Carbon sequestration in dry agricultural soils

THEME 2

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INTRODUCTION

Can we mitigate atmospheric CO_2 through improved soil management?

The importance of improved soil management practices in the mitigation of the current atmospheric CO_2 increase through the enhancement of soil organic carbon (SOC) levels has long been recognised (Aguilera *et al.* 2013). But a proper understanding of the response of Mediterranean soils to climate change and their mitigation capacity, if managed sustainably, is still lacking.

Study sites and improved soil management practices

Our study was conducted in two organic rainfed almond (*Prunus dulcis* Mill.) orchards located in the province of Murcia (SE Spain). The climate is semiarid Mediterranean. Annual rainfall and temperature average 300 mm and 16 °C, respectively. Soils (Calcisols) in the sites are relatively shallow (~ 35 cm depth) with moderate slopes (7-15%), have a silt-loam texture and high contents of $CaCO_3$(~45%). Soil management practices (conventional tillage, reduced tillage, reduced tillage plus green manure, and no tillage; Figure 1) were implemented in October 2008. The management practices differ in the number of passes, the presence or not of plant cover in the rows, the quantity and quality of plant residues, and whether these are incorporated into the soil or left on the soil surface.

OBJECTIVES

We assess:

- i) the short-term response of soil CO_2 flux to tillage operations and its implications for annual soil CO_2 emissions;
- ii) the effect of improved soil management practices on SOC stabilization; and
- iii) if the response of soil CO_2 flux to soil temperature and water content varies among soil management practices.

MAIN RESULTS

Implications for organic carbon stabilization in agricultural soils

Passing from conventional tillage to reduced tillage combined with the incorporation of plant residues (native vegetation or green manure) increased the SOC stocks by 30% at Alhagüeces (Table 1). At Burete, green manure increased the SOC stock by 45% compared to the reduced tillage treatment. The longest mean residence times (MRTs) of SOC stocks at both sites were observed under green manure, which highlights that green manure can be a promising option for SOC preservation.

Tab. 1: SOC content, Particulate and Mineral Associated OC, C:N ratios, OC stocks, respired C from soil and mean residence time (MRT) of SOC for each soil management practices at each site

	Alhagüeces site			Burete site		
	Conventional tillage	Reduced tillage	Green manure	No tillage	Reduced tillage	Green manure
SOC (g kg^{-1})	19.1 ± 0.8a	22.4 ± 0.8b	27.4 ± 0.9c	10.0 ± 1.00a	10.4 ± 0.9a	11.6 ± 0.8a
Particulate OC (g kg^{-1})	7.4 ± 0.5a	9.5 ± 0.5b	9.38 ± 0.5c	2.45 ± 0.3a	2.04 ± 0.3a	3.33 ± 0.25b
Mineral OC (g kg^{-1})	11.7 ± 0.4a	12.1 ± 0.5b	14.2 ± 0.3c	7.9 ± 0.55a	9.02 ± 0.44a	8.38 ± 0.5a
C:N	10.9 ± 0.7	10.6 ± 0.4	11.2 ± 0.4	10.50 ± 1.03	9.55 ± 0.75	11.60 ± 0.25
SOC stock (g m^{-2})	4223	5448	5551	2544	2517	3703
C respired (g m^{-2} yr^{-1})	399	469	439	405	492	492
MRT (SOC:C respired)	10.6	11.6	12.6	6.3	5.1	7.5

Improved soil management will enhance soil resilience against global warming

Soil CO_2 flux was more sensitive to temperature increments under conventional tillage than under both reduced tillage treatments during the growing season (Fig. 2B).

Soil under no tillage showed the lowest soil CO_2 flux rates and less responsiveness to soil moisture fluctuations during the dry period (Fig. 2C).

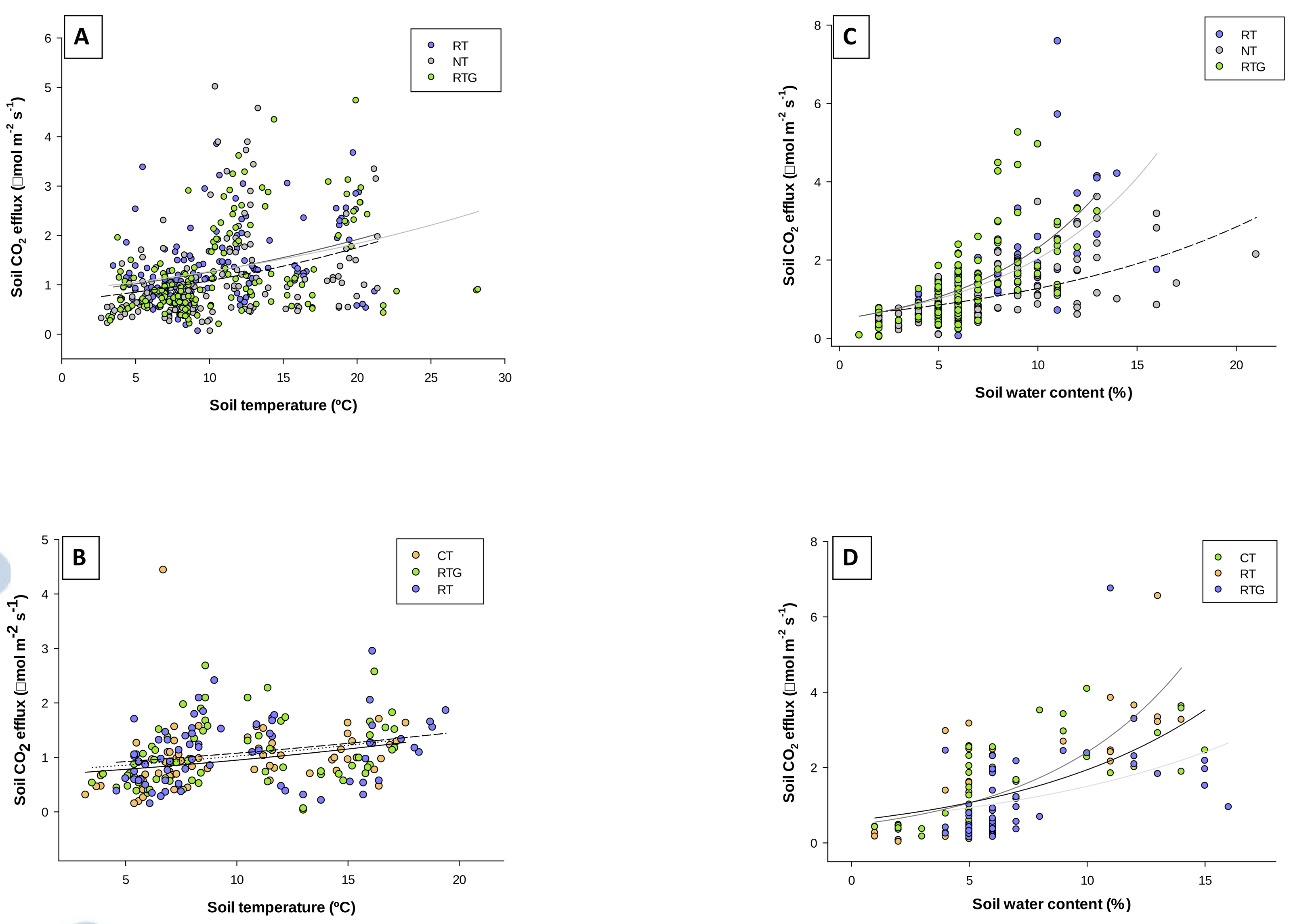
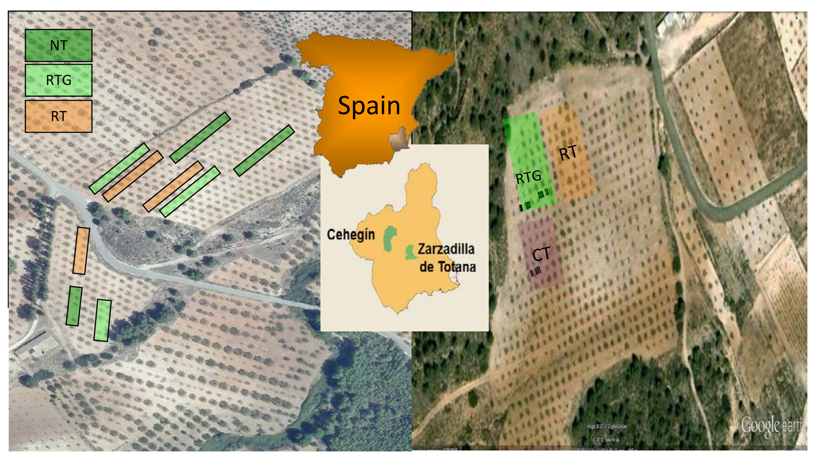


Fig. 2: Response of soil CO2 efflux rate to soil temperature during the growing period (panels A and B). and to soil water content during the dry period (panels C and D) for each soil management practice at each site



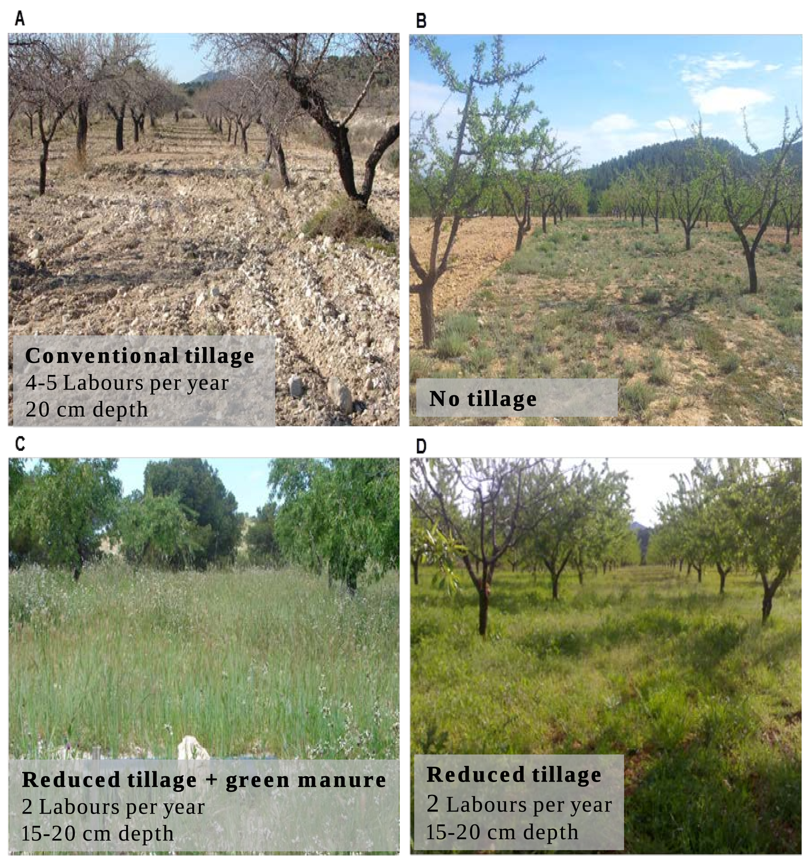


Fig. 1: Different soil management practices showing the aspect of the plant cover in the rows at the end of the growing season: A Conventional Tillage (CT); B No Tillage (NT); C Reduced Tillage plus Green Manure (RTG); and D Reduced Tillage (RT)

CONCLUSION

Tillage operations had a rapid but short-lived effect on soil CO_2 flux rates with no significant influence on the annual soil CO_2 emissions. According to our results, bare soils will be more prone to mineralization as global warming proceeds.

Plant residues incorporation promoted soil aggregation and organic carbon preservation, making soils more resilient to abrupt changes in temperature and moisture.

Studies at larger spatial scales representing a wide range of climatic conditions as well as results derived from longer-term studies (> 10 years) are needed to fully understand the mitigation potential of improved soil management practices in semiarid Mediterranean woody cropping systems under climate change.