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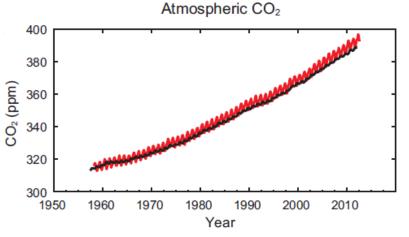


Could organic viticulture Mitigate effects of climate change?

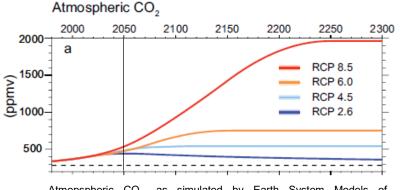
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Department of General and Organic Viticulture, Geisenheim University

Climate change CO₂ - concentration



Multiple observed indicators of a changing global carbon cycle: atmospheric concentrations of carbon dioxide (CO2) from Mauna Loa (19°32'N, 155°34'W - red) and South Pole (89°59'S, 24°48'W - black) since 1958



Atmopspheric CO2, as simulated by Earth System Models of Intermediate Complexity (EMICs) for the four Representative Concentration Pathways (RPC) up to 2300 (Zickfeld et. al 2013). The dashed line indicates the pre-industrial CO₂ concentration.

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- annual atmospheric CO₂-increase of 1.5-3 ppm according to several emission-scenarios
- mid of 21st century \rightarrow +20 % CO₂ (IPCC, 2013)
- studies on plant response to CO₂ enrichment are of high interest regarding future crop production

Is viticulture sensitive to elevated CO_2 ?

VineyardFACE experiment

- started as part of the LOEWE research cluster FACE2FACE
- investigation of consequences of climate change, adaption to climate change and reduction of greenhouse gas emissions to 2050



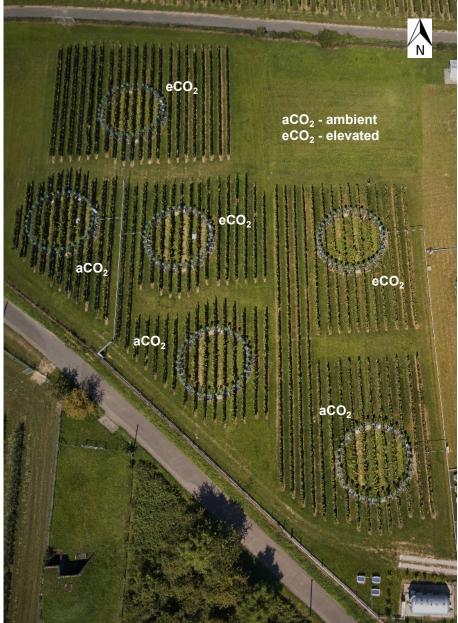


Marburg

Experimental setup -VineyardFACE @ HGU

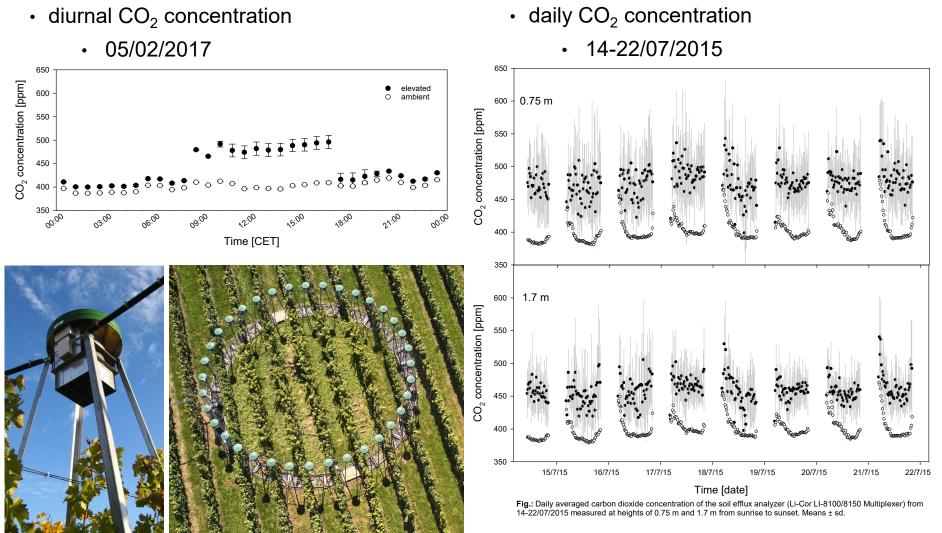
- Geisenheim, Rheingau, Germany (50°N, 8°E)
- sandy loam
- temperate oceanic climate:
 - 10.5 °C, 543 mm (Ø 1981-2010)
- ring system with two treatments:
 - $aCO_2 \rightarrow ambient CO_2 400 ppm$
 - · eCO₂ → elevated CO₂ + 20 %
- CO₂ enrichment started 2014
- 365 days from sunrise to sunset
- two varieties:
 - Riesling cl. 198-30 Gm, SO4
 - Cabernet Sauvignon cl. 190, 161-49 Couderc
- spacing: 1.8 m x 0.9 m / 1.6 m² per vine
- cane pruned 5 nodes/m²
- management following GAP and IPM

Wohlfahrt et al., 2018



Experimental setup -VineyardFACE @ HGU

Hochschule Geisenheim University

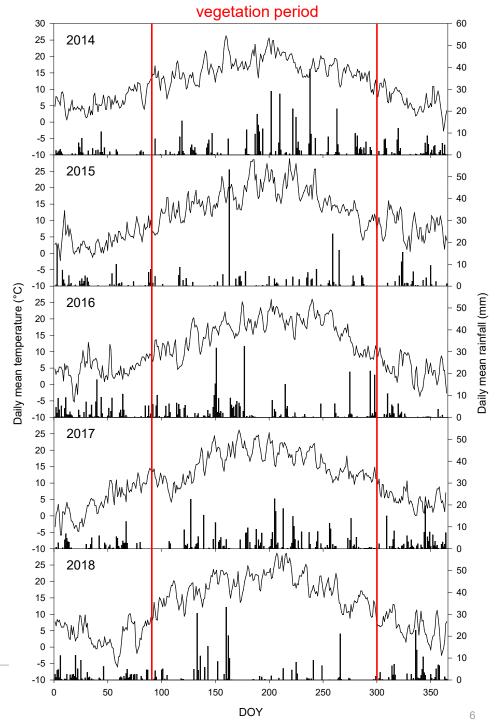


Wohlfahrt et al., 2018

Climatic conditions -VineyardFACE @ HGU

- daily mean air temperature (solid line) and rainfall (black bars) at Geisenheim in 2014, 2015, 2016 and 2017
- annual average temperature:
 - 2014: 12.2 °C
 - 2015: 11.7 °C
 - 2016: 11.2 °C
 - 2017: 11.3 °C
 - 2018: 12.3 °C
- annual rainfall:
 - 2014: 599 mm
 - 2015: 396 mm
 - 2016: 583 mm
 - 2017: 590 mm
 - 2018: 470 mm

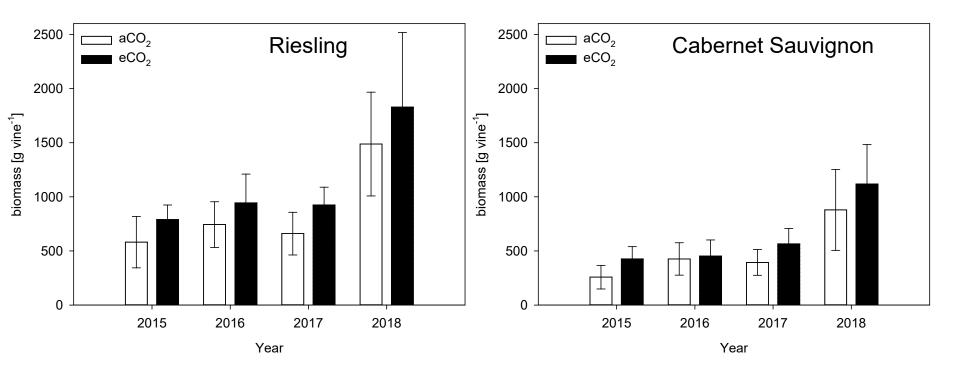
Wohlfahrt et al., unpublished



VineyardFACE Leaf biomass



- increased leaf biomass under eCO₂
- increased lateral leaf area under eCO₂
- supported by higher photosynthesis rates under eCO₂
- \rightarrow higher water uptake (transpiration), even though WUE increased under eCO₂



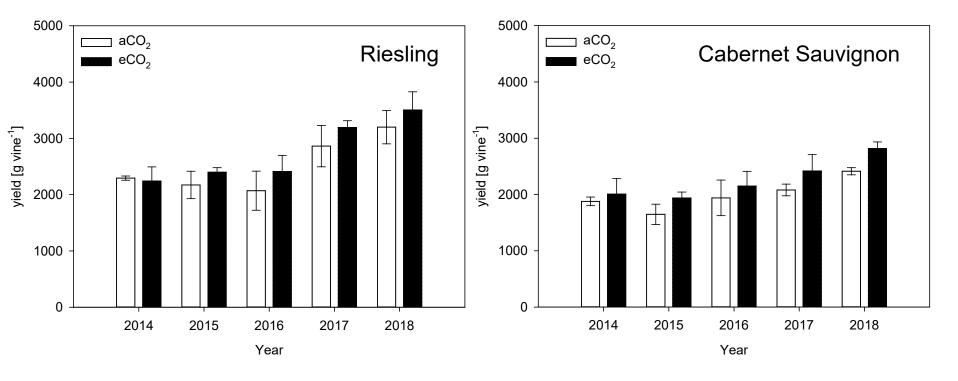
Wohlfahrt et al., unpublished

VineyardFACE Yield

- bunch number not affected by eCO₂
- yield & bunch weight increased under eCO₂
- 2014 did not differ significantly → fruit set 2013 (no eCO₂)



	Bunch number [bunches vine-1]			
Year	$CS aCO_2$	$CS eCO_2$	$RaCO_2$	R eCO ₂
2014	14.3 ± 0.1	13.1 ± 0.9	18.5 ± 0.5	18.2 ± 0.8
2015	14.0 ± 0.2	13.7 ± 0.4	19.4 ± 0.3	19.0 ± 0.2
2016	12.2 ± 0.7	12.4 ± 0.3	17.2 ± 0.5	17.6 ± 0.6



Wohlfahrt et al., unpublished

VineyardFACE Fruit quality

- no differences in total soluble solids under eCO₂
- higher sugar yield under CO₂ due to higher crop load
- organic acids (malic acid) mostly affected in warmer years under eCO₂
- no differences in must and wine quality



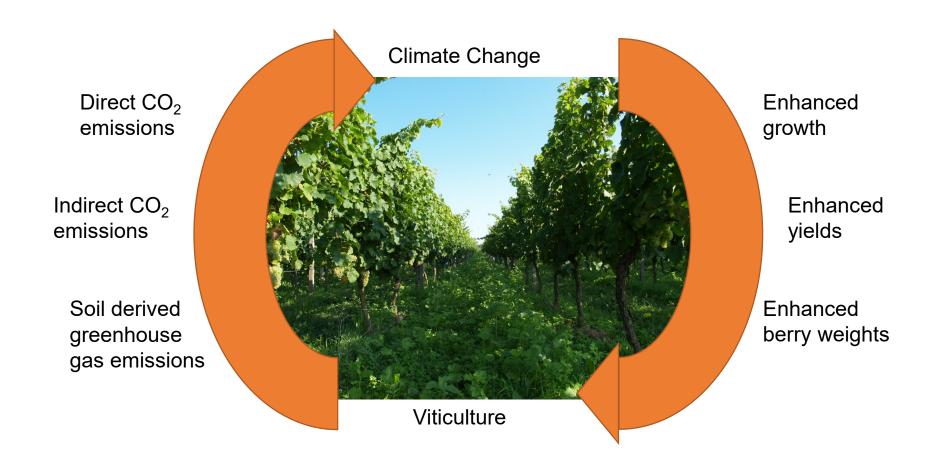




Wohlfahrt et al., 2018



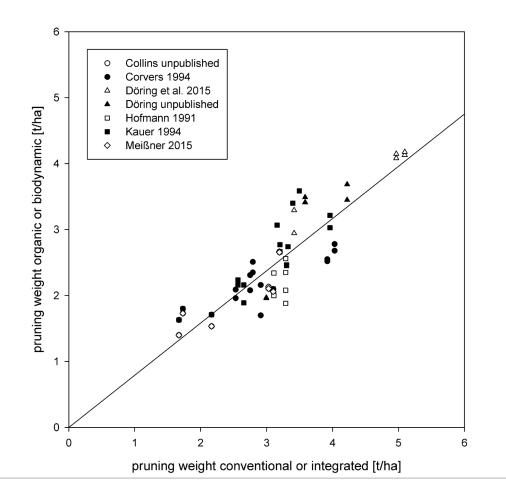
Climate Change ↔ Viticulture





Organic Viticulture Affecting Growth

Döring et al. (2019)

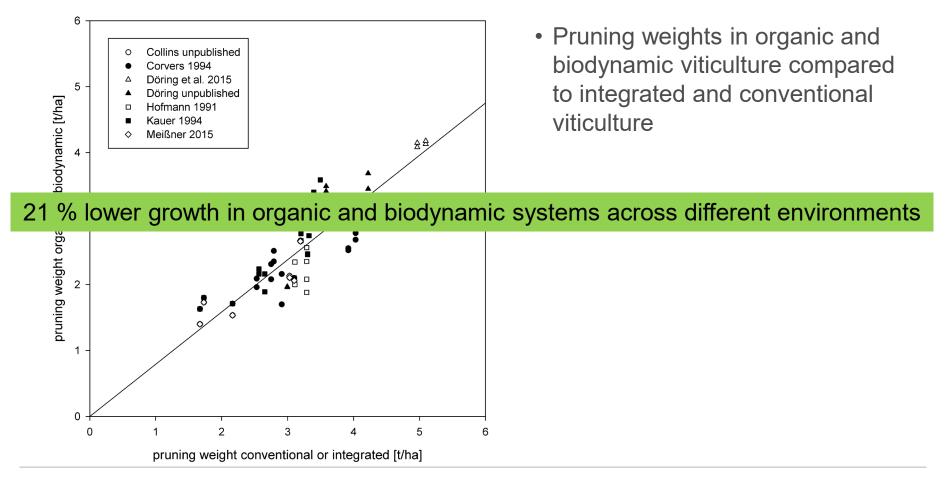


 Pruning weights in organic and biodynamic viticulture compared to integrated and conventional viticulture



Organic Viticulture Affecting Growth

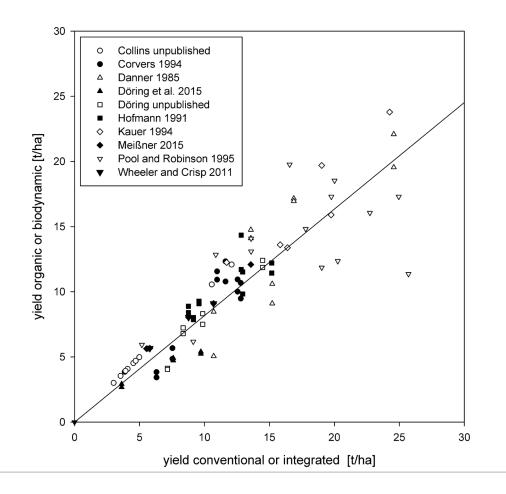
Döring et al. (2019)





Organic Viticulture Affecting Yields

Döring et al. (2019)

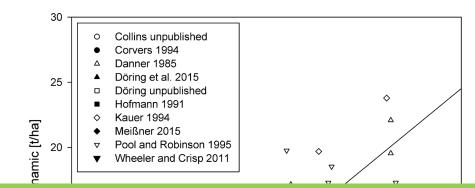


 Yields in organic and biodynamic viticulture compared to integrated and conventional viticulture



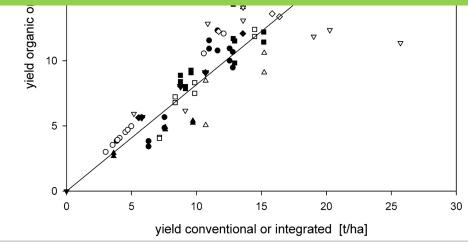
Organic Viticulture Affecting Yields

Döring et al. (2019)



 Yields in organic and biodynamic viticulture compared to integrated and conventional viticulture

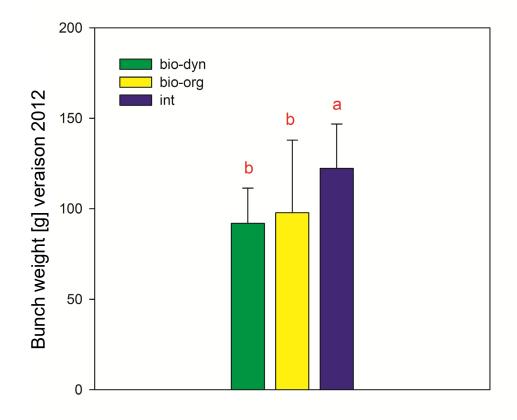
18 % lower yields in organic and biodynamic systems across different environments



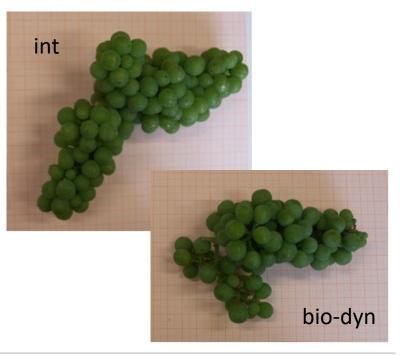


Organic Viticulture Affecting Bunch Weights

Döring et al. (2015)



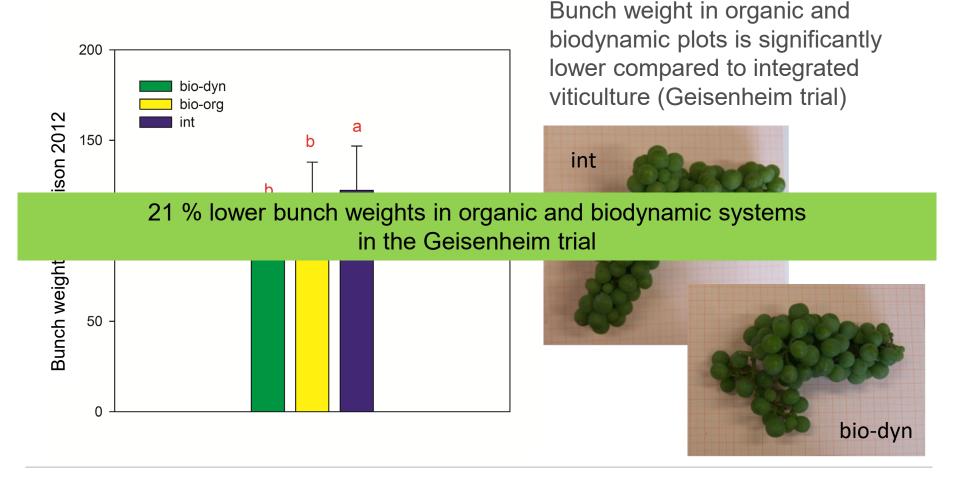
Bunch weight in organic and biodynamic plots is significantly lower compared to integrated viticulture (Geisenheim trial)





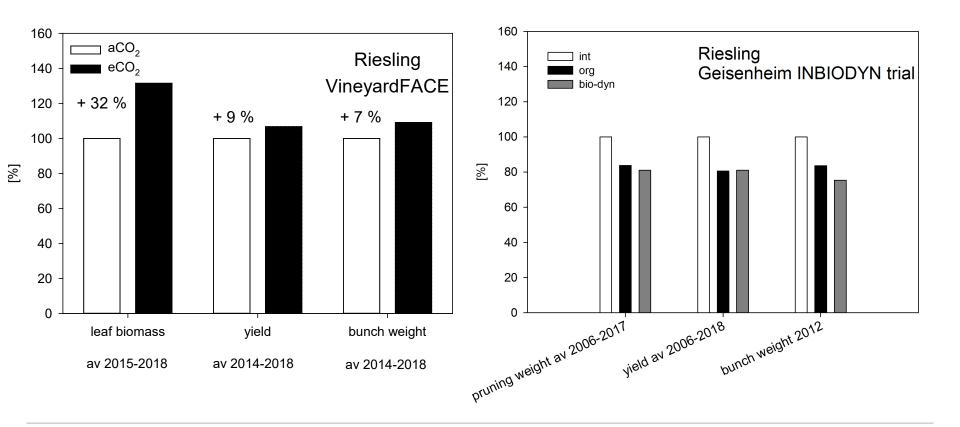
Organic Viticulture Affecting Bunch Weights

Döring et al. (2015)



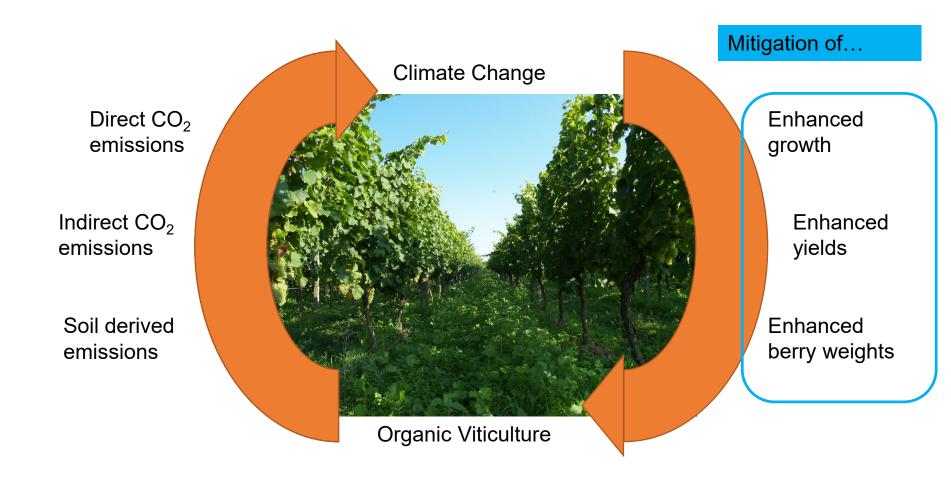
<u>Hypothesis:</u> Organic Viticulture Mitigates Effects of Climate Change on Growth, Yield, and Bunch Weight







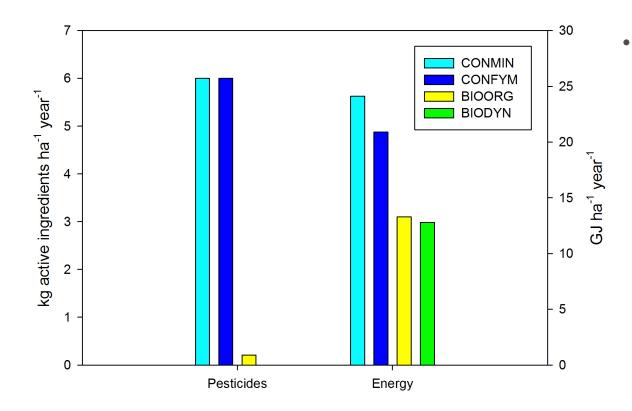
Climate Change ↔ Organic Viticulture





Agriculture Affecting Climate Change (1)

Mäder et al. 2002 – inputs of pesticides and energy

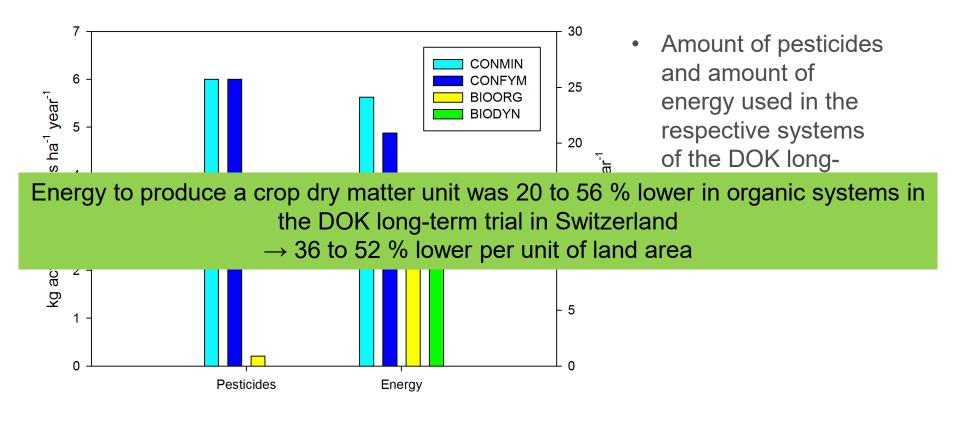


Amount of pesticides and amount of energy used in the respective systems of the DOK longterm trial 1985-1991 (modified according to Mäder et al. 2002)



Agriculture Affecting Climate Change (1)

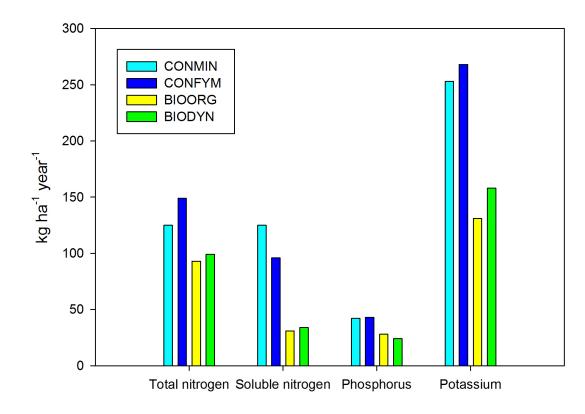
Mäder et al. 2002 - inputs of pesticides and energy





Agriculture Affecting Climate Change (2)

Mäder et al. 2002 – nutrient inputs

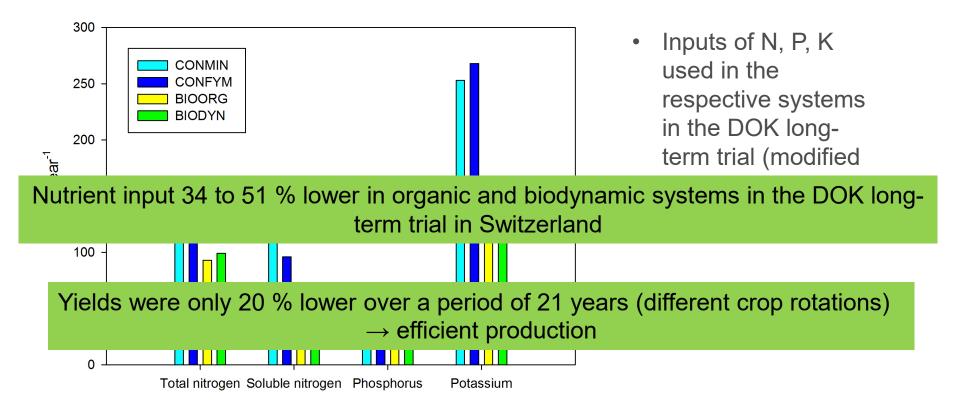


 Inputs of N, P, K used in the respective systems in the DOK longterm trial (modified according to Mäder et al. 2002)



Agriculture Affecting Climate Change (2)

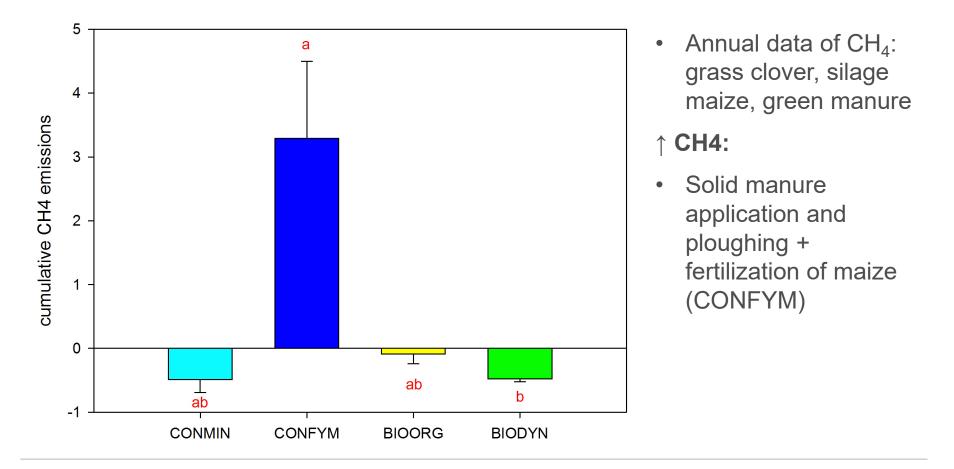
Mäder et al. 2002 – nutrient inputs





Agriculture Affecting Climate Change (3)

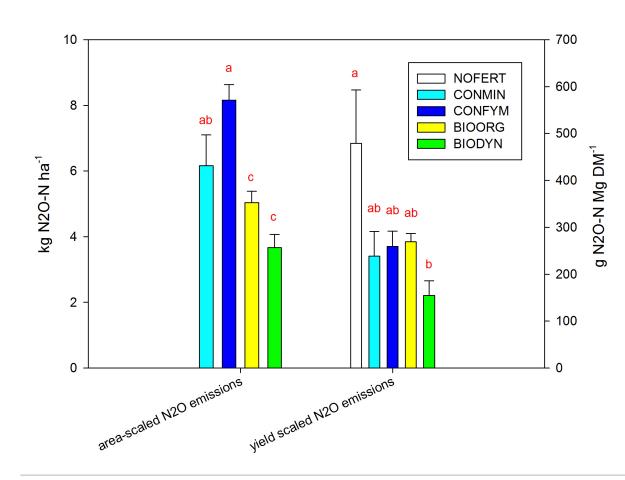
Skinner et al. 2019 – soil derived greenhouse gas emissions





Agriculture Affecting Climate Change (4)

Skinner et al. 2019 – soil derived greenhouse gas emissions



Annual data of N₂O-N: Grass-clover, silage maize, green manure

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\uparrow N_2O:
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- Solid manure application
 + ploughing (CONFYM)
- Mineral fertilization + sowing (CONMIN)
- Fertilization of silage maize (all systems)
- Dependent on soil moisture + Nmin

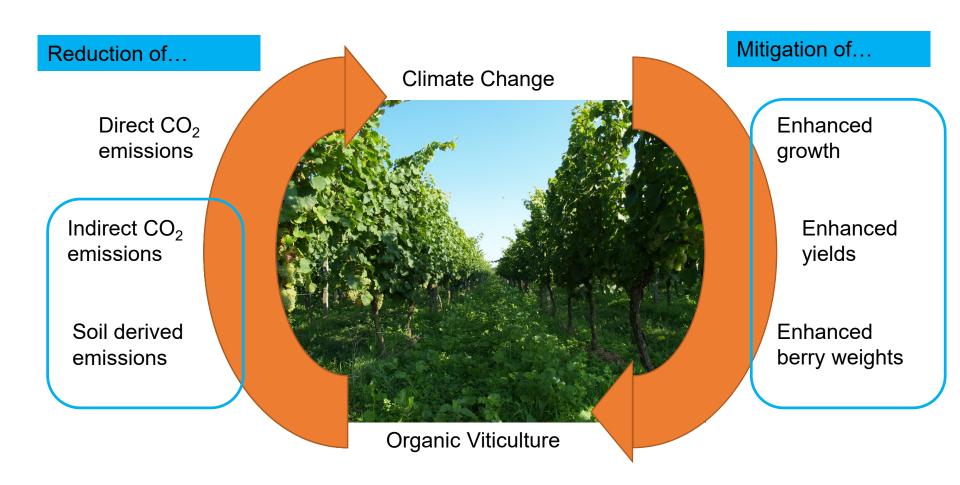
<u>Hypothesis:</u> Organic Viticulture Mitigates Climate Change



- Organic viticulture is expected to reduce inputs due to denial of herbicides, mineral fertilizers, and synthetic spray agents (low input system; M\u00e4der et al. 2002)
 - It exclusively relies on products of natural origin
- Organic viticulture is expected to use slightly higher amounts of fuel compared to conventional/ integrated systems
- Organic viticulture is expected to reduce gas emissions from the soil
 - No mineral N fertilizers: ↓ N₂O emissions (Skinner et al. 2019)
 - Cover crop with legumes: $\uparrow N_2O$ emissions (Muhammad et al. 2019)
 - Higher microbial activity: ↑ CO₂ emissions (Muhammad et al. 2019)
 - Higher carbon sequestration, higher SOC: \downarrow CO₂ emissions (Longbottom, Petrie 2015)
 - ↓ NO emissions (preliminary results Hieber 2011)
 - NH₃, CH₄, NO_x emissions? Herbicide application under-vine area?



Climate Change ↔ Organic Viticulture





- Wohlfahrt Y., Tittmann S., Schmidt D., Rauhut D., Honermeier B., Stoll M. The effect of elevated CO₂ on berry development and bunch structure of *Vitis vinifera* L. cvs. Riesling and Cabernet Sauvignon. Appl. Sci. 2020, 10, 2486.
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- Wohlfahrt, Y., Collins, C., & Stoll, M. (2019). Grapevine bud fertility under conditions of elevated carbon dioxide. OENO One, 53(2).
- Wohlfahrt Y., Smith J.P., Tittmann S., Honermeier B, Stoll M. (2018). Primary productivity and physiological responses of *Vitis vinifera* L. cvs. under Free Air Carbon dioxide Enrichment (FACE). European Journal of Agronomy, 101, 149-162.
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- Mäder P, Fließbach A, Dubois D, Gunst L, Fried P, Niggli U. Soil fertility and biodiversity in organic farming. Science 2002; 296: 1694-1697.