Effects of Using Sheep to Manage Vineyard Cover Crops in Soil Labile C & N and Greenhouse Gas Emissions

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BACKGROUND

California vineyard soils are susceptible to erosion and degradation due to factors like variable topography, and extreme droughts and temperatures exacerbated by the changing climate. These conditions might negatively impact production and quality of grapes and other essential soil ecosystem services. Cover crops are a recommended for improving soil health in vineyards; however, its success depends on its termination strategies. Some effective cover crops termination strategies include using herbicides and/or tillage, but these have caused negative non-targeted effects in human, environmental, and/or soil biota quality.

Sheep grazing is an environment friendly alternative proposed for managing cover crops especially in no-till systems which are proposed for improving soil health through organic matter accumulation. However, the effects of grazing cover crops in tilled vs not-tilled soil health are not well understood. Also, it is thought that these practices could promote soil greenhouse gas (GHG) emissions, which are of serious environmental and health concerns.

AIM & SIGNIFICANCE

- **Aim**: study how cover crop sheep grazing across tillage intensities impact labile carbon (C) and nitrogen (N) pools as soil health indicators sensitive to management and GHG emissions in a vineyard.
- ↑ **Soil Health +** ↓ **GHG emissions** in CA vineyards (top global wine grape producer) is essential for agricultural and environmental sustainability.

HYPOTHESES

1. Soils under grazing and no-till will result in higher labile C and N.
2. Soils under grazing and tillage will result in higher GHG emissions.

EXPERIMENTAL DESIGN & METHODS

- Tablas Creek Vineyard, Paso Robles, CA
- Syrah grape, Organic and Biodynamic
- SoilMax Organic Legume Cover Crop Mix
- Project initiation: 2018
- Full Factorial Randomized Complete Block Design
- Treatments: Tillage | No-Till; Grazing | No-Grazing

Figure 1. Experimental Design

- Grazing event: Feb 24, 2020
- Data Analysis: 3-way Analysis of Variance (ANOVA), n=16
- N_2O, CH_4 and CO_2 samplings from in situ gas chambers:

Before Grazing: Feb 22 → After Grazing: Feb 25-27 & Mar 1 → Shimadzu GC-2014 gas chromatograph

- Soil Sampling and General Information:

Depth	Location:	Time:	Soil pH:	Mollisols	Organic Matter:
0-15 cm 15-30 cm	Vine Tractor Row	Feb 2020	7.5 - 8.8	Calcic Haploxerolls	4%

METHODS

- Soil Labile C & N Indicators:

Permanganate Oxidizable C (POXC)
Soil + $KMnO_4$, dilution H_2O, quantified 550nm

Mineralizable C (Min C)
Re-wetted soil incubation 48-hr, CO_2 quantified with IRGA

Microbial Biomass C (MBC)
$CHCl_3$ fumigation, K_2SO_4 extraction, DOC quantification

Soil Nitrate (NO_3^-)

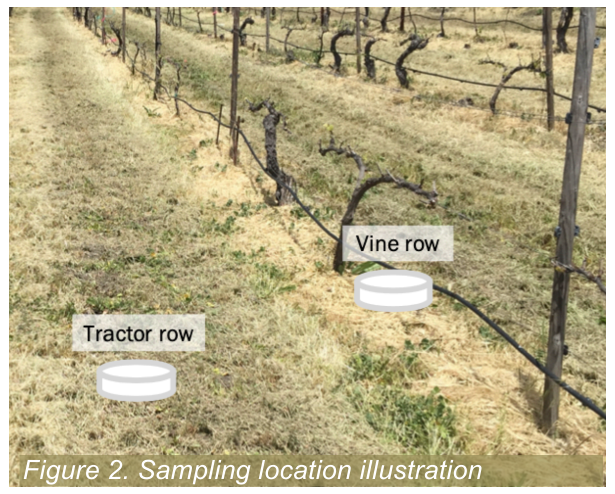

Figure 2. Sampling location illustration

RESULTS

Source:	POXC F value	POXC Signif.	Min C F value	Min C Signif.	MBC F value	MBC Signif.	Nitrate F value	Nitrate Signif.
Vine Row								
Grazing (G)	0.02		0.42		1.91		4.36	*
Tillage (T)	2.66		0.48		0.00		1.71	
Depth (D)	41.86	***	1.08		21.07	***	3.62	.
G x T	1.20		0.82		0.84		2.09	
G x D	1.38		0.04		0.06		0.57	
T x D	5.92	*	1.09		0.16		0.14	
G x T x D	0.00		0.06		0.05		0.37	
Tractor Row								
Grazing (G)	0.90		0.08		0.12		0.52	
Tillage (T)	1.05		0.00		0.47		0.35	
Depth (D)	39.62	***	0.61		22.96	***	13.55	**
G x T	0.64		1.04		1.74		3.05	.
G x D	0.40		0.31		1.93		11.01	**
T x D	0.01		0.08		0.00		1.48	
G x T x D	0.54		4.50	*	0.44		4.52*	

*Table 1. Analysis of Variance (ANOVA) of the soil labile C and N indicators. Signif. codes: $p < 0.001$ = '***'; $p<0.01$ = '**'; $p<0.05$ = '*'; $p<0.1$ = '.'*

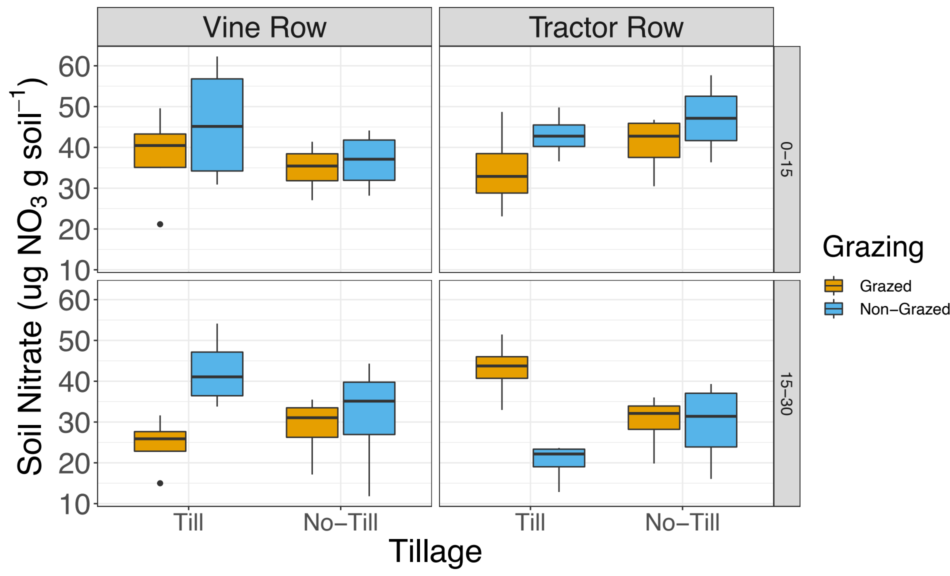

Figure 3. Soil Nitrate (Labile N) content boxplots

Soil Nitrate

- Vine Row: higher NO_3^- in Non-Grazed + Tillage bottom depth
- Tractor Row: higher NO_3^- in Till + Grazed bottom depth

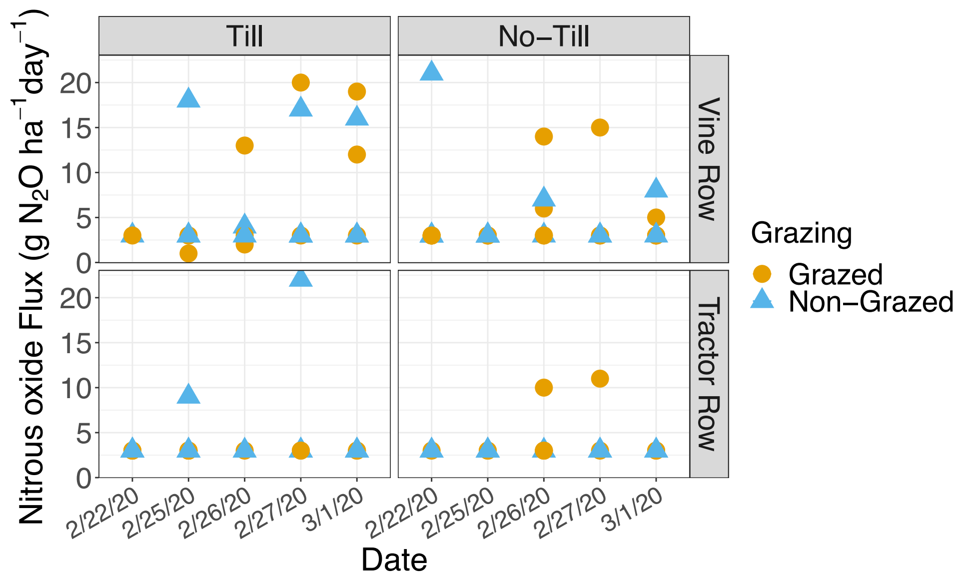

Figure 4. Nitrous oxide flux mean values by day per hectare

N_2O Flux

- Vine Row: No trends
- Tractor Row: Higher N_2O in Non-Grazed + Till

RESULTS

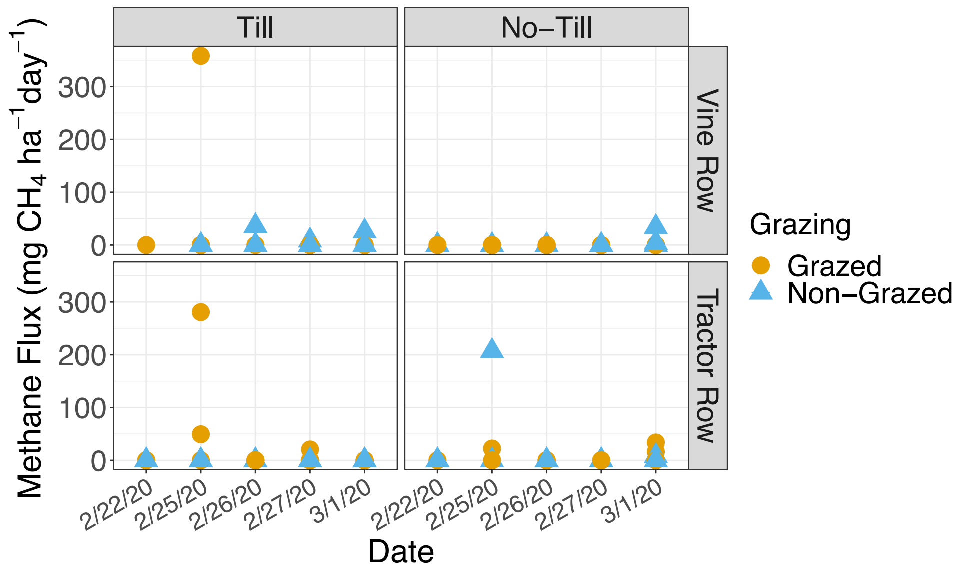

Figure 5. Methane flux mean values by day per hectare

CH_4 Flux

- Higher CH_4 Flux in Till + Grazed

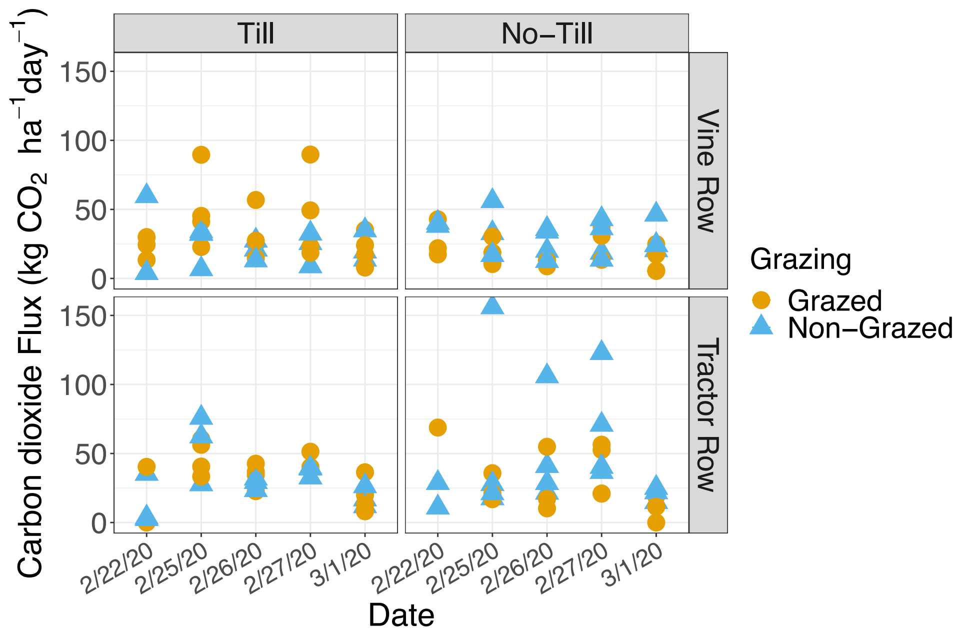

Figure 6. Ni flux mean values by day per hectare

CO_2 Flux

- Vine Row: Higher CO_2 Flux in Till + Grazing
- Tractor Row: Higher CO_2 flux in NT + Non-Grazed

SUMMARY & DISCUSSION

- Tilled and Non-Grazed soil in the vine row had higher Nitrate.
- No significant effects of the grazing and tillage treatments for soil C.
- Minimum effects of treatments in C and N might indicate that Grazing and No-Till cause no negative impacts in soil or might be due to the short-term history of the study (2 years).
- Higher C and N values in the top depth were expected due to higher exposition to organic inputs and water.
- High clay and soil organic matter soil , and Biodynamic Vineyard management practices might cause tillage and grazing to not have a negative impact in soil health indicators.
- Tillage and Grazing increased CO_2 and CH_4 emissions, but further analysis is needed to strengthen these results and conclusions.

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