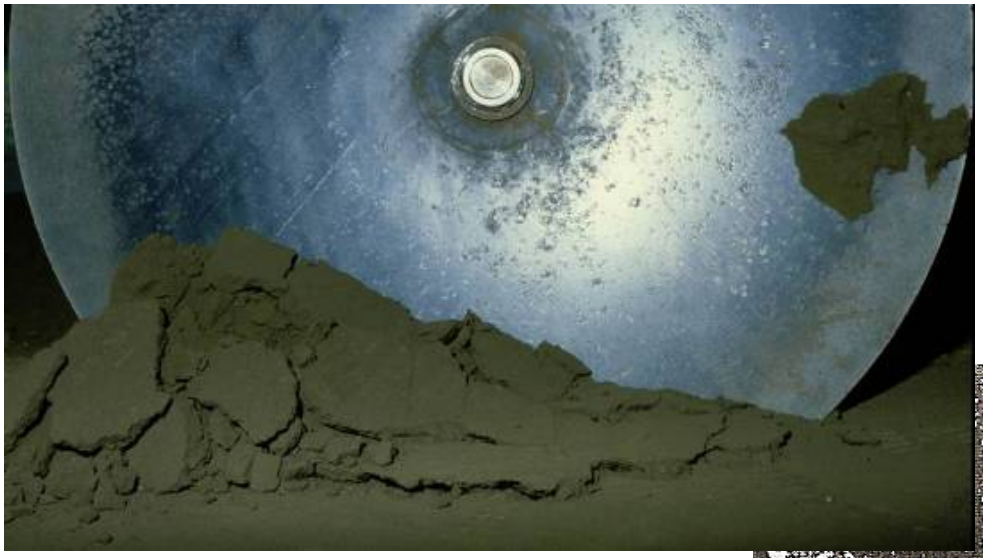
Depth (mm)

Tyre

Track

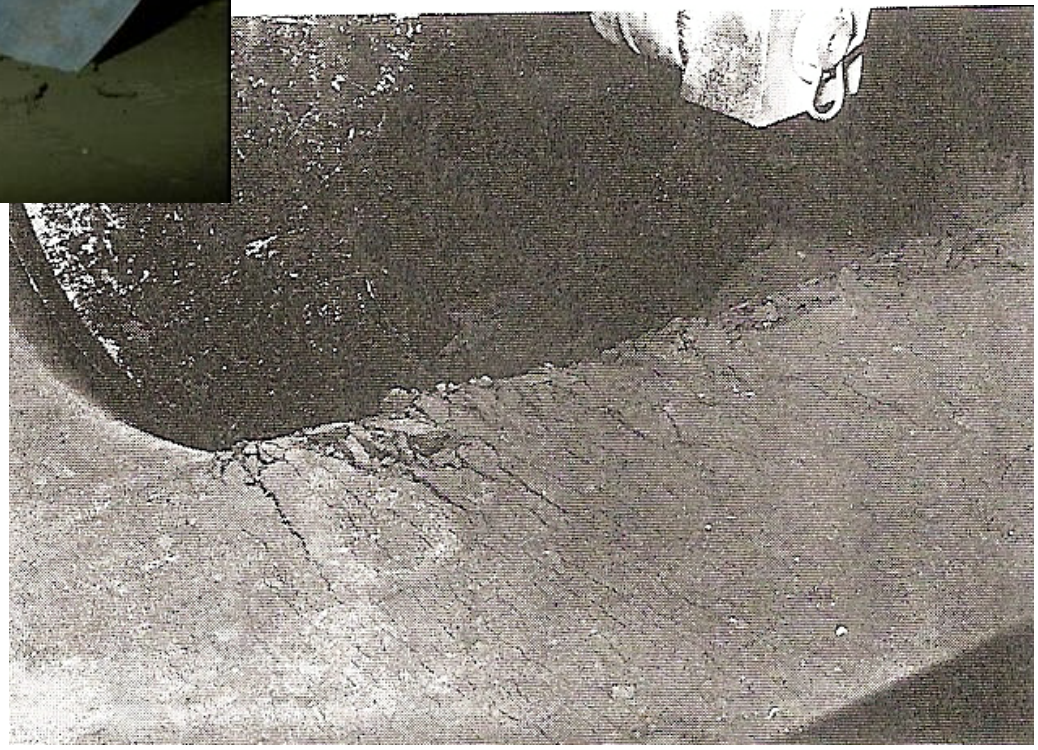
After: Ansorge and Godwin, 2007

Disc settings



< Passive soil failure

Scrubbing – compressive soil failure >



Effect of sweep angle on draught force

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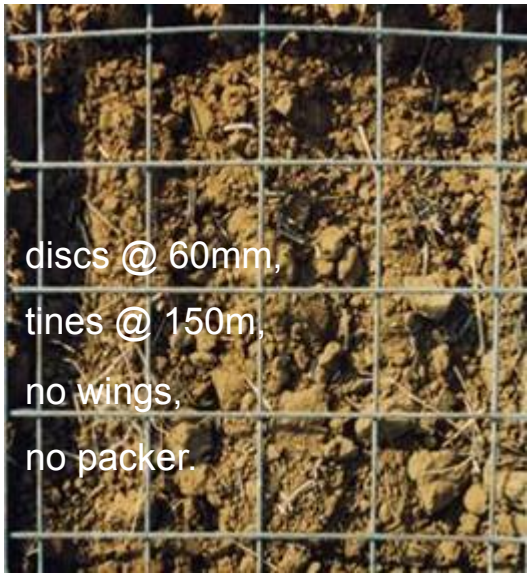
After. Godwin, Sieg and Allott, 1987

Implement adjustment

Clod size distribution and residue levels



Black Grass Control by Cultivation

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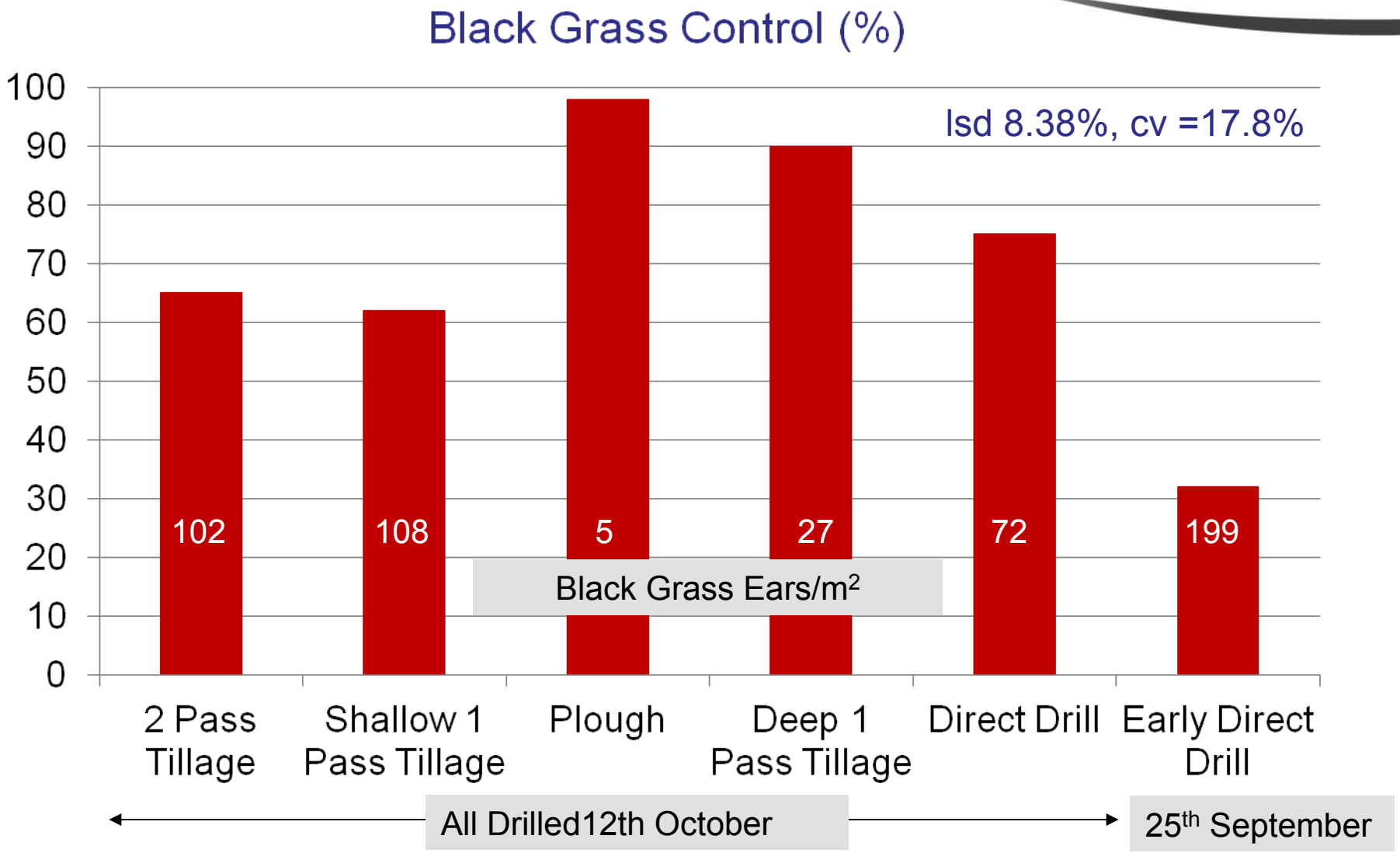
LEMKEN

Agrii

Harper Adams University



Black Grass Control by Cultivation

1. A plough anywhere in the system reduces black grass numbers.
2. Use good ploughing techniques. Poor ploughing is of little help as it will not bury the weed seeds.
3. Ploughing for a second year brings resistant black grass seeds back to the surface too soon for effective control.
4. Good ploughing followed by 2 years of direct drilling has reduced black grass and increased yields.
5. Continual direct drilling or shallow min till allows black grass numbers to increase. These systems work well if a good stale seedbed is achieved first and the herbicide chemistry works well.
6. With resistance issues, cultivations are having a greater effect on black grass control than current pre and post–emergence chemical options.

Mouldboard plough adjustment

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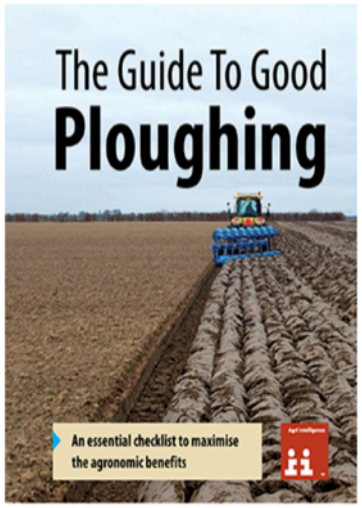
New Growers Guide Highlights Rotational Ploughing Essentials

Rotational ploughing can be a key weapon in reducing black-grass infestations and increasing crop performance, according to a handy new weatherproof growers pocket guide to the technique published this winter. But, it insists, bad ploughing is a waste of both time and money.

Produced by Agrii and Lemken, the 30 page Guide to Good Ploughing summarises the main conclusions of the first three years of their large scale rotation-wide establishment trials on a Cambridgeshire farm with serious black-grass problems. Alongside this, it provides practical and well-illustrated guidance on plough setting and operation as well as top tips on making the most of the plough in effective cultural control.



"Our work at the country's most comprehensive long-term black-grass management trials site clearly show a plough anywhere in the rotation reduces black-grass numbers," reports joint guide author, Agrii head of agronomy, Colin Lloyd. "By burying all surface residues with the plough, we've achieved a reduction of over 98% in highly resistant black-grass in the season.

- Work deep enough to bury all weed seeds
- Set skimmers to the correct depth
- Fully invert furrow slice
- Use a slatted mouldboard if soil is sticky
- Use a press to close the furrow
- Ensure the line of draft enables the tractor to pull effectively with the tractor on the land when ploughing with larger ploughs.

http://www.agrii.co.uk/blog/2013/10/24/the-good-ploughing-guide-from-agrii-and-lemken/

Conclusions

1. The effect of changes in geometry and speed on soil disturbance and soil-implement forces for a range of tillage tools are understood.
2. Minimising the draught force is not always the main issue and the correct “job” is the key requirement.
3. Reducing the magnitude of the specific resistance (draught force/ disturbance) is a better indicator of overall tillage efficiency.
4. However, to minimise draught reduce both depth and rake angle (where possible).
5. Most tillage machines are designed to be adjusted!
6. Do not work with excessively worn implements.
7. Ploughs can be effective in managing Black Grass.

Photo Courtesy: Philip Wright