Tillage's direct impacts on the soil

duration of looseness

Influencing factors: a) tillage process, b) tillage quality (resulted loosened or non-loosened state), c) soil quality (e.g. sensitivity to settling), d) climate, d) modes of tillage followed loosening process

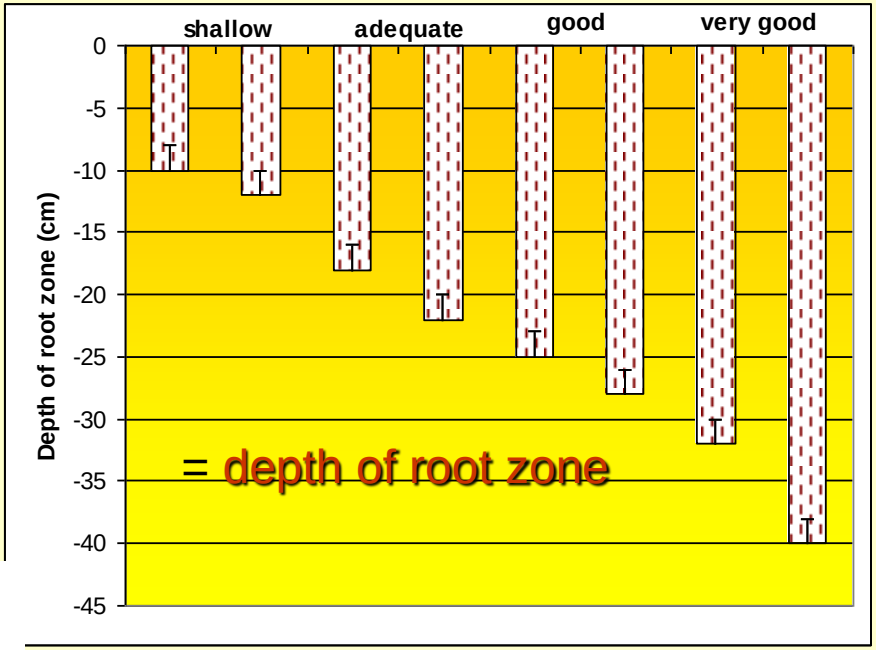
So: some months / 1 or more seasons

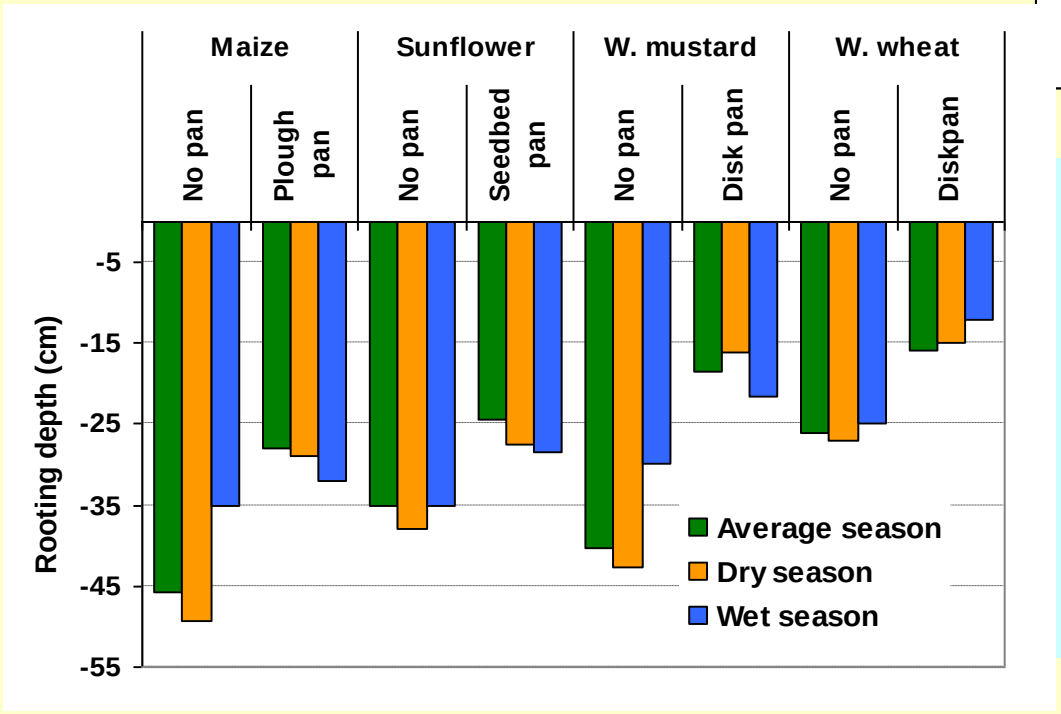
Bad example: soil may resettle by surface tillage operations

Tillage's direct impacts on the soil

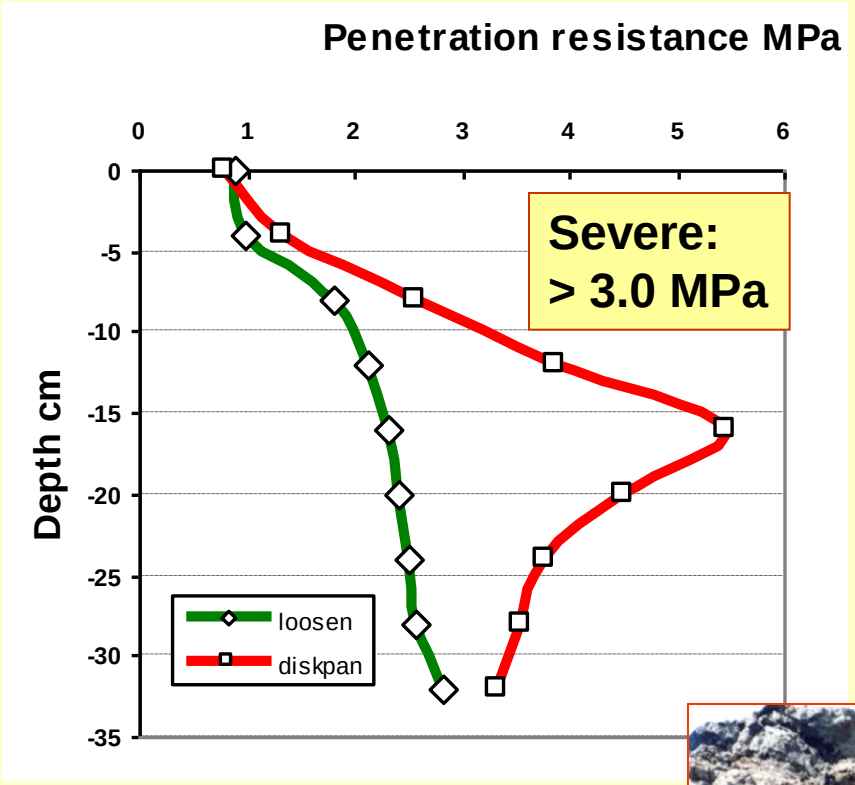
depth of the loosened layer

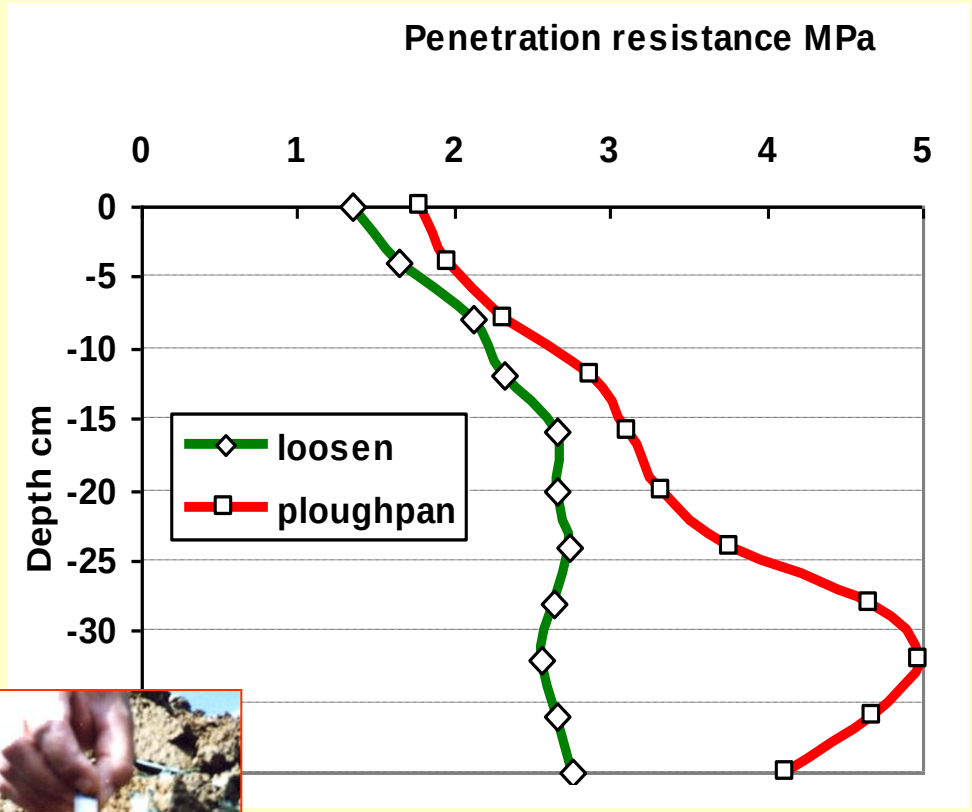
..it may either help or hinder the development of the roots of plants of a particular species





Rooting depths (cm) of crops in experimental conditions
(Hatvan, 2002-2013)
Legend:
A: average season,
D: dry season,
R: rainy season





Soil in a loosened state and deteriorated by disk pan

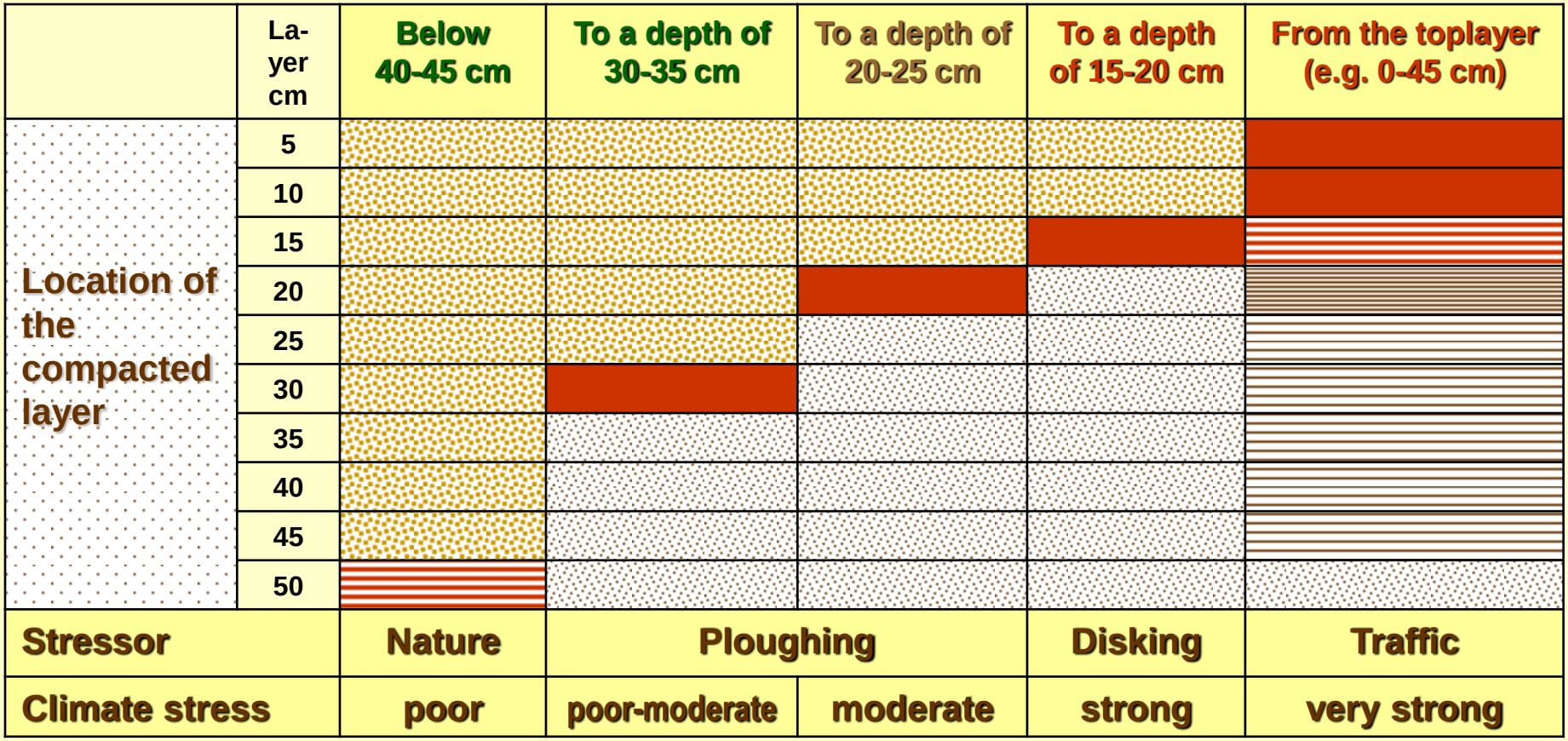
Soil in a loosened state and deteriorated by plough pan

Subsoil compaction observed on 17,280 ha of land during six examination periods in Hungary (1976-2010)

Location of subsoil compaction	Examination periods					
	1. 1976-1987	2. 1988-1990	3. 1991-1997	4. 1998-2001	5. 2002-2007	6. 2008-2010
	Percentage of observed area					
below 60 cm	14	4	1	0	11	9
below 40 cm	22	12	6	2	21	26
at the depth of 28-32 cm	44	47	42	36	30	34
at the depth of 22-26 cm	14	22	23	14	21	16
at the depth of 18-22 cm	6	10	16	22	12	10
2 c. layer below 16 cm	0	3	7	14	5	5
3 c. layer below 16 cm	0	2	5	12	0	0
Examined area (ha)	2420	2860	2580	1860	4690	2870

Tillage's direct impacts on the soil

Occurrence and extension of the compacted layer



Ranking of extension:

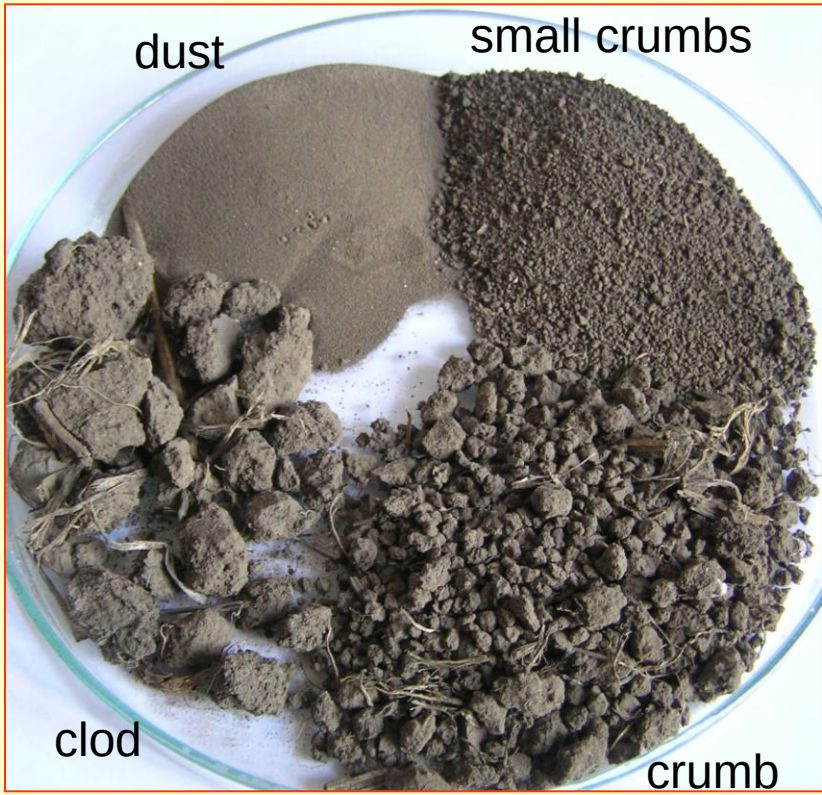
0-10 mm compact layer: slight
10-30 mm: medium
30-50 mm: heavy
50-100 mm: severe damage

Tillage's direct impacts on the soil

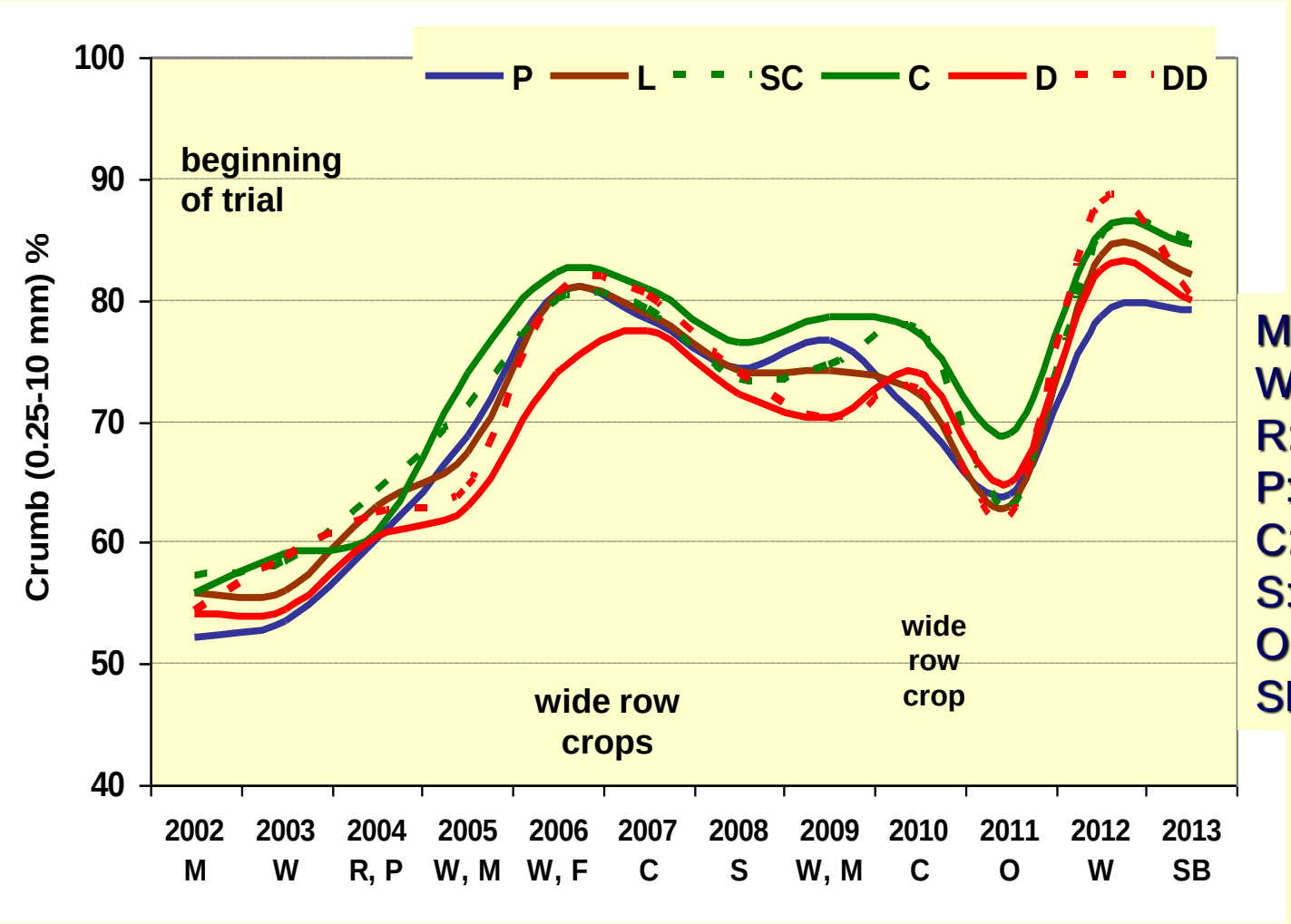
agronomical structure (aggregation)

proportion of **dust** (<0.25 mm), **small crumbs** (0.25-2.5mm), **crumbs** (2.5-10 mm), and **clods** (>10 mm ∅)

- A soil with a 70-80 % *crumb* fraction has a good structure, while a soil
- with a higher than 50 % *dusts* has a poor structure.
- The trend of crumb forming is affected by tillage, the crop sequence and the degree of surface protection
- Growing crumb fraction is a result of carbon and moisture conserving tillage and of effective surface protection
- Originally well-structured soils have been pulverised by excessive tillage



Soil crumbling improvement and maintenance (Hatvan, 2002 – 2013)



M: Mustard
W: W. wheat
R: Rye
P: Pea (green)
C: Corn
S: Sunflower
O: Oat
SB: Spring barley

Hatvan, 2002 – 2013; P: ploughing + levelling, L: loosening, SC,C: cultivator use, D: disking, DD: direct drilling

Tillage's direct impacts on the soil

surface form

100 % (flat), 200-300 % (rough, cloddy)

- it should be minimised to reduce loss of water in any season and particularly important in the summer months
- water is lost through the large surface of a dry cloddy soil
- surface area may be enlarged in a wet season

Tillage treatment	Surface forming	Soil moisture loss	Climate-induced damage after sowing in late summer
Deep ploughing	yes	medium	medium
	no	great	heavy
Deep loosening	yes	medium	medium
	no	great	heavy
Mulch in surface	yes	little	little

Relationships between summer tillage and the likely climate risks


A large surface is acceptable in wet soil condition, but…

Tillage's direct impacts on the soil

surface cover

Soil surface is exposed to weather and farming impacts:
Soil structure damages, it turns into silt by rain, it dries and later on crust forms; it dries and perhaps even blows away by wind

Protection may good or inadequate during the growing season, depending on the crop cover; Dense crops and grasses give better protection.

- **Soil needs particular protection during the critical periods, especially in the summer after harvest and in the spring after sowing.**
- **In summer the chopped crop residues should be spread on the soil surface for protection.**

The advantages of surface cover out of growing season:

- **reduced soil moisture loss,**
- **protection of the top-layer against climate-induced damage,**
- **maintaining / encouraging favourable biological activity,**
- **improving soil workability.**

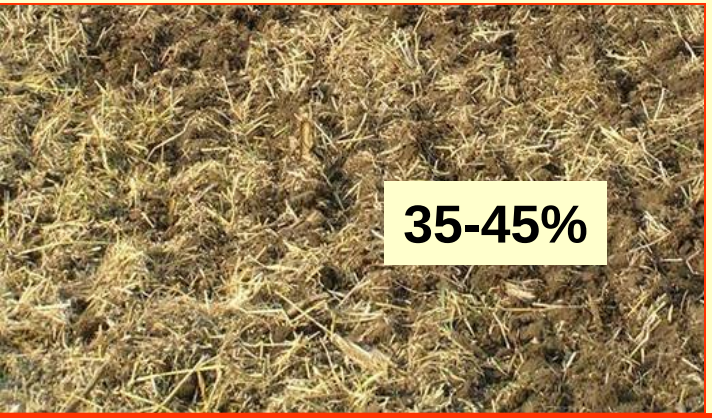
Surface protection by cover during critical periods

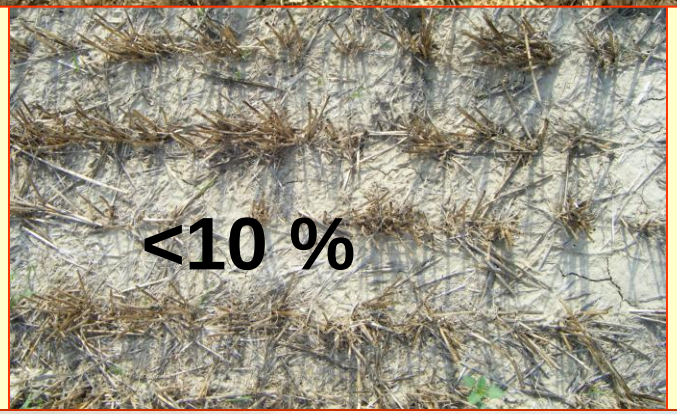
great risk

Cases	Cover rate (%) and protection		
	GOOD	MEDIUM	POOR
Following harvest	55 – 65	35 – 45	< 10
Stubble tillage (summer)	45 – 55	35 – 45*	< 10
Primary tillage (summer)	25 – 35	15 – 25	0 – 5
Primary tillage (winter)	15 – 25	10 – 15	0
Between wide rows (hot spring days)	15 – 25	10 – 15	0
Risk	low	moderate	great

* accepted by practice

Surface cover





Tillage's indirect impacts on the soil

Water transport

Balance between **intake**, **storage** and **loss**

The proportion of precipitation actually ends up in the soil: **70-80 % in favourable cases**, but **often it is around 65-70 %.**

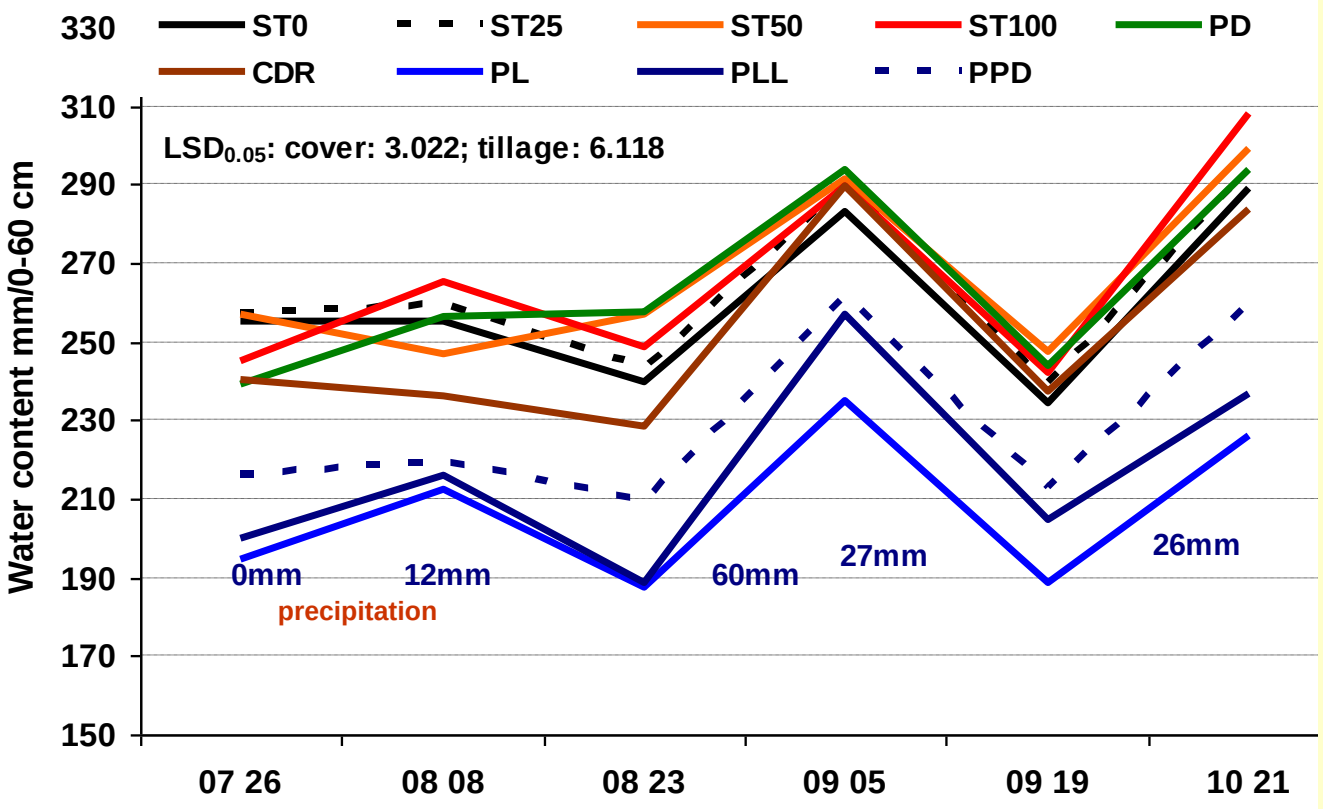
Tillage improves soil **water intake** capacity but it may increase its **water loss**

Water intake and storage depend on the depth of the loosened layer and the permeability of the soil below disturbed layer

water-loss increasing surface

water conserving surface

Soil moisture trend at different stubble treatment during 85 days
(Hatvan, July-Oct. 2013)



Legend

ST0: stubble, no cover

ST25, **50**, **100**: **covered stubble**

PD: **used plate disk (6-10 cm)**

CDR: conventional disk + roll (10-14 cm)

PL: ploughed

PLL: ploughed and levelled

PDP: ploughed, and prepared by plate disk

Outside the growing season the extent of water loss is affected by the **shape of the tilled surface, surface cover and the depth of disturbance**.

Water conservation or loss

Independent of farming

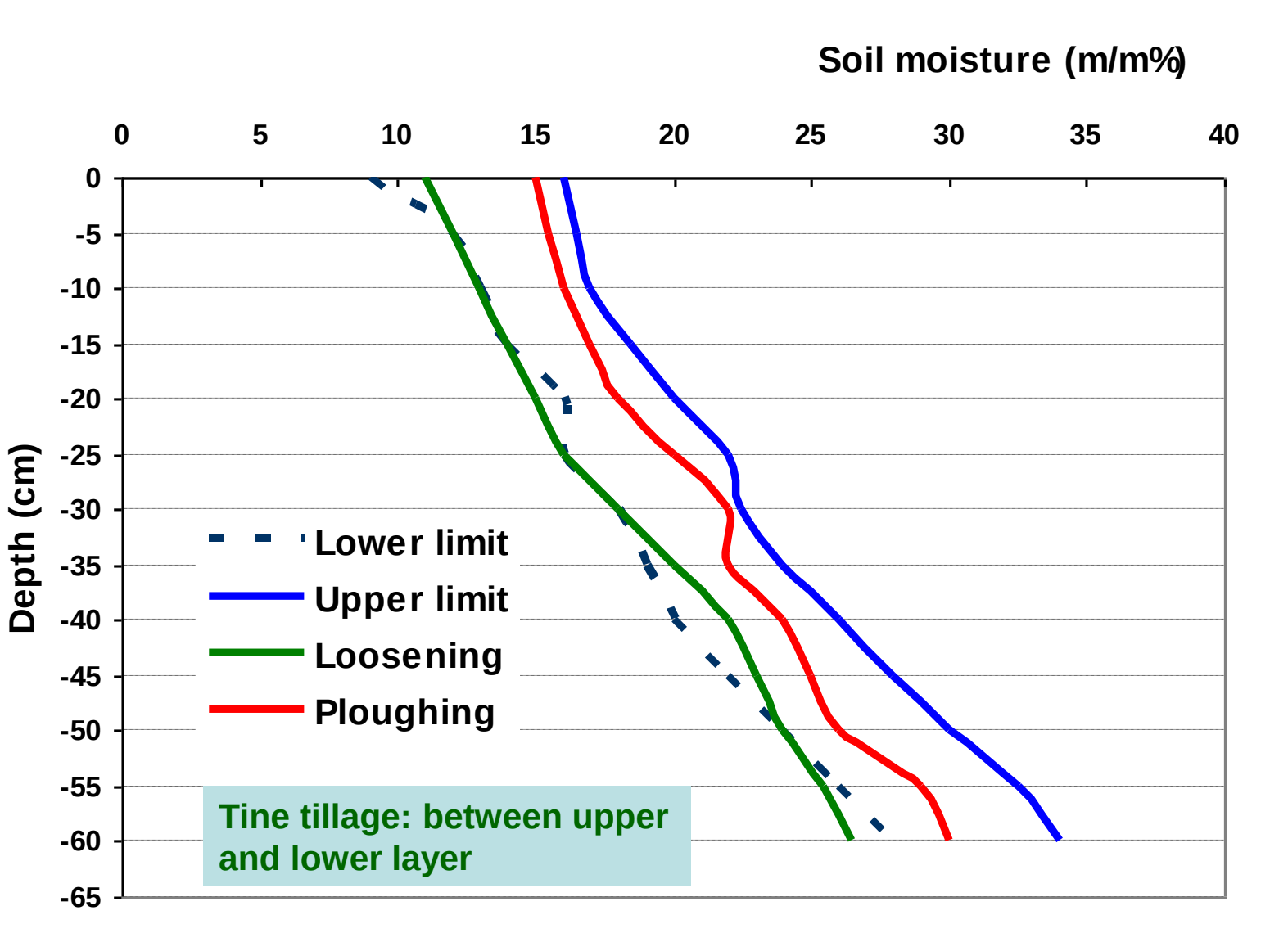
1) **Precipitation** (input)
2) Soil **water** management (±)

Depends on farming

Long-term land use
– water loss or water conserving

- ❑ **water utilization of plants**
- ❑ **soil tillage**
  (water loss or water conserving)
- ❑ **soil condition**
  - **capability of intake and storage;**
  - **capability to transport from deeper layers to the root zone**

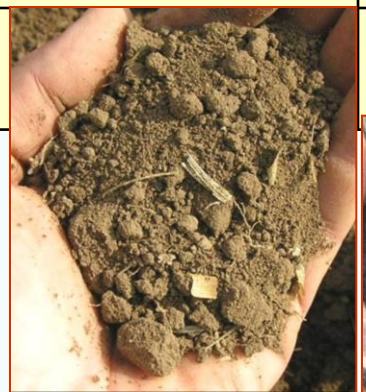
Water content for workability in a Chernozem soil at Hatvan



Water content levels ($m^{-3}m^{-3}$) related to soil tillage

(forest/loamy soil)

< 13	14 – 17	18 – 21	21 – 24	24 – 28	> 29
Wilting point: 9.42 – 10.34		Optimum (21 – 22)			
Dry	Moderately dry	Humid		Wet	Over-wet
Solid state		Semi-solid state			Plastic state
Clod/dust, forming	Clod/crumb forming moderately	Crumb forming		Structure deterioration	Smearing, puddling
Soil disturbance non-recommended	Good for subsoiling, disking	Good for ploughing and levelling, tine, surface preparing, sowing		Trafficable, but soil may be damaged Tine tillage? Direct drilling?	Non-trafficable, non-workable (non ploughable)
More energy, more damage		Least energy, least damage			Most energy, most damage



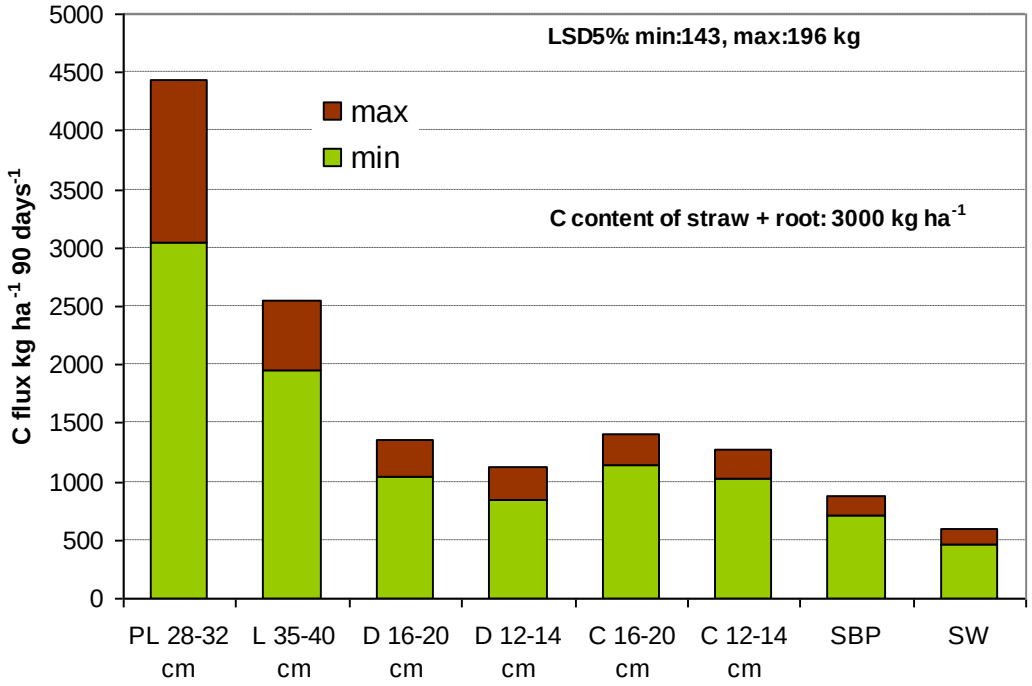
Water that cannot seep into the soil will never be utilised by crops!

farming-induced water-logging

Precipitation mm > water seeping into the soil

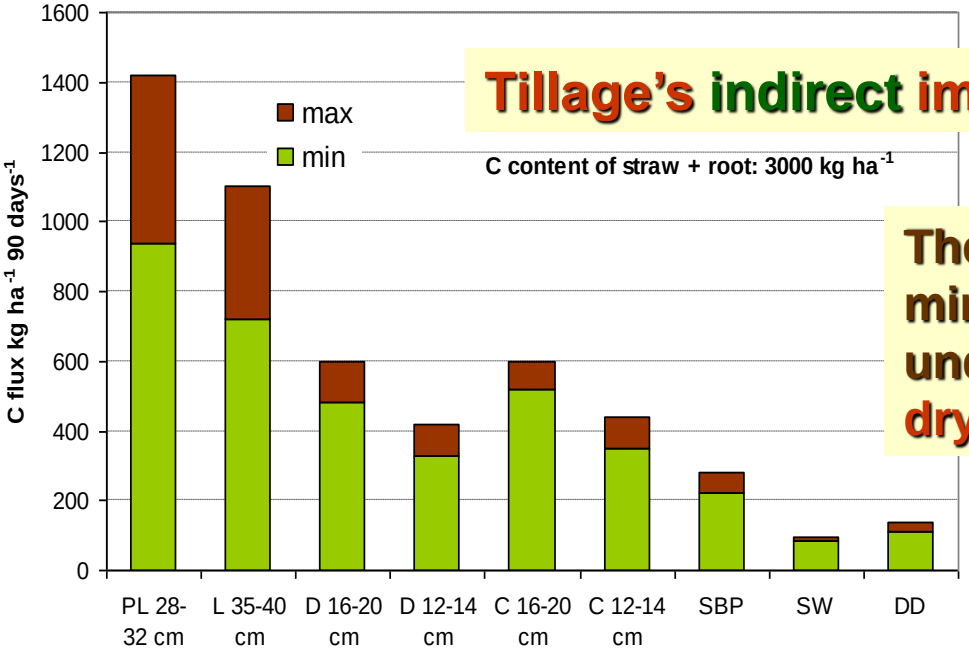
Bad soil state = less stored water + greater loss

We have to identify the real cause of the water-logging (natural or human / farming induced)



The possible C-loss of soil leaving relatively large surface under 90 days, in a moderately dry season

Legend:
PL: ploughing, L: loosening,
D: disking, C: tine tillage,
SBP: seedbed preparation,
SW: sowing, DD: direct drilling



Tillage's indirect impacts on soil state – CO_2 release

The possible C-loss of soil at minimised tilled surface under 90 days, in a moderately dry season

Carbon balance in case of maize following w. wheat

C input t/ha		Bad tillage	C output t/ha/season	Good tillage	C output t/ha/season
Straw	5.0	Stubble tillage (inadequate)	0.59 – 0.64	Stubble tillage (appropriate)	0.33 – 0.41
C content of straw	2.0	Weedy stubble	0.02 – 0.06	Chemical weed control	0.02 – 0.06
Roots	2.5	Ploughing 22-25 cm, non prepared	2.58 – 2.63	Ploughing 22-25 cm + preparation	0.86-1.07
C content of roots	1.0	Preparation by disk + roll	0.32 – 0.39	Cross-board levelling + roll	0.007 – 0.009
		Seedbed preparation 1x/2x + sowing	0,054 – 0,092	Seedbed preparation, sowing, in a day!	0.036 – 0.039
		Other traffic	0.152 – 0.323	Other traffic	0.152 – 0.323
Total C input	3.0	C loss	3.716 – 4.135	C loss	1.405 – 1.911
Balance			- 0.72 / - 1.14		+1.60 / +1.09
Risk			Moderate C reduction		C and humus increase
Roots + stubble stub	1.55				
C content of stub	0.62				
Balance			- 3.10 / - 3.52		- 0.79 / - 1.29
Risk			Great C reduction		Moderate C reduction