Igor Bogunovic, Ivan Dugan, Manuel Matisic, Boris Lazarevic, Ivica Kisic

Tillage and amendment management impact on saline soil properties and crop yields in Mediterranean organic farm in Croatia

University of Zagreb Faculty of Agriculture, Svetosimunska 25, 10000 Zagreb, Croatia

Introduction

Climate change alters the global hydrological cycle and results in land degradation. Salinity is increasing at 1–2% per year (Kumar et al., 2021). The reclamation of saline/sodic soils is an important goal to maintain soil productivity. Reclamation techniques are challenging in organic farming since they require significant expertise, as agrochemicals are prohibited. Our objectives were to identify proper soil management and assess the effect of organic amendments on meeting the crop requirements in saline-sodic soils.

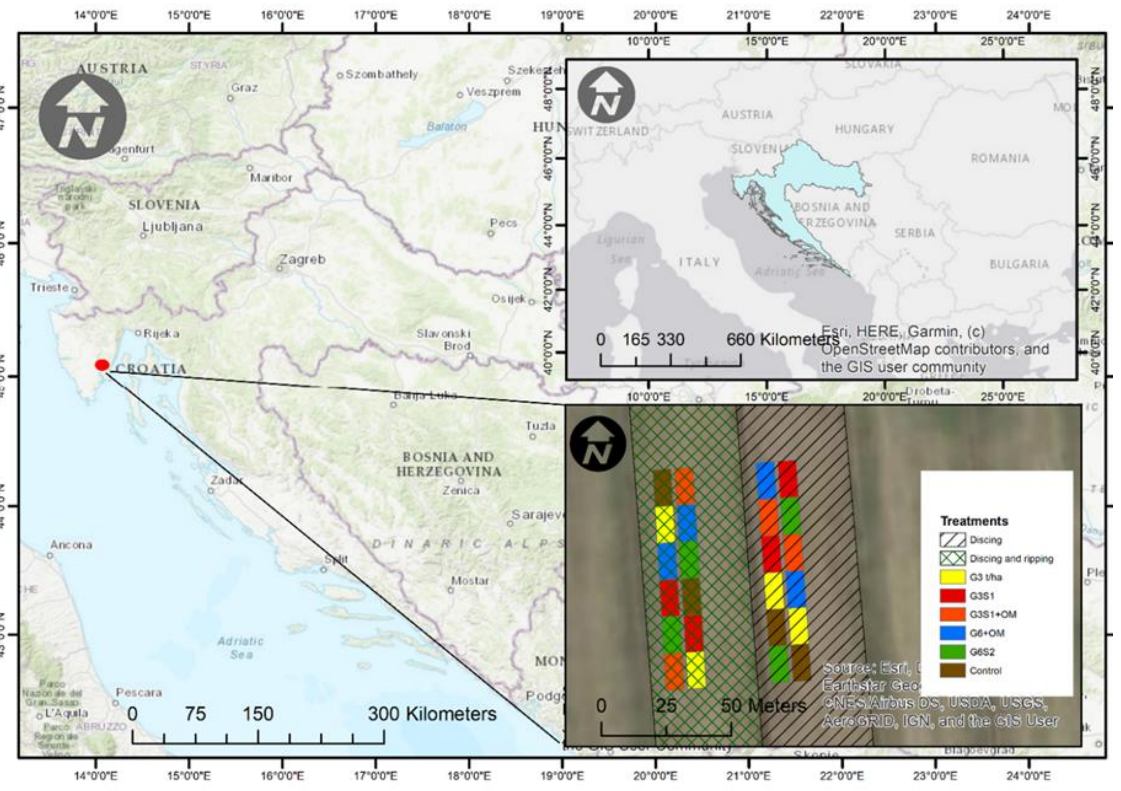

Figure 1: Study area and experimental design

Methodology

Agricultural land is part of the Rasa basin, a polders divided by the river and channels. The terrain is flat and ameliorated, below sea level (about 1.5 m), where the water level is controlled by pumping stations (Fig. 1).

Land was abandoned at least two decades, while re-cultivation begins in summer of 2015. Climate is Mediterranean while soils are silty clay loam Anthrosols (Table 1).

This research studies the impact of different tillage managements: shallow disc-harrowing (10 cm depth) and disc-harrow with ripping (30 cm depth). Inside each tillage management, three selected treatments: control, G6+OM (6 t ha^{-1} gypsum + 40 t ha^{-1} farmyard manure), and G6S2 (6 t ha^{-1} gypsum + 2 t ha^{-1} sulfur) we test to show the reclamation impact on soil physical and chemical properties in saline-sodic soils of River Raša Valley (Croatia). We run the experiment for four years (2016-2019).

Table 1: Main characteristics of soils in the study area.

	Anthrosols		
	0–35 cm	**35 – 90 cm**	**90 – 160 cm**
pH (H_2O)	7.7	8.2	8.0
pH (KCl)	7.2	7.4	7.4
$CaCO_3$ (%)	32.9	30.4	26.5
Organic matter (%)	1.9	-	-
Total N (%)	0.14	-	-
C/N	7.8	-	-
ECe (dS m^{-1})	8.03	-	-
CEC (cmol(+) kg^{-1})	25.67	-	-
ESP	22.16	-	-
Sand (%)	8.74	3.62	1.69
Silt (%)	56.57	50.55	40.26
Clay (%)	34.69	45.83	58.05
Texture	Silty Clay Loam	Silty Clay	Clay

Results and Discussion

Results show that disc-harrow with ripping treatment significantly increased soil moisture and significantly reduced bulk density and penetration resistance compared to disc-harrow treatment. Aggregate stability is higher on disc-harrow with ripping treatment.

Table 2: Post-hoc results of amendment and tillage impact for soil water content (SWC, %), bulk density (BD, g cm^{-3}), penetration resistance (PR, MPa) and water stable aggregates (WSA, %). Different letters inside a column indicate significant differences between treatments. DH- disk harrow, DH+RIP – disk harrow with ripping

Factor	SWC	BD	PR	WSA
Tillage				
DH	42.6b	1.49a	1.39a	74.2a
DH+RIP	43.5a	1.44b	1.30b	73.2a
Amendment				
G6S2	44.0a	1.43b	1.33a	74.2a
G6+OM	43.4ab	1.44b	1.29a	76.2a
Control	42.8b	1.50a	1.34a	70.1a

Table 3: Post-hoc results of amendment x tillage x year interaction for soil water content (SWC, %), bulk density (BD, g cm-3), and penetration resistance (PR, MPa). Different letters inside a column indicate significant differences between treatments.

Amendment	Tillage	Year	SWC	BD	PR	WSA
G6S2	Discing	2016	45.1a	1.46a	1.41a	68.2a
G6+OM	Discing	2016	42.5b	1.47a	1.17b	72.7a
Control	Discing	2016	44.6a	1.48a	1.36ab	70.0a
G6S2	Ripper	2016	45.1a	1.36b	1.20a	71.8a
G6+OM	Ripper	2016	45.1a	1.39b	1.23a	72.3a
Control	Ripper	2016	43.1b	1.52a	1.19a	70.4a
G6S2	Discing	2019	42.9a	1.48ab	1.36a	76.8a
G6+OM	Discing	2019	43.3a	1.44b	1.46a	78.7a
Control	Discing	2019	41.3b	1.51a	1.43a	70.0a
G6S2	Ripper	2019	43.1a	1.41b	1.35a	80.3a
G6+OM	Ripper	2019	42.7a	1.44ab	1.31a	81.3a
Control	Ripper	2019	42.1a	1.49a	1.38a	70.0a

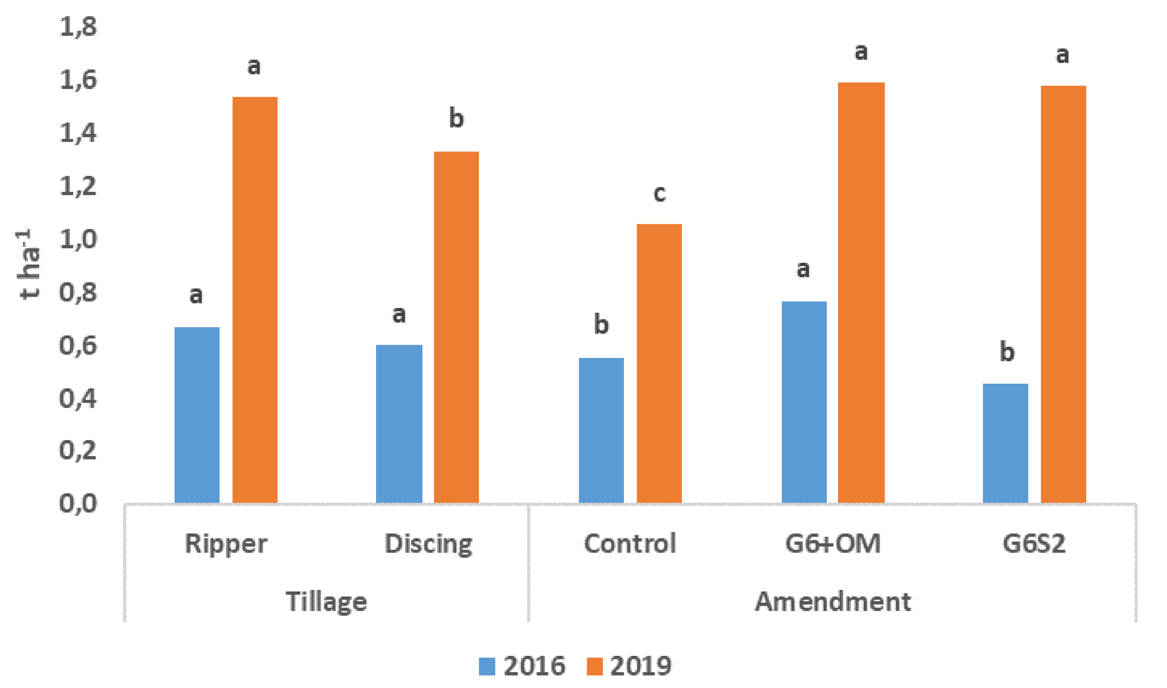

Figure 2: Post-hoc single factor effect of tillage and amendment for oat grain yield (t ha^{-1}) in 2016 and 2019. Different letters inside same year indicate significant differences between treatments.

Soil amendments significantly impacted soil properties. The G6S2 recorded significantly higher soil moisture than at control plots. The penetration resistance was significantly lower, while aggregate stability was higher at G6+OM and G6S2 than at control plots. Yields of oats at the beginning of the experiment are insignificant between tillage managements.

At the end of the experiment, disc-harrow with ripping recorded a significantly higher yield of oats than disc-harrow. During the first year of research, the G6+OM treatment recorded significantly higher oats yields than the control and G6S2 treatments. At the end of the experiment, G6S2 recorded a significantly higher oat yield than control.

Conclusions

Results showed that managing saline/sodic soils under organic farming is challenging and exhibits reduced grain yields. According to the present research, the most appropriate soil management is loosening tillage management and gypsum-manure application, which ensure the optimal soil physical environment and stable yields.

References

[1] Kumar, C., Ramawat, N., Verma, A. K. (2022). Organic fertigation system in saline-sodic soils: A new paradigm for the restoration of soil health. Agronomy Journal, 114(1), 317-330.

Acknowledgements

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Salt-affected soils: threats and potentials