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SSS5.5
Biomass and waste valorization within a circular economy: from urban mining to soil amendments

The Biochar challenge in Mediterranean viticulture:
Results from 10 years of field experiment

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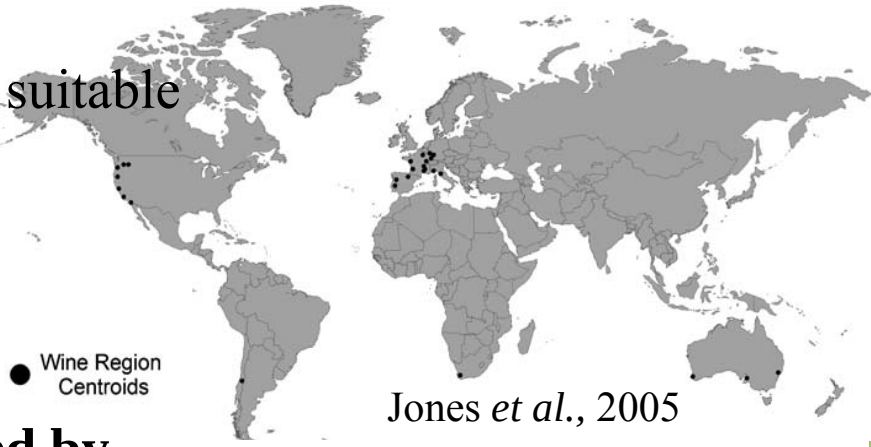
The use of biochar as a soil amendment in agriculture is a suitable option that helps to mitigate the effects of climate change.

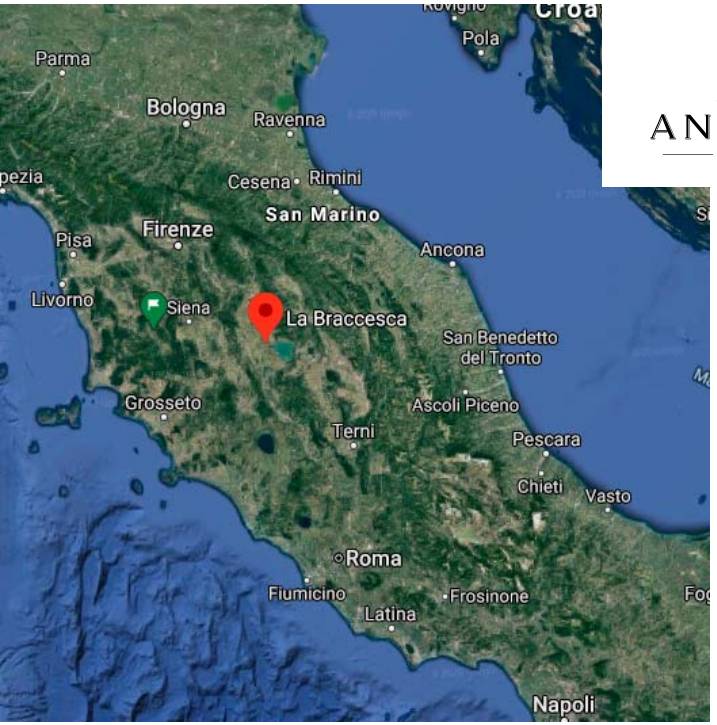


Jones *et al.*, 2005

An option to fill this knowledge gap is represented by long-term field experiments.

GOAL:

Investigate the effect of biochar application, on plant water relations of *V. vinifera* and on soil properties during 10 years (2009-2019) in a field experiment in Central Italy



Marchesi ANTINORI 26 GENERAZIONI

La Braccesca Estate" "Marchesi Antinori (Lat. 43◦1015N; Long.11◦5743E; 290 m a.s.l.), Montepulciano (Tuscany, central-Italy).

The vineyard was planted in 1995 (cv. Merlot, clone 181; rootstock 3309 Couderc),
The trellis system is a single curtain with plant-row spacing of 0.8 m and 2.5 m; The vineyard is not irrigated.

The soil is a shallow acids sandy-clay-loam (USDA, 2005), Vineyard roots mainly explore the more superficial soil layer (0–0.5 m)

Soil characteristics	
Sand (g kg-1)	700
Silt (g kg-1)	150
Clay (g kg-1)	150
Bulk density (Mg m^{-3})	1.45
CEC (meq/100g)^{e}	12,1
pH	5.37

Chemical/physical characteristics of pure biochar applied in the field experiment.

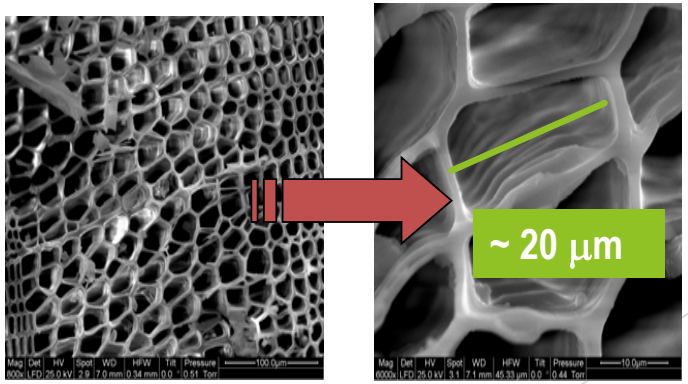
	Unit	Value
C	%	77.81
N	%	0.91
Al	mg kg^{-1}	268
C/N	-	63.53
pH	-	9,8
Max water absorption	(g g^{-1} of d. m.)	4.53
Bulk Density	g cm^{-3}	0,43
Hydrophobicity (WDPT)[a]		Hydrophilic
BET	m^2 g^{-1}	410 ± 6
Total porosity	mm^3/g	2722
Transmission pores	mm^3/g	318
Storage pores	mm^3/g	1997
Residual pores	mm^3/g	406

The Biochar: commercial charcoal provided by "Romagna Carbone s.n.c." (Italy)

Feedstock: orchard pruning

Process: slow pyrolysis 500°C

The biochar at theend of the pyrolisis was crushed into particles smaller than 5 cm of diameter before the soil application.



Experimental set-up :

Randomized plot experiment with 3 treatments and 5 replicates

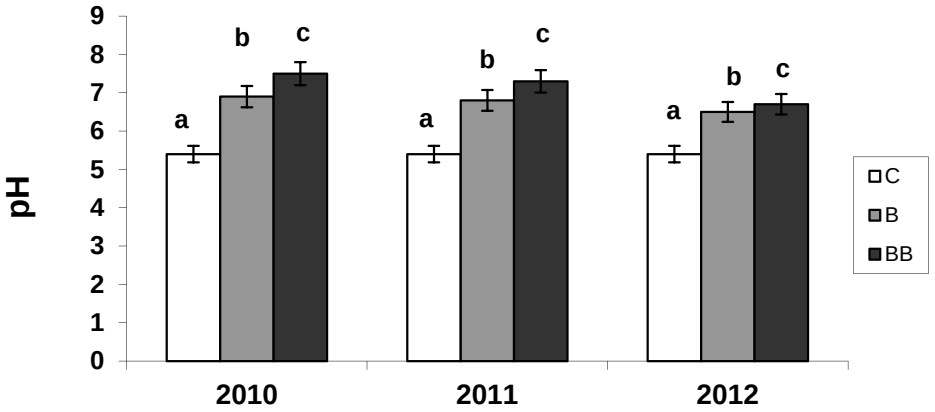
7.5 m x 30 m = 225 m² each plot including 4 vine-yard rows and 3 inter-rows

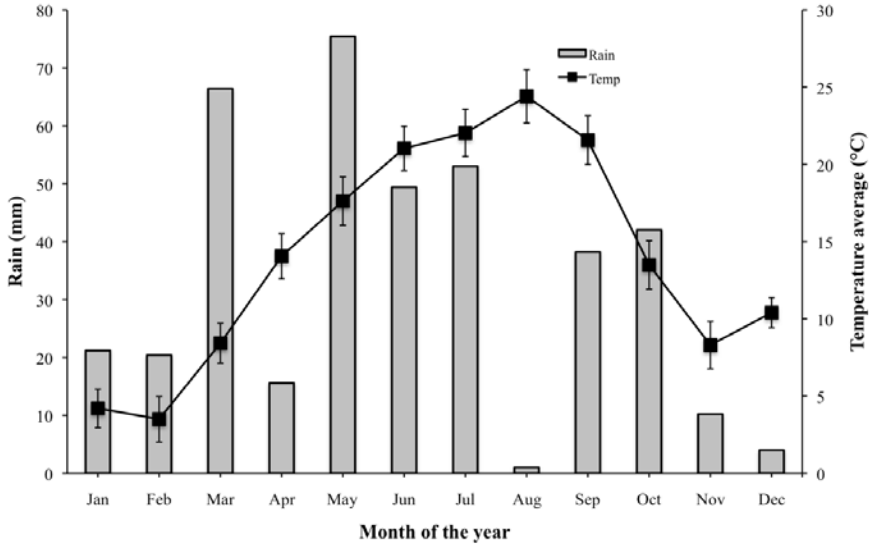
3 Treatments:

- **Control (C)**
- **Single Biochar applcation 22 t /ha in 2009 (B)**
- **Double biochar application 22 t/ha + 22 t/ha 2009 + 2010 (BB).**

Short-Term Results
(*after 1-2 years Biochar application*)

Soil properties





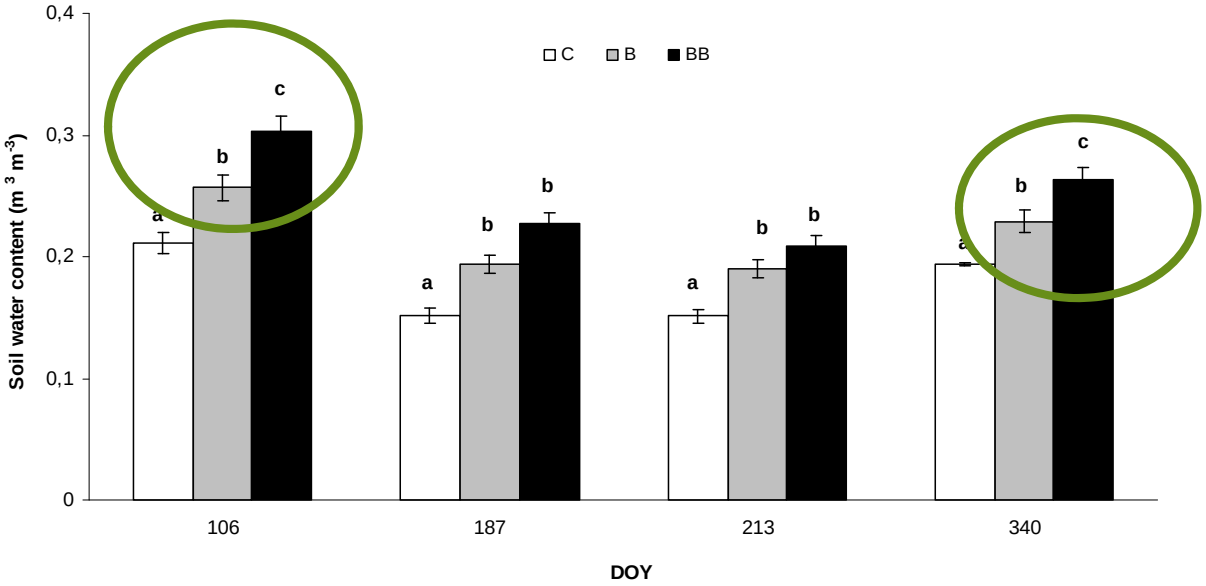
	C	B	BB
Corg %	**0.78**	**1,36**	**4,18**
Bulk Density (g cm-3)	**1.45**	**1.43**	**1.38**
CEC (meq100 g-1)	**12.1**	**17**	**24**

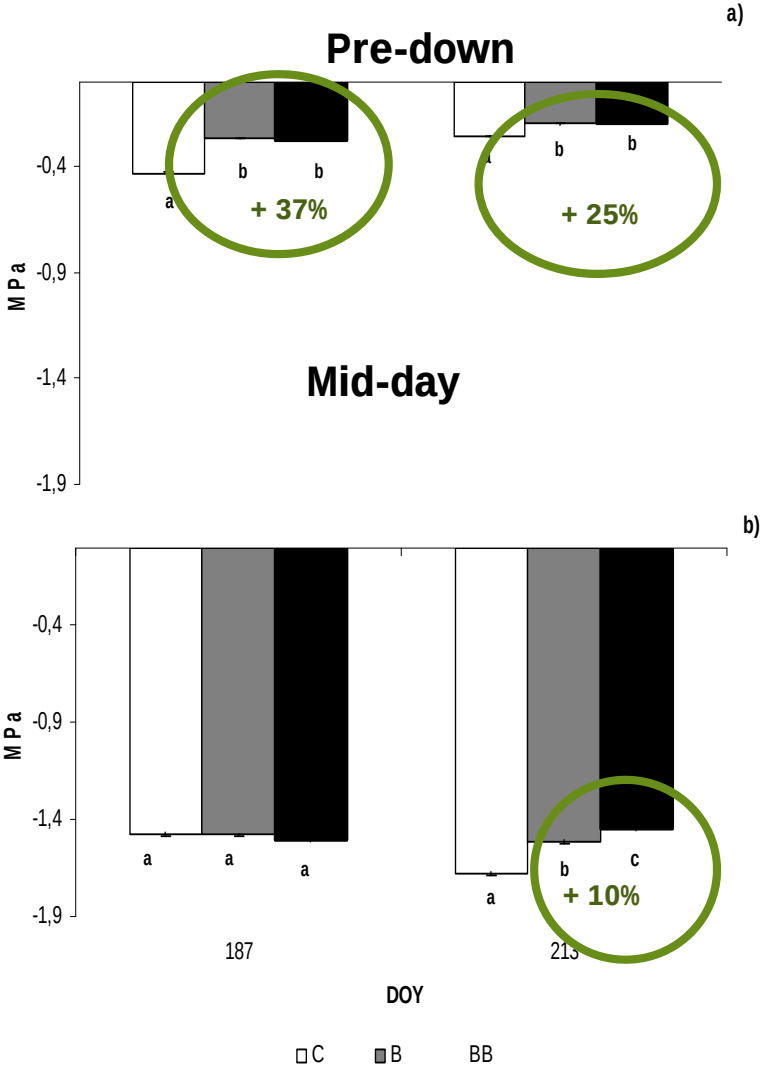
Baronti et al., 2014

Short-Term Results

(*after 1-2 years Biochar application*)

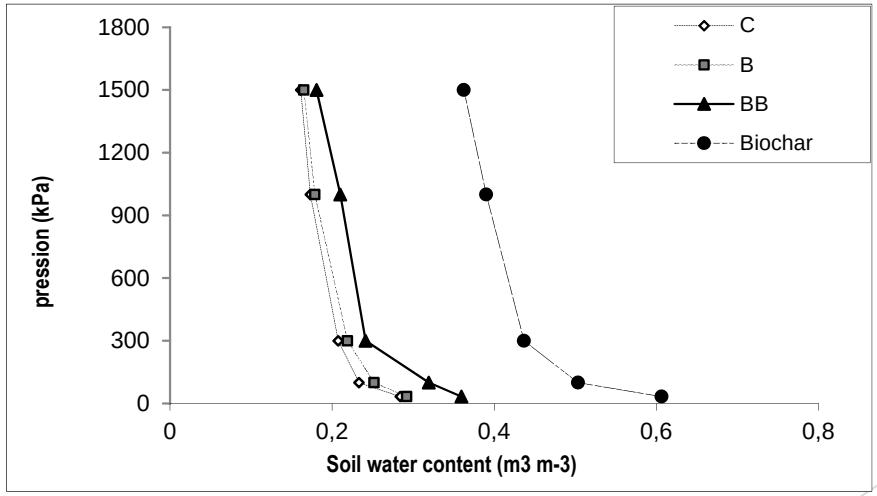
Plant water relation





	Available water content (m^3 m^{-3})
C	0,12
B	0,13
BB	0,18
Biochar	0,24

Baronti et al., 2014



Plant production

The grape yield per plant significantly increase in biochar treated plots

Not difference in re-application biochar plot

Significantly bigger berries

Year	Treat.	Yield ± s.e (kg plant^{-1})	Sign. code	Δy (%)
2009	C	1.36 ± 0.08	a	
	B	1.63 ± 0.09	b	20
2010	C	1.34 ± 0.09	a	
	B	2.12 ± 0.19	b	58.1
	BB	1.90 ± 0.16	b	42.3
2012	C	1.05 ± 0.09	a	
	B	1.62 ± 0.14	b	54.6
	BB	1.75 ± 0.14	b	66.8
2013	C	1.44 ± 0.11	a	
	B	1.68 ± 0.11	ab	16.1
	BB	1.95 ± 0.15	b	35.3

Year	Treat.	Fresh weight 50 berries ± s.e (g)	Sign. codes	Δy (%)
2010	C	63.20 ± 5.28	a	
	B	66.21 ± 5.79	a	4.8
	BB	67.02 ± 5.93	a	6.0
2012	C	46.92 ± 1.12	a	
	B	51.52 ± 1.46	b	9.8
	BB	49.40 ± 1.12	a	5.3
2013	C	81.20 ± 2.52	a	
	B	88.40 ± 2.50	b	8.9
	BB	93.20 ± 3.14	b	14.8

Genesio et al., 2015

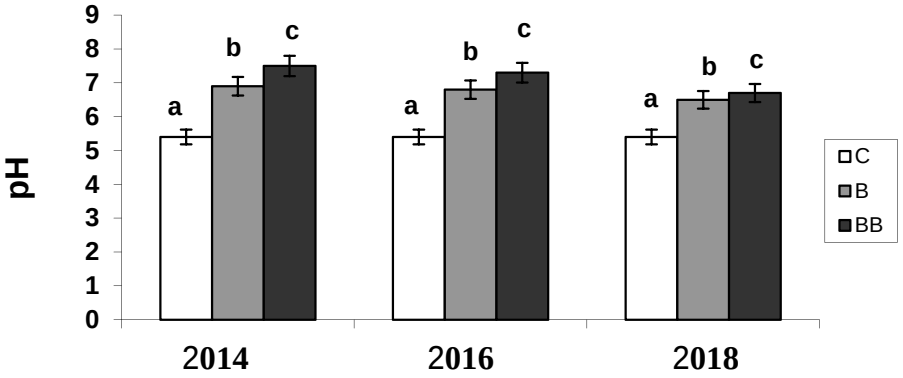
Year	Treat.	°Brix	Sign. codes	ANT	Sign. codes
2009	C	24.65 ± 0.33	a	1123 ± 44	a
	B	23.95 ± 0.53	a	1186 ± 73	a.
2010	C	24.74 ± 0.2	a	1024 ± 24	a
	B	25.02 ± 0.24	a.	1045 ± 41	a
	BB	24.82 ± 0.22	a	1019 ± 29	a
2012	C	24.32 ± 0.12	a	937 ± 48	a
	B	24.08 ± 0.26	a	949 ± 75	a
	BB	23.92 ± 0.26	a.	994 ± .51	a
2013	C	23.51 ± 0.07	a	1143 ± 38	
	B	23.23 ± 0.17	a.	1038 ± 68	a
	BB	23.19 ± 0.28	a	1001 ± 70	a

NO DIFFERENCE in the QUALITY PRODUCTION

Long-Term Results

(*after 8-10 years Biochar application*)

Soil properties



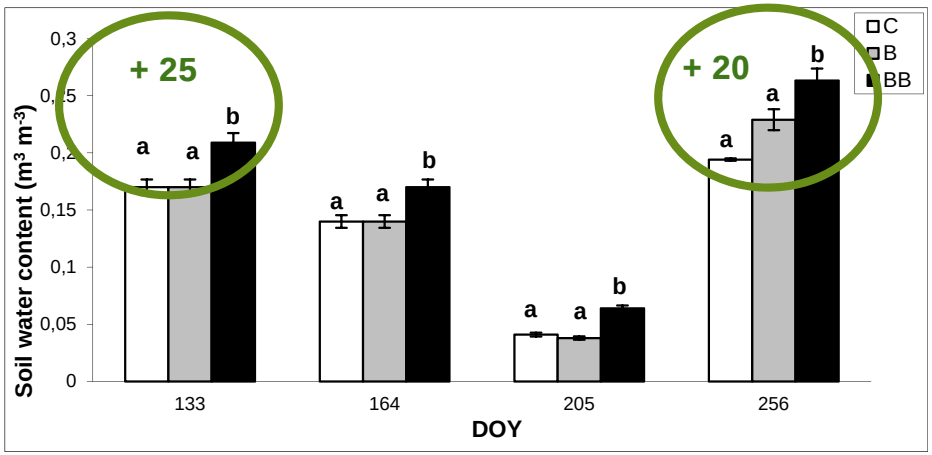
	C	B	BB
Corg %	**0.78**	**2.56**	**2.71**
Bulk Density (g cm-3)	**1.40**	**1.40**	**1.38**
CEC (meq100 g-1)	**12.1**	**17**	**20**

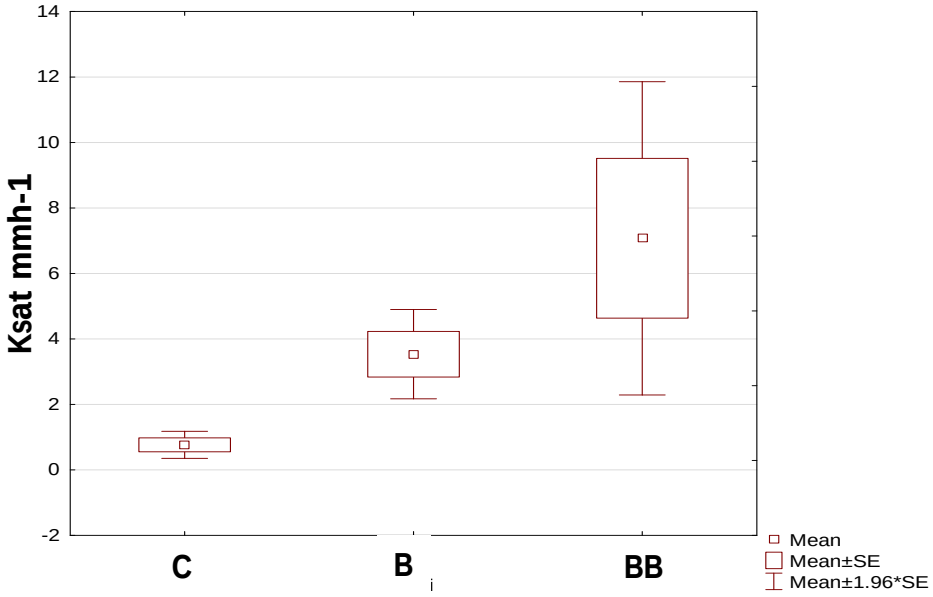
Baronti et al., in preparation

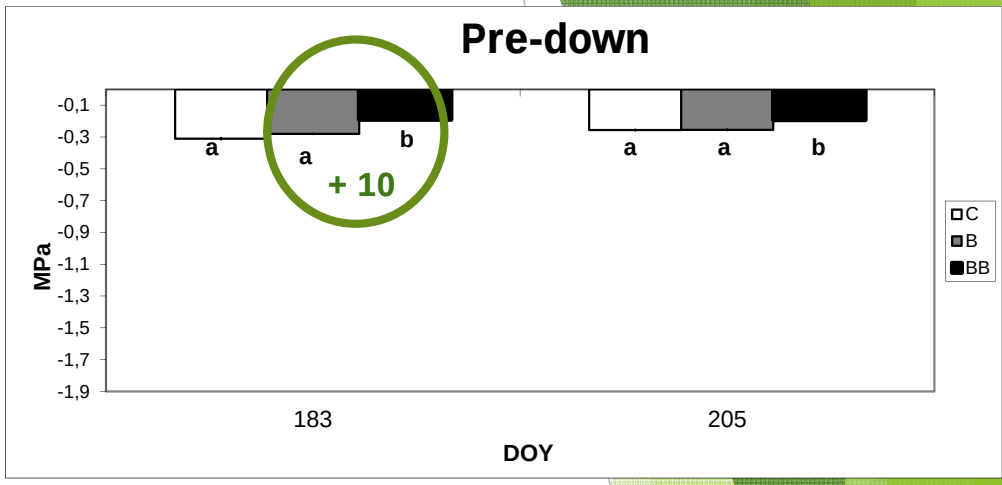
Long-Term Results

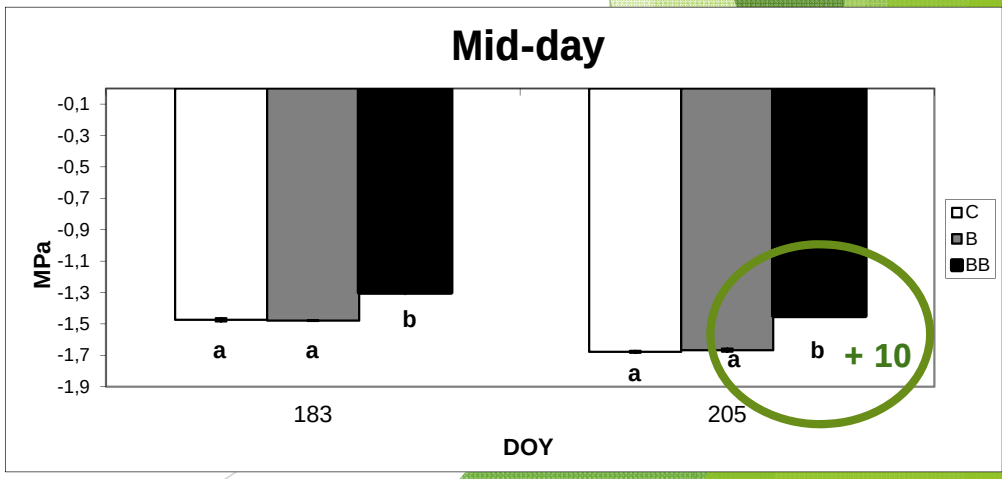
(*after 10 years Biochar application*)

Plant water relation





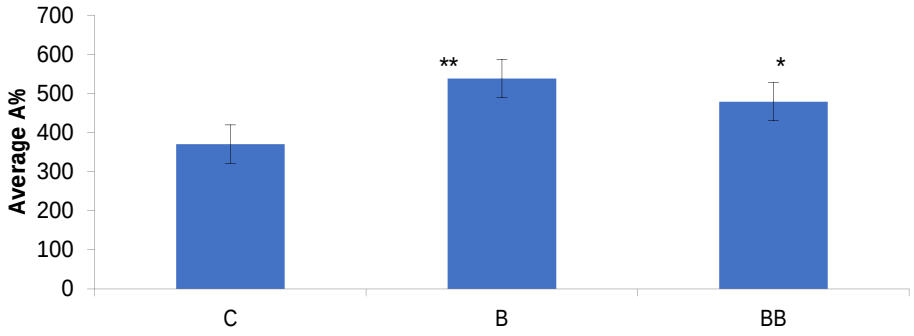




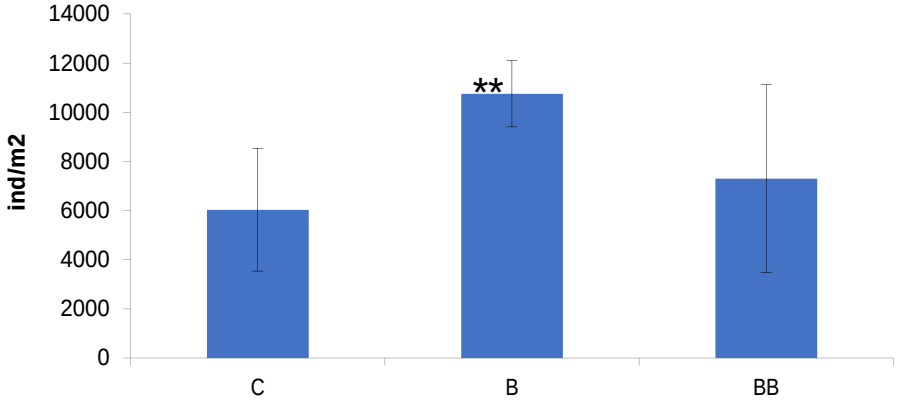
Baronti et al., in preparation

Soil biota Long-Term Results
(*after 10 years Biochar application*)

Soil meso fauna



Collembola



Preliminary results on edaphic fauna

After 10 years is reported a significant increase of total abundance of edaphic fauna (especially micro-arthropods) in the soil amendment with biochar.

The most representative taxa in the Biochar thesis are Collembolan (especially species with high eco-functional adaptation and **that are strictly related to soil moisture and water availability)**

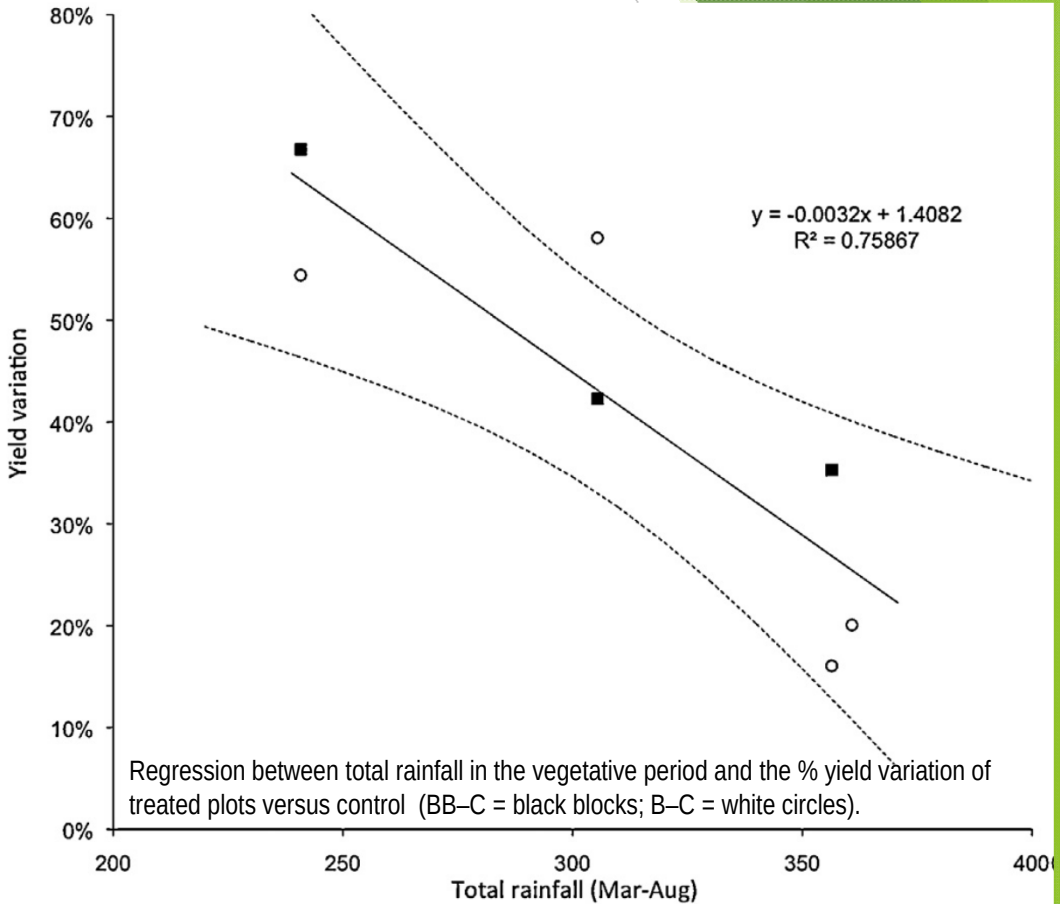
Maienza et al., in preparation

Plant production

Long-Term Results
(*after 8-10 years Biochar application*)

Year	Treat.	Yield ± se (kg plant^{-1})			D y (%)
2017	C	1.06	±	0.10	
	B	1.76	±	0.25	66.0
	BB	1.58	±	0.39	49.1
2019	C	1.65	±	0.20	
	B	2.40	±	0.51	45.5
	BB	2.57	±	0.49	55.8

The grape yield per plant significantly increase in biochar treated plots



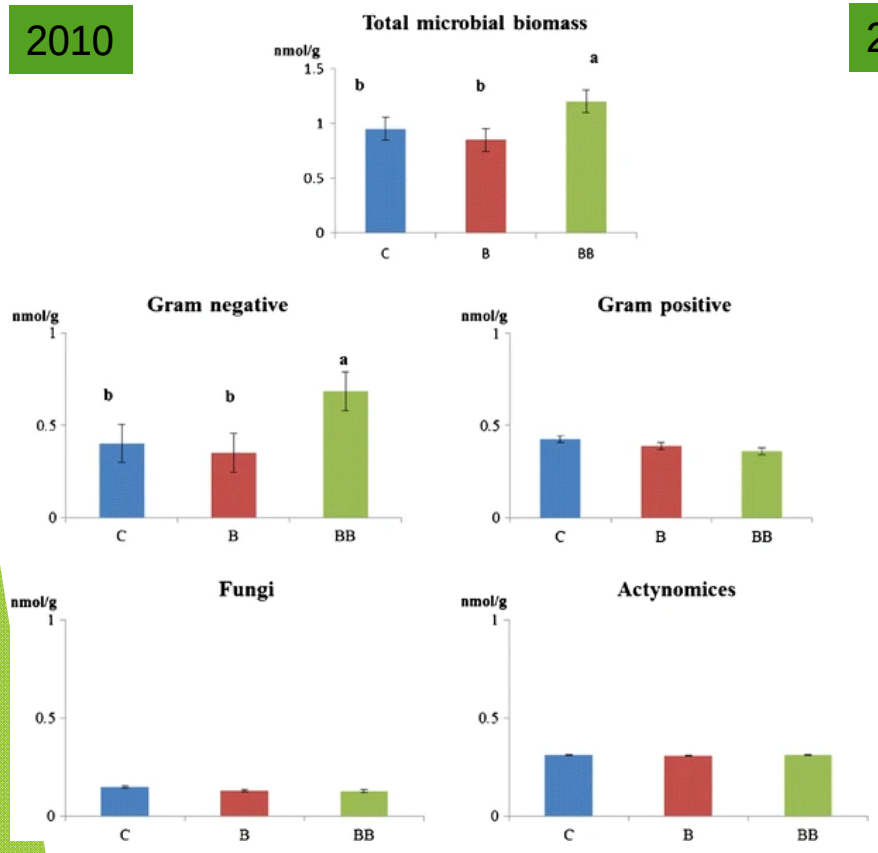
Regression between total rainfall in the vegetative period and the % yield variation of treated plots versus control (BB–C = black blocks; B–C = white circles).

In addiction…

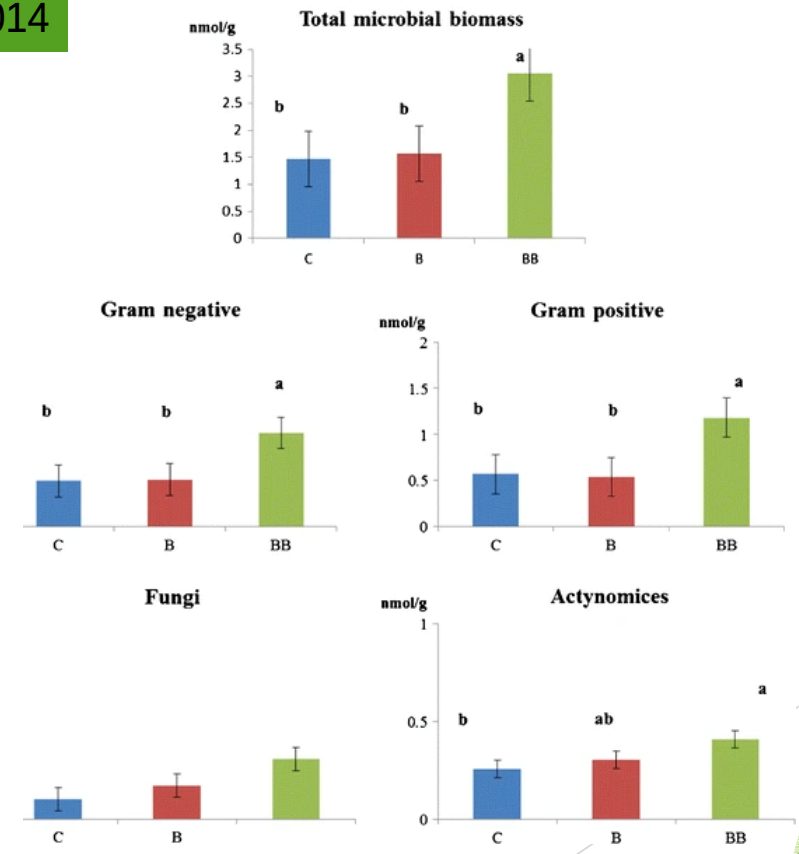
Long-Term Results
(*after 5 years Biochar application*)

Soil community structure (PLFAs)

2010



2014



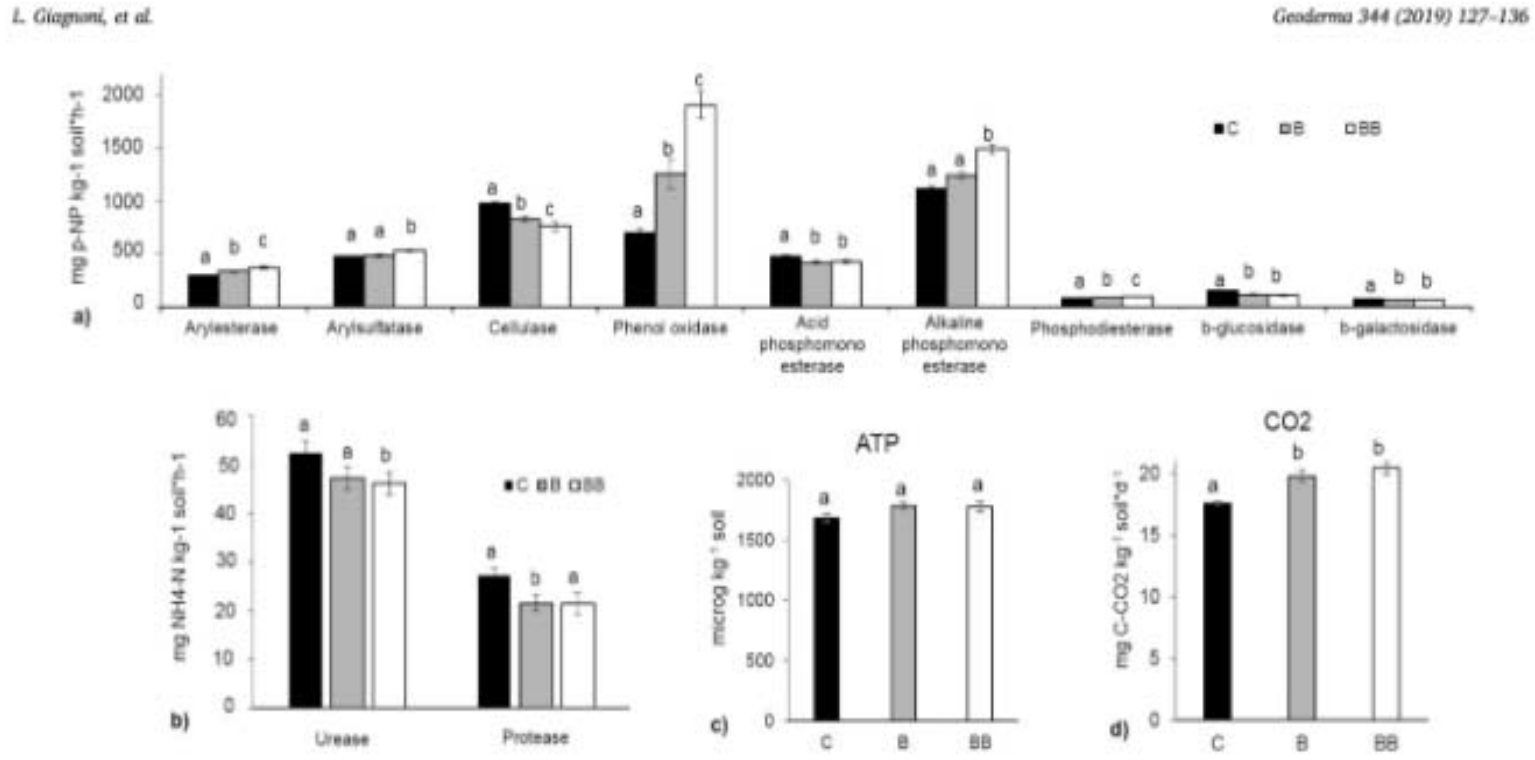
After 5 year of application BB increases the total microbial biomass, didn't changing the community structure (all G-, G+, Fungi and actynomices are enhanced in same way).

No soil toxicity is reported during the years by *Vibrio fisheri* bacteria test data (luminescent basteria test, ISO 11348-2007).

Maienza et al., 2017

Long-Term Results
(*after 7 years Biochar application*)

Soil functions



The single biochar application still increase all soil functions to support plant nutrition:

- **enzymes activity**
- **Soil Heterotroph respiration**

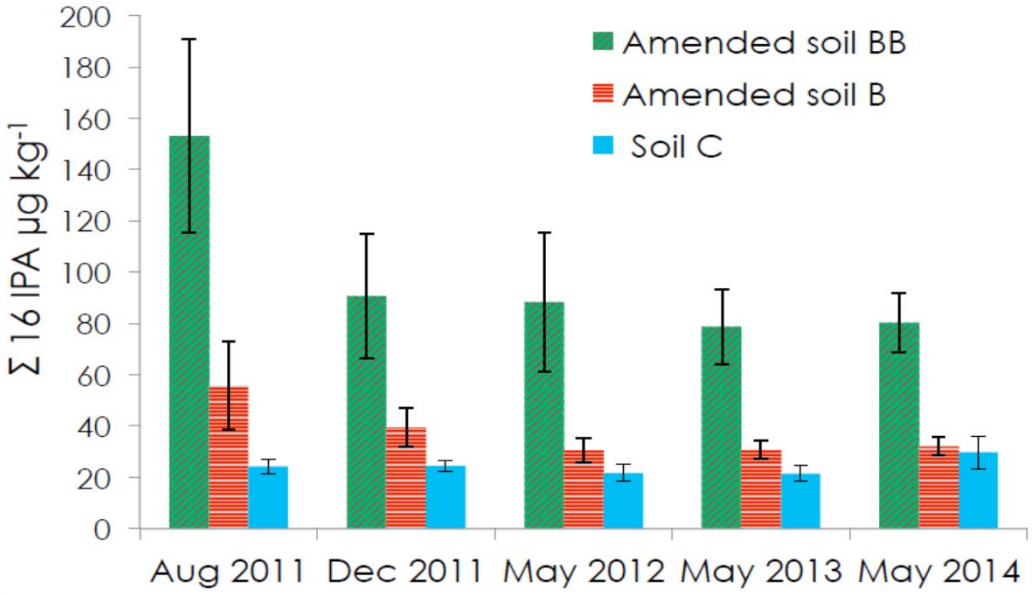
The total microbial biomass (ATP) after 7 years of application is non significantly different between treatments.

Giagnoni et al., 2019

Long-Term Results

PHAs soil

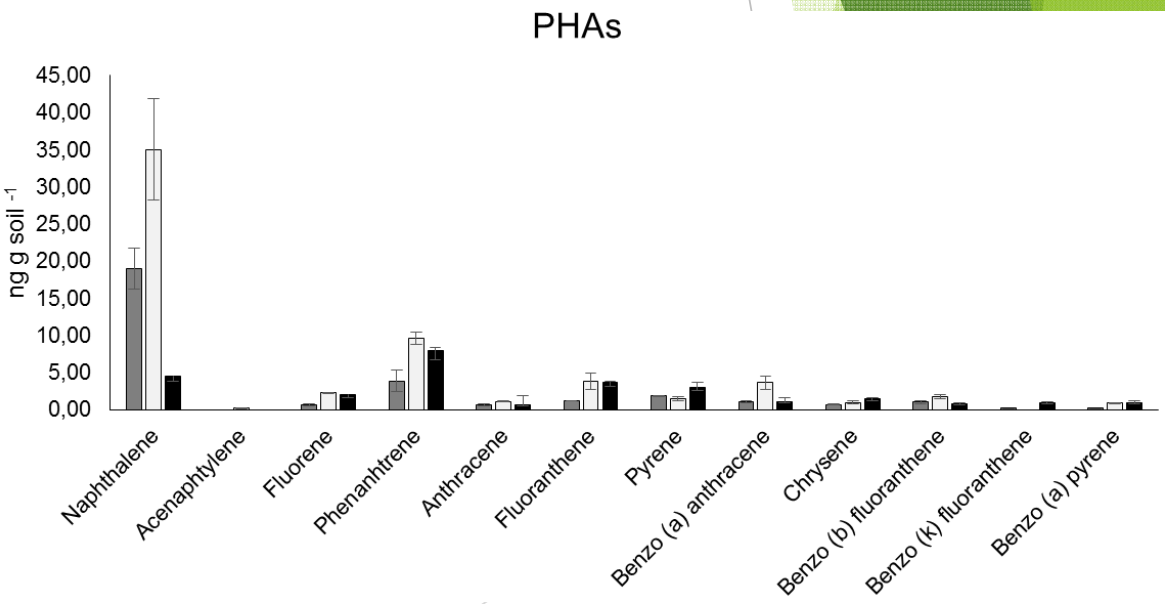
After 4 years



PHAs in the biochar: 4.3 mg kg-1

Rombolà et al., 2019

After 8 years



Maienza et al., 2017

Conclusion and future perspectives

- The addition of biochar to soil caused a substantial and significant change in soil physical characteristics in short (after 1-2 yers) and long period (after 10 years).

- The Biochar increase **in short and long period** the AWC and plant water status during the driest period of the summer when soil water is in short supply …**After 10 years no different in single dose biochar application respect to control**

- Biochar increase vineyard production in all harvest-years and no detrimental effects on key grape quality parameters **in short and long period**

- **NO soil toxicity detected**

- **NO PAHs in soil**

A biochar based strategy could be effectively adopted in vineyards in drought prone areas as an alternative to irrigation

Thanks for your attention

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