22nd ISTRO International Conference

"Living Roots, Living Soil"

Spatio-temporal dynamics of soil penetration resistance depending on different conservation tillage systems

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Centralna agrobiotehnička analitička jedinica

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Presentation structure:

- Something about Conservation Agriculture [CA] ongoing Project
- Site description
- Tillage treatments
- Tillage methods
- Penetration resistant measurement results
- Schematic conclusion
- Final remarks

Research Project

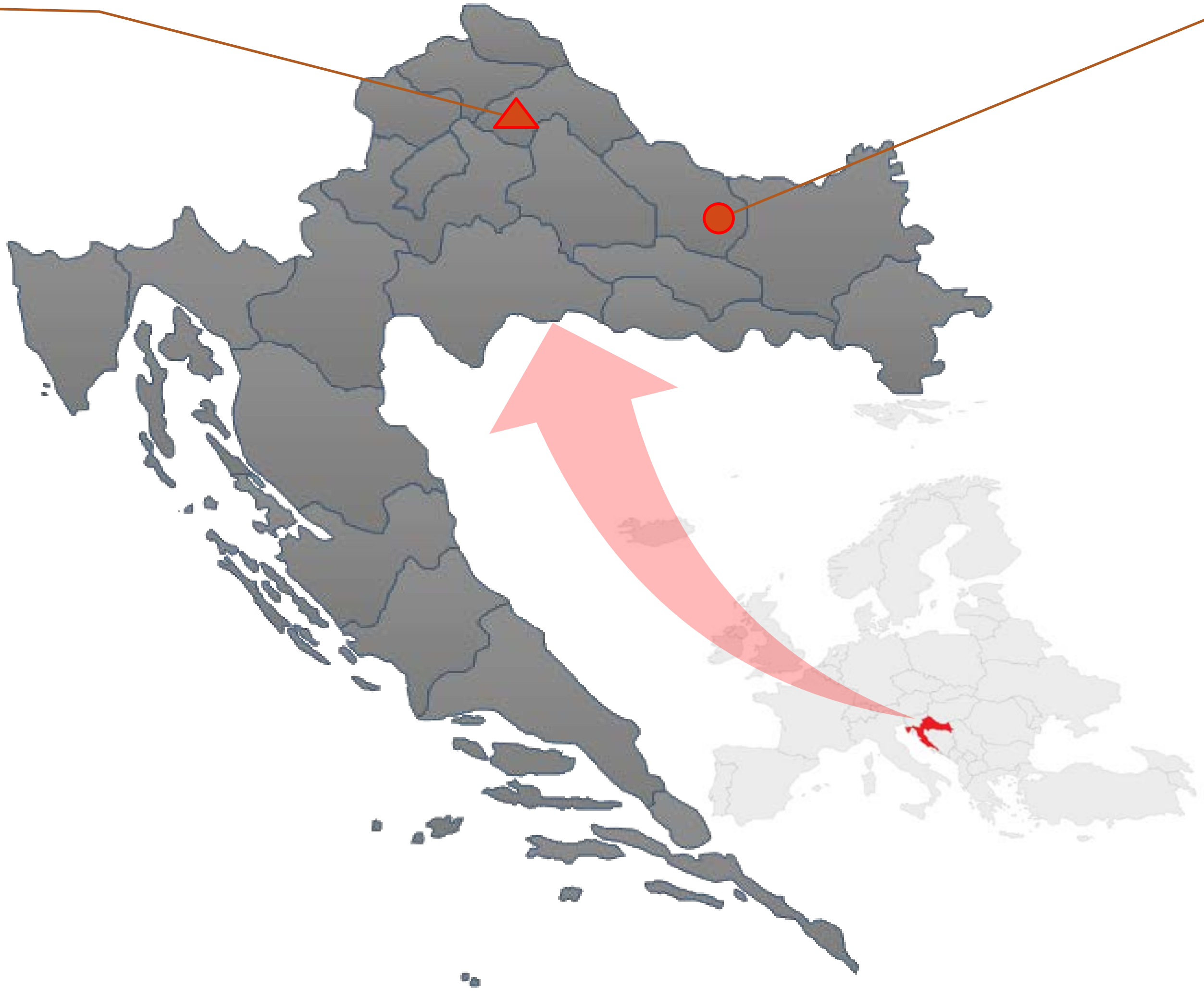
Assessment of conservation soil tillage as advanced methods for crop production and prevention of soil degradation

ACTIVEsoil

The aim of these Project studies is to determine the level of degradation of selected components of the physical, chemical and biological soil complexes by comparison of conventional and conservation soil tillage systems. Also, defining positive measures and procedures for stopping, preventing and mitigating anthropogenic and natural degradation processes in the soil at different agroecological research sites will be of great pertinence to environmental protection, agricultural producers, scientific and professional community, decision-makers, and will certainly serve as a basis for further scientific research.

Experimental ES2 (Križevci)

Gleysol



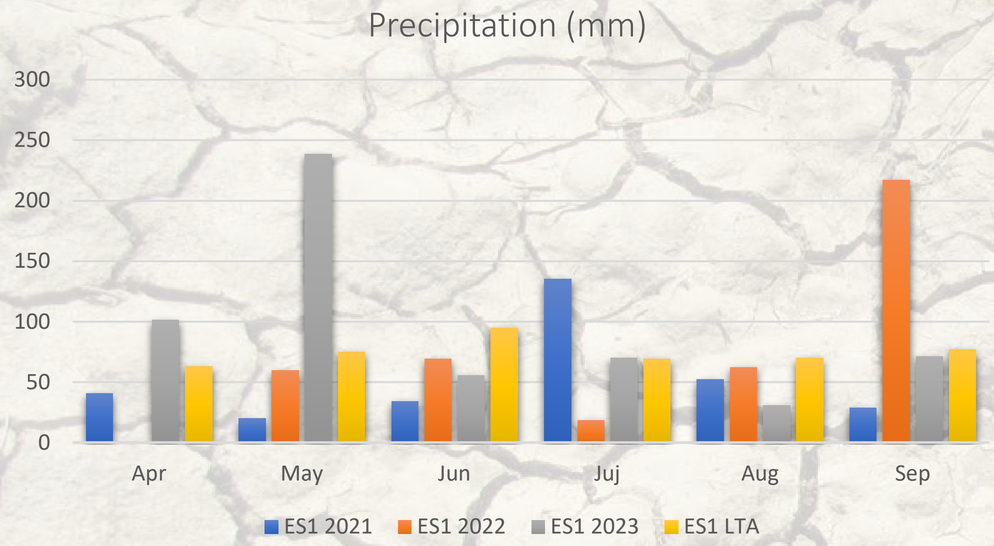
Experimental ES1 (Čačinci)

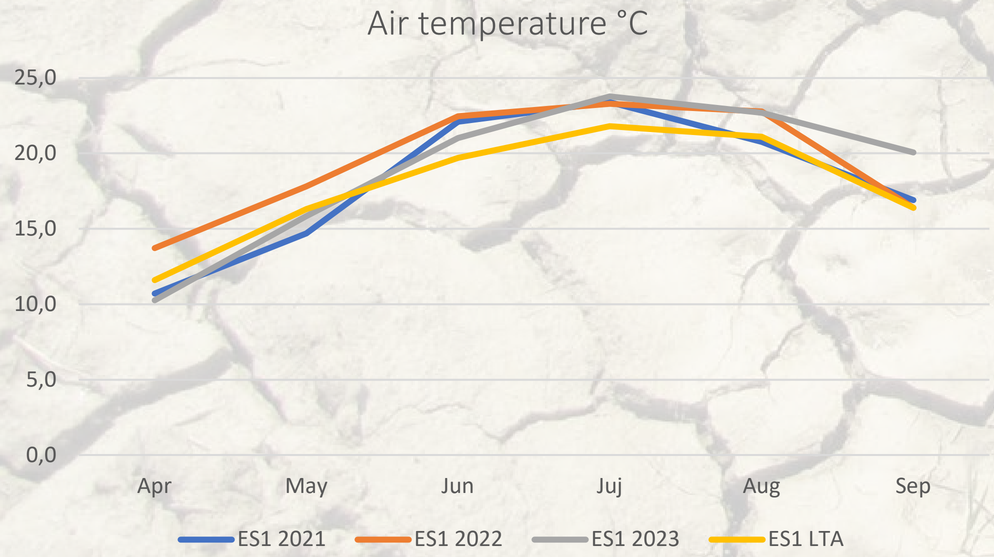
Stagnosol

Basic description of the mechanical, physical and chemical properties of the experimental sites

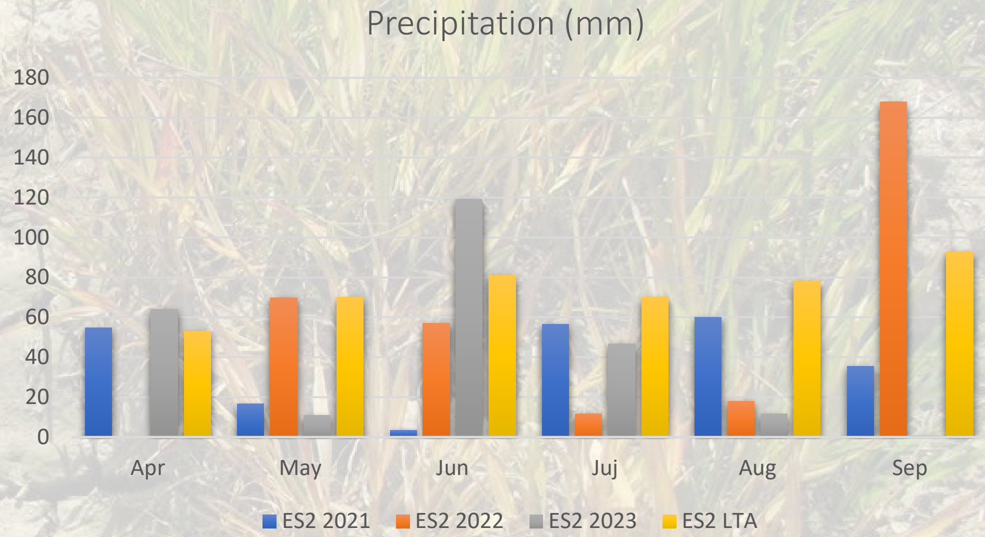
Parameter	ES1[1]	ES2
Location	17°86'36'' E	16°33'32'' E
	45°61'32'' N	46°01'38'' N
	111 m a. s. l.	141 m a. s. l.
Mechanical properties		
Soil type	Stagnosol	Gleysol
Soil texture	Silty clay loam	Silt
Soil particles (%)[4]	*Depth[2] 0–32 cm:*	*Depth 0–36 cm:*
	Silt = 60.84	Silt = 82.95
	Clay = 29.35	Clay = 9.61
	Sand = 9.81	Sand = 7.44
	Depth 32–65 cm:	*Depth 36–97 cm:*
	Silt = 57.61	Silt = 80.41
	Clay = 34.08	Clay = 14.08
	Sand = 8.31	Sand = 5.52
	Depth 65–200 cm:	*Depth 97–175 cm:*
	Silt = 58.92	Silt = 78.96
	Clay = 30.29	Clay = 14.90
	Sand = 10.79	Sand = 6.15
Physical properties		
Field capacity – FC (vol.%)	*D1[3]:* 43.04	*D4:* 42.44
	D2: 42.58	*D5:* 37.69
	D3: 40.13	*D6:* 36.31
Particle density – ρ_b ($g\ cm^{-3}$)	*D1:* 2.65	*D4:* 2.69
	D2: 2.74	*D5:* 2.73
	D3: 2.71	*D6:* 2.78
Packing density – PD ($g\ cm^{-3}$)	*D1:* 1.76	*D4:* 1.51
	D2: 1.87	*D5:* 1.73
	D3: 1.83	*D6:* 1.79
Total porosity – ε (%)	*D1:* 43.50	*D4:* 47.21
	D2: 42.97	*D5:* 41.39
	D3: 40.65	*D6:* 39.91
Chemical properties		
pH(KCl)	*D1:* 3.92	*D4:* 5.22
	D2: 4.23	*D5:* 5.73
	D3: 4.39	*D6:* 5.68
pH(H_2O)	*D1:* 5.12	*D4:* 6,65
	D2: 6.16	*D5:* 7.44
	D3: 5.92	*D6:* 7.50
Hidrolitic acidity – Hy (cmol(+) kg^{-1})	*D1:* 7.48	*D4:* 2.47
	D2: 4.07	*D5:* –
	D3: 3.15	*D6:* –
P_2O_5 (AL), mg kg^{-1} soil	*D1:* 75	*D4:* 154
	D2: 20	*D5:* 26
	D3: 18	*D6:* 32
K_2O (AL), mg kg^{-1} soil	*D1:* 111	*D4:* 75
	D2: 107	*D5:* 52
	D3: 114	*D6:* 48
Soil Organic Matter – SOM (%)	*D1:* 2.83	*D4:* 1.64
	D2: 0.83	*D5:* 0.52
	D3: 0.48	*D6:* 0.41

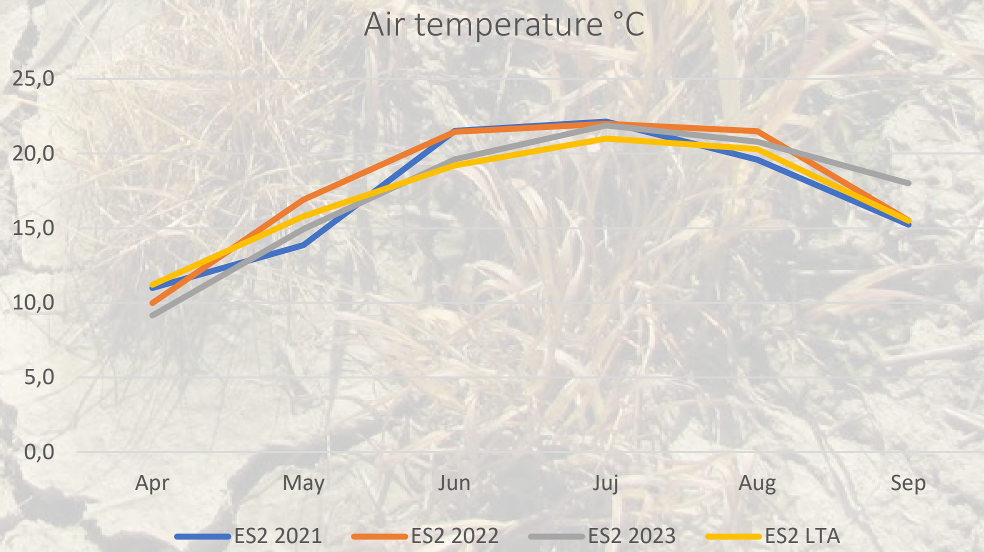
Stagnosol





Gleysol





Soil tillage treatments

ST standard (conventional) tillage

- Ploughing
- Up to 30 cm deep
- Soil surface covered with crop remains at maximum 15%

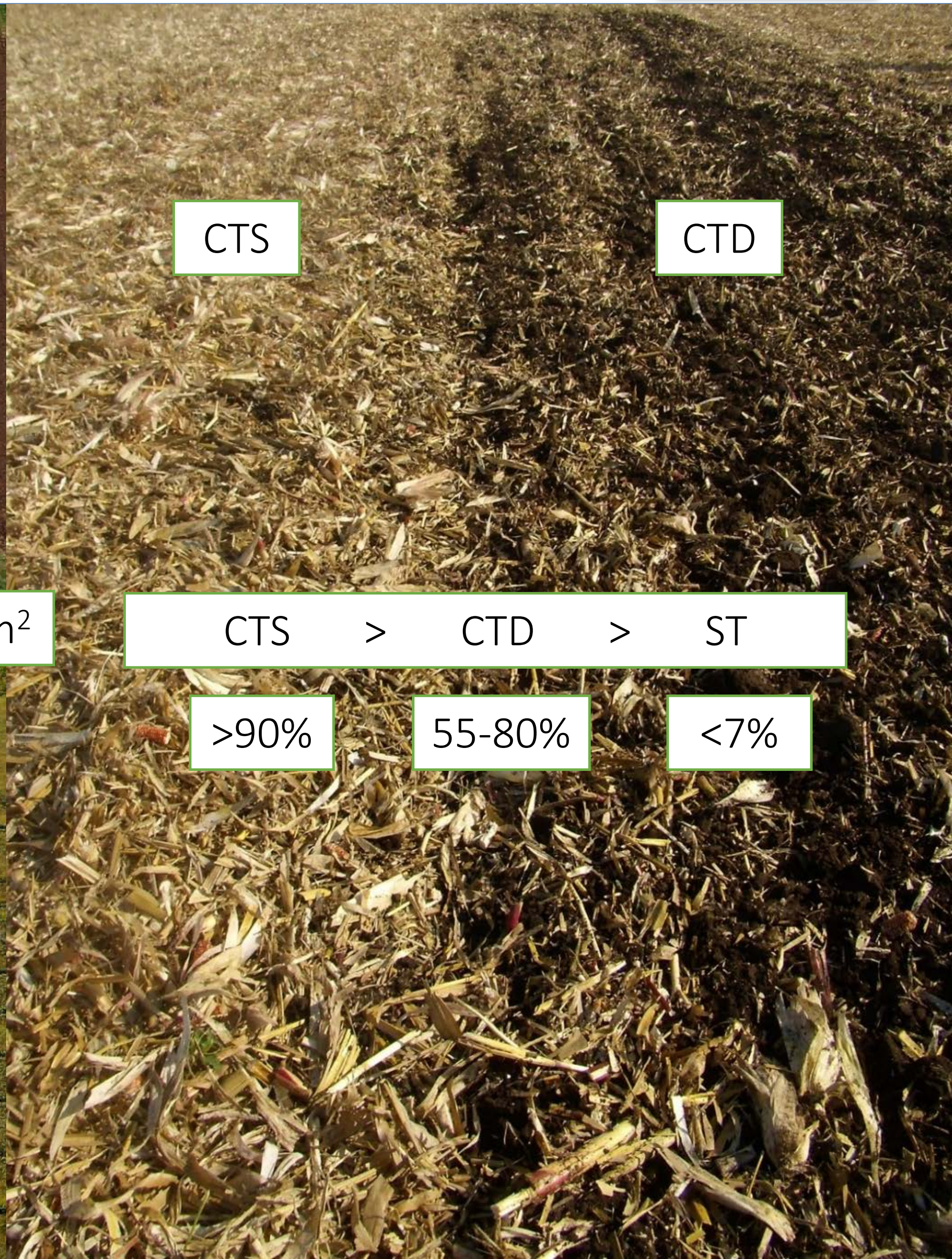
CTD Conservation tillage - Deep

- Chiseling
- Up to 30 cm deep
- Soil surface covered with crop remains at minimum 30%

CTS Conservation tillage - Shallow

- Chiseling
- Up to 10 cm deep
- Soil surface covered with crop remains at minimum 50%


Experimental ES2 (Križevci)
1st year: MAIZE (2021)
2nd year: SOYBEAN (2022)
3rd year: W. Wheat (2022/2023)
4th year: MAIZE (2024)
Basic experimental plot 640 m^2
Experimental ES1 (Čačinci)

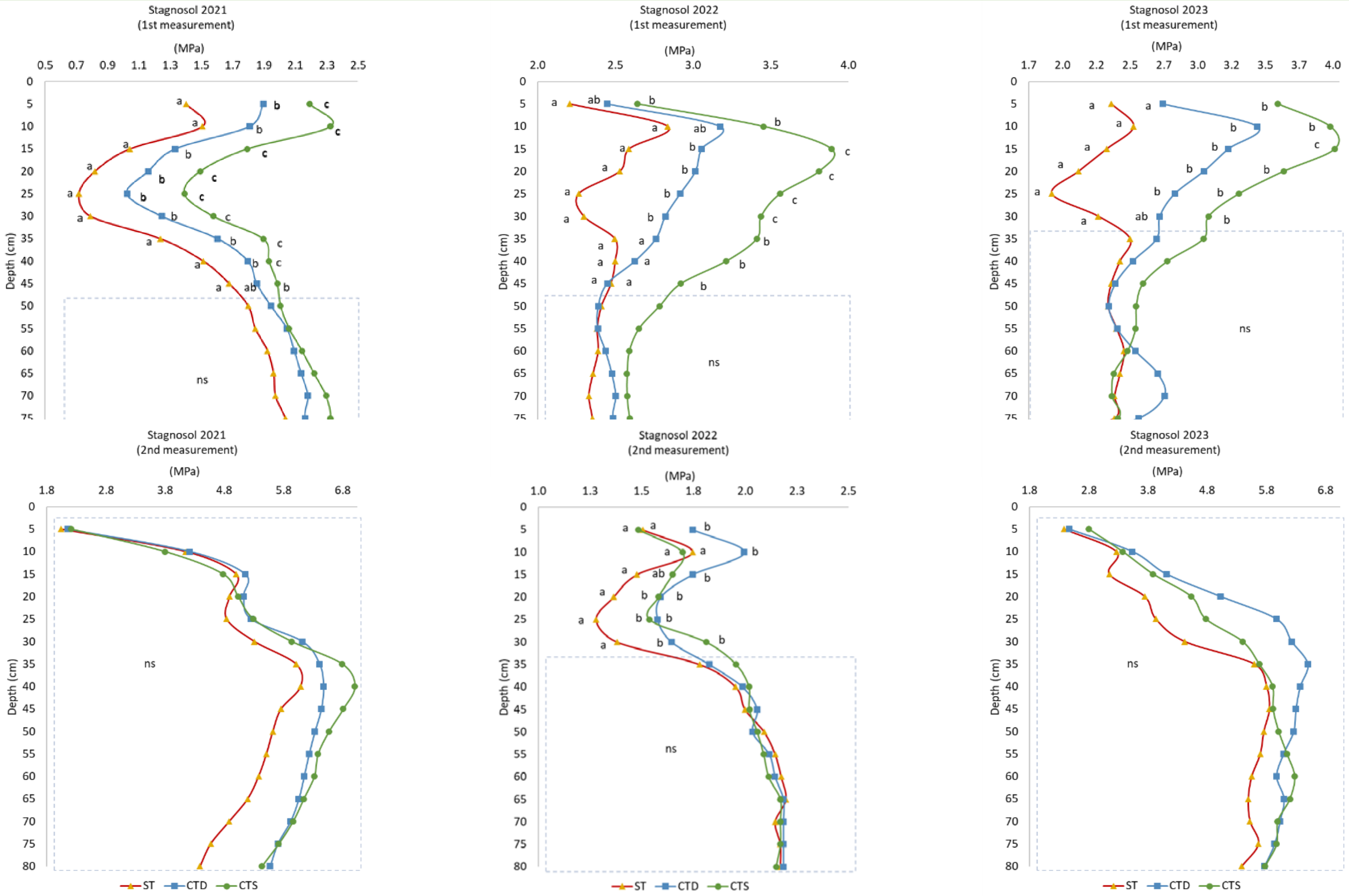

CTS
CTD
CTS > CTD > ST
>90%
55-80%
<7%

Dates of sowing, harvesting and penetration resistance measurements on both experimental sites

Season	Crop	Site	Sowing date	Harvest date	Penetration resistance measurement	
					GS	Date[2]
2020/2021	Maize	ES1[1]	06/05/21[2]	22/09/21	V3	04/06/21
					R5	23/09/21
		ES2	10/05/21	25/09/21	V3	05/06/21
					R5	25/09/21
2021/2022	Soybean	ES1[1]	14/04/22	29/09/22	V3	27/05/22
					R8	17/10/22
		ES2	29/04/22	03/10/22	V3	03/06/22
					R8	17/10/22
2022/2023	Winter wheat	ES1[1]	20/10/22	06/07/23	Feekes 6	10/04/23
					Feekes 11	10/04/23
		ES2	21/10/22	12/07/23	Feekes 6	01/06/23
					Feekes 11	01/06/23

- electronic penetrometer „*Eijkelkamp Penetrologger SN*”
- cone tip with a base area of 1 cm^2, and an angle of 60°
- measuring up to 80 cm
- readings on each 1 cm of depth, with mean velocity 1 cm s^{-1}
- GPS-located network
- each point on the grid was 2 m in diameter
- 8 measurements per each tillage plot

Stagnosol

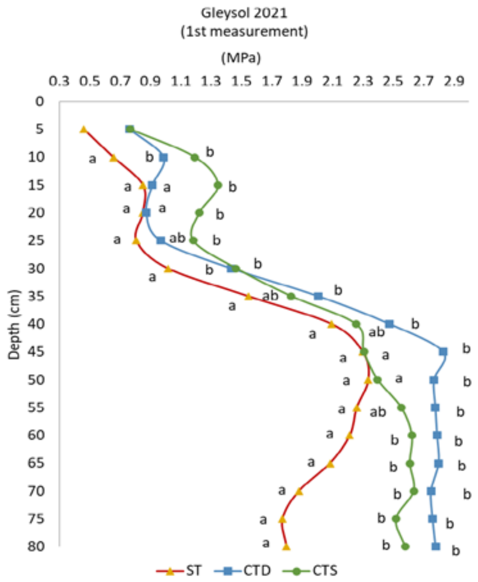

Stagnosol 2021
(1st measurement)
Stagnosol 2022
(1st measurement)
Stagnosol 2023
(1st measurement)
Stagnosol 2021
(2nd measurement)
Stagnosol 2022
(2nd measurement)
Stagnosol 2023
(2nd measurement)
(MPa)
Depth (cm)
ns
ST
CTD
CTS

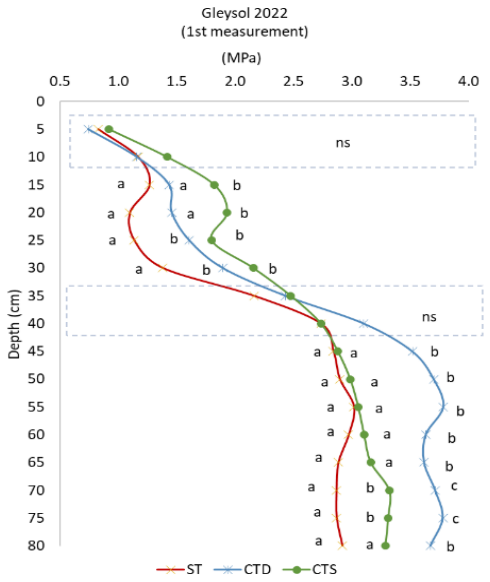
ACTIVEsoil

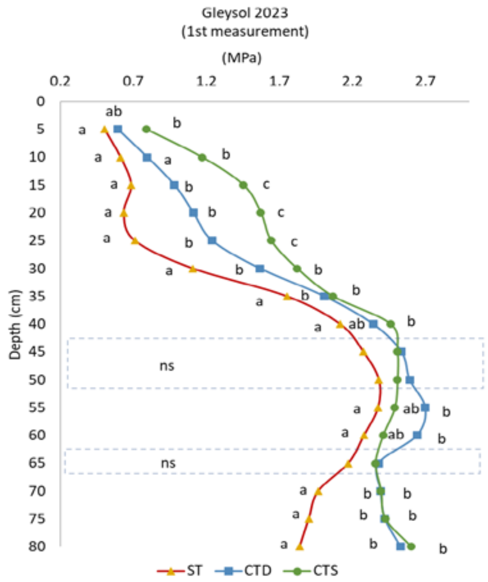
HRZZ (Croatian Science Fundation) project:
"Assessment of conservation soil tillage as advanced methods for crop production and prevention of soil degradation"
ACTIVEsoil: IP-2020-02-2647

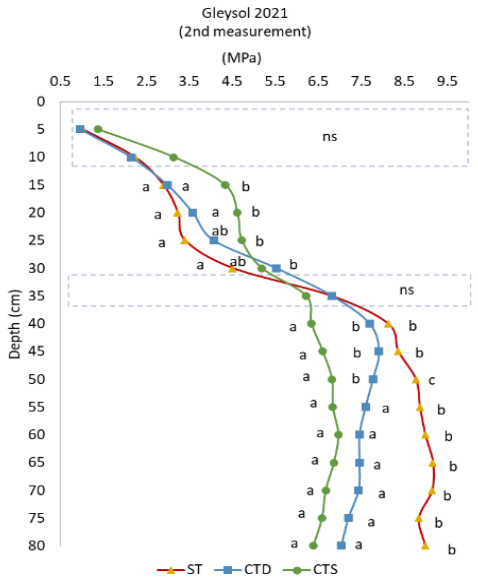
Hrzz Croatian Science Foundation

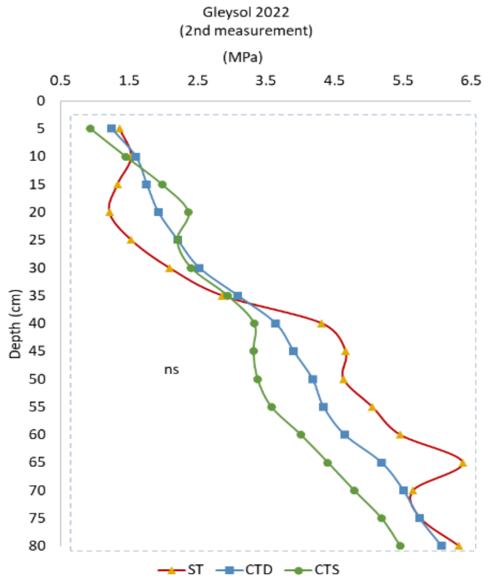
Gleysol

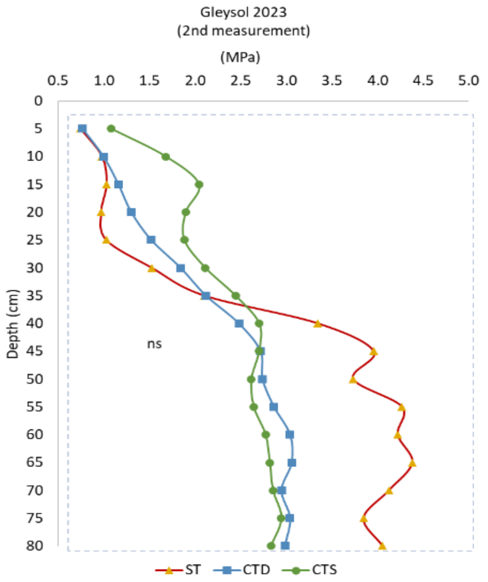












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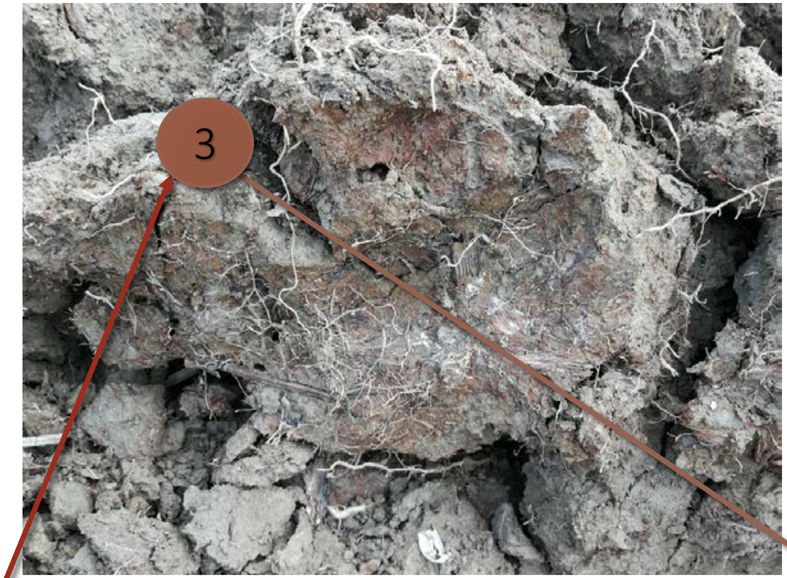
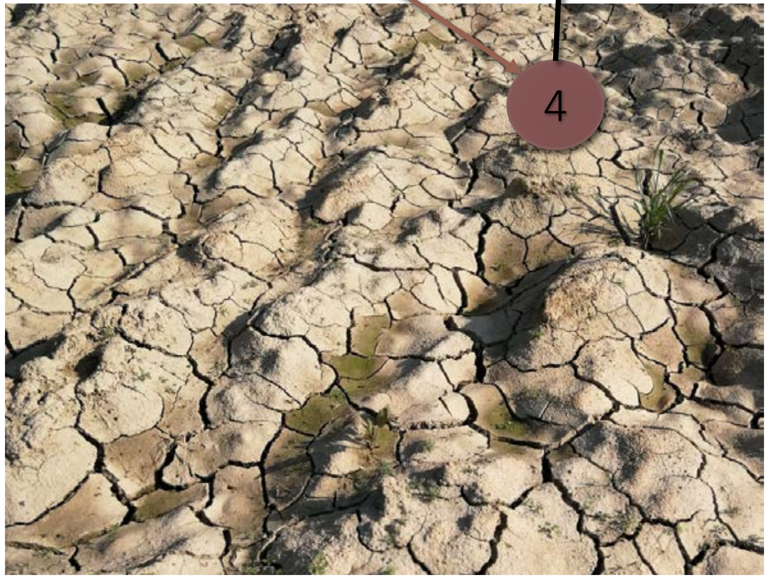
Plowing



Soil degradation

Inappropriate soil management – pathways to soil degradation



Final remarks

- Penetration resistance is more strongly influenced by weather conditions than by different tillage systems.
- Stagnosol soil type is more compact than Gleysol, but only in 1st measurement, while in the 2nd measurement results are reversed.
- In the upper layers (up to 35 cm), PR values were in most cases below the root-limiting critical value (3.5 MPa) at both experimental sites and on both measurement dates.
- By increasing the depth, the PR values at each tillage treatment began to stabilize and smooth out, with similar dynamics on both soil types and measurement dates.
- On Stagnosol, during all investigated years in 1st and 2nd measurements, the highest values of PR values were measured at the CST treatments.
- On Gleysol, during 1st measurement throughout all three years, the highest PR was measured for CST treatments, while during the 2nd measurement, the highest PR was on ST.

- Compared to ST both CST types showed after three years of experiments a significant overall reduction in PR values on both soil types especially on the Gleysol soil type.
- This trend indicates first an increase in PR in ST systems and then a stagnation or decrease in PR in CST treatments.
- The achieved results indicate the potential of replacing ST with CST treatments that ensure better and more efficient rooting of crops and consequently higher yields.
- PR measurement provides valuable results on soil compaction and can be a very useful tool in short-term response.

Thank you for your kind attention!!!

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