Influence of Biochar Additions on Net Greenhouse Gas Production

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USDA

Agricultural Research Service

Biochar Research

- Benefits of biochar additions to oxisol soils are known

- What happens for other soils with the addition of biochars?

Biochar Research

- Part of new ARS multi-location

Biochar and Pyrolysis Initiative

- 6 ARS locations :
  - Ames, IA; Kimberly, ID; St. Paul, MN;
  - Big Spring, TX; Florence, SC; Prosser, WA.
- Continuous corn (same crop for comparison)

- In addition to following crop yield and soil carbon:
  - ✓ Soil gas concentrations and trace gas fluxes
  - ✓ Continual subsurface CO_2 measurements (25 cm)

Rosemount Biochar Field Trials

- Small scale triplicate plots (16’ x 16’) largely due to the limited availability of biochar.

(Application rate : 20,000 lbs/acre)

  - Fast pyrolysis biochar (sawdust, CQuest™ Dynamotive[1])
    - With and without manure addition (5,000 lb/acre)
  - Slow pyrolysis biochar (woodchip, Best Energies[1])
  - Slow pyrolysis biochar (macadamia nut, Biochar Brokers[1])

- Larger strip plots (16’ x 93’)
  - Hardwood charcoal (ground lump charcoal, Kingsford[1])
  - Slow pyrolysis biochar (macadamia nut, Biochar Brokers[1]) (3 rates: 5,000, 10,000 and 20,000 lb/acre)

1-Names are necessary to report factually on available data; however, the USDA neither guarantees nor warrants the standard of the product, and the use of the name by USDA implies no approval of the product to the exclusion of others that may also be suitable.

Laboratory Studies

- 16 different biochars evaluated
- 7 different biomass parent materials

BC #	Parent Material	Source	Pyrolysis Temp (°C)	C	N	O	Ash	Surface Area (m^2 g^{-1})
1	Corn stover	Best Energies	815	45	0.5	1	55	4.4
2	Pine wood chip	EPRIDA	465	75	0.3	9	6	0.1
3	Peanut hulls	EPRIDA	481	59	2.7	12	15	1.0
4	Corn stover	R. Brown – Iowa State	500	25	0.6	5	69	4.2
5	Corn stover	EPRIDA	410	42	1.0	11	54	2.2
6	*N/A*	Char C Group (Biosource™)	465	43	2.2	*N/A*	*N/A*	63.5
7	Turkey manure Woodchip	SWROC-Univ. of MN	850	1	0.1	3	89	4.8
8	Hardwood	D. Laird (USDA-ARS)	*N/A*	69	0.7	9	14	19.2
9	Pine woodchip	EPRIDA	465	71	0.2	11	9	0.2
10	Peanut hulls	EPRIDA	481	60	0.9	10	15	286
11	Corn stover	EPRIDA	505	66	1.2	4	54	17.3
12	Corn stover	EPRIDA	515	51	1.0	0	74	9.9
13	Coconut shells (Activated)	Willinger Bros.	450	83	0.4	0	12	960
14	Woodchip (pellet)	Chip Energy	*N/A*	69	0.1	20	5	24
15	Hardwood lump charcoal	Kingsford	538	53	0.4	10	27	7.2
16	Macadamia shells	Biochar Brokers (EternaGreen™)	*N/A*	84	0.6	2	2	0.4

Weathered impact

BC #	Parent Material	Pyrolysis Temp (°C)	C	N	O	Ash	Surface Area ($m^2\ g^{-1}$)
3	Peanut hulls (fresh)	481	59	2.7	12	15	1.0
10	Peanut hulls (weathered)	481	66	0.9	10	15	286

Weathered char (1 yr on outdoor storage pile):

- Minor changes in composition data (loss of N)
- Major change in surface area (286x)

Impact of degassing treatment on surface area

- Samples were degassed for 3 hrs at a temperature of 300 and 400 ^{o}C

Parent Material	Surface Area ($m^2 g^{-1}$: 300 ^{o}C)	Surface Area ($m^2 g^{-1}$: 400 ^{o}C)
Coconut shells (activated charcoal)	960	976
Wood pellets	62	177
Hardwood lump charcoal	7	34
Macadamia shells	0.4	7
Hardwood chips	24	66
Sawdust (pine)	0.8	46

Increase in surface area: 2.5 to 57 times

Laboratory Incubations

Soil incubations used to assess the impacts of these 16 different biochars with soils from 3 different ecosystems:

- Minnesota agricultural soil
  - Waukegan silt loam

- Wisconsin forest nursery soil
  - Vilas loamy sand

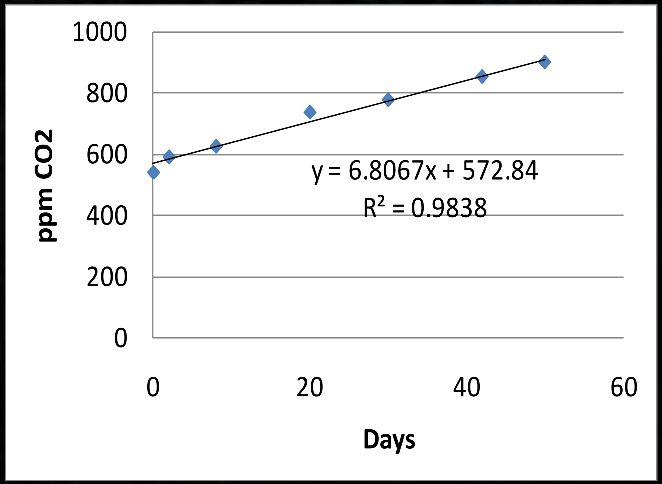
- California landfill cover soil
  - Marina loamy sand

Assessment of Gas Production

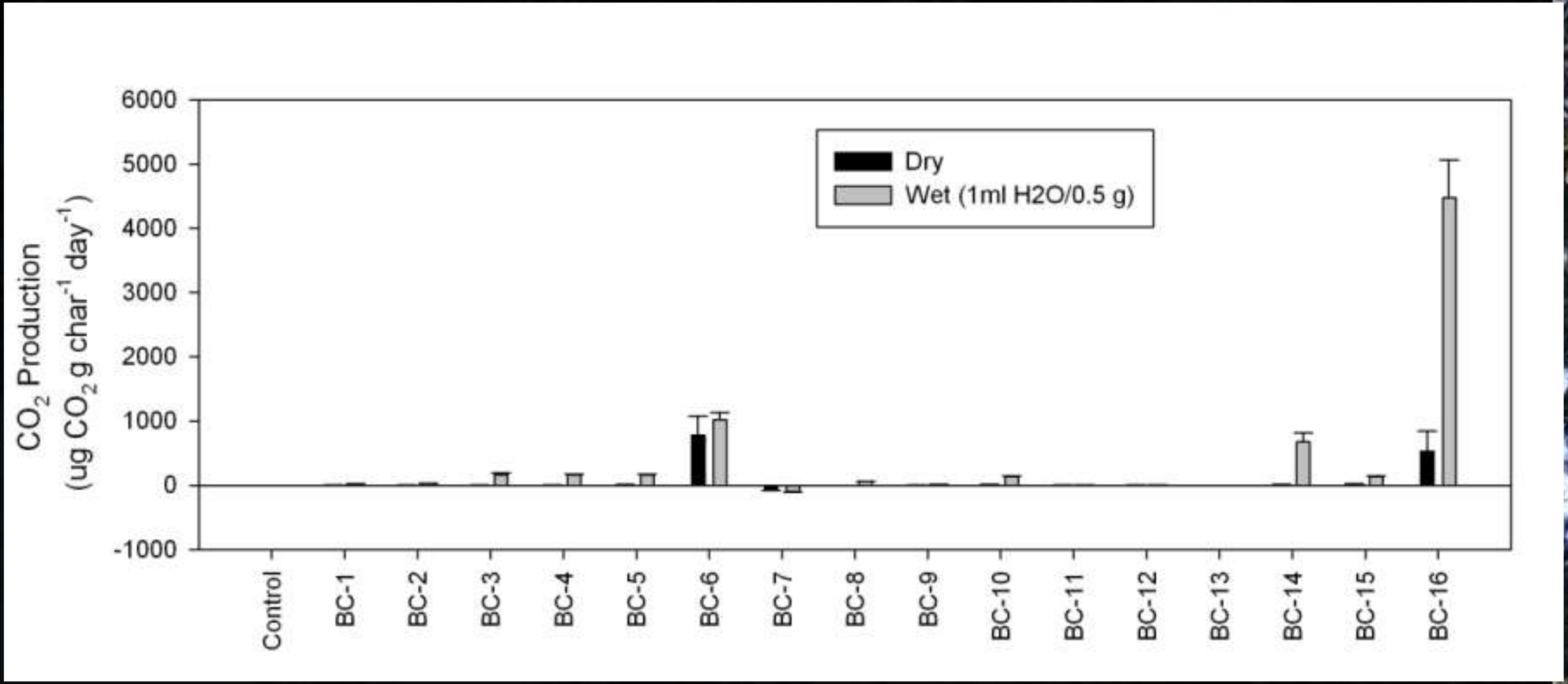
- 5 g of soil mixed with 0.5 g biochar (10% w/w)
- Headspace periodically monitored with GC/MS.
- Production rates estimated from the change in concentration with time.
- Length of incubations

  25 – 100 days
- Requirement:

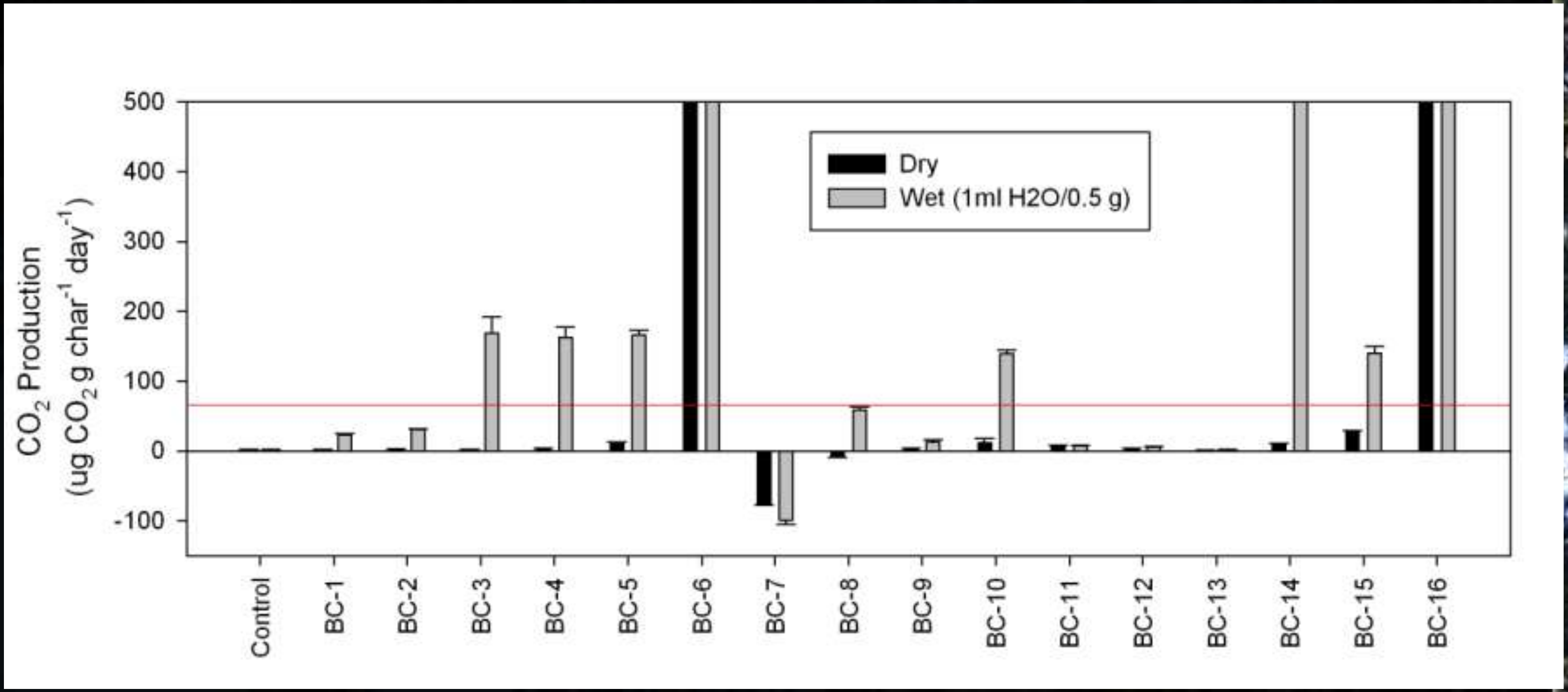
  O_2 concentrations >15%



Biochar CO_2 Production

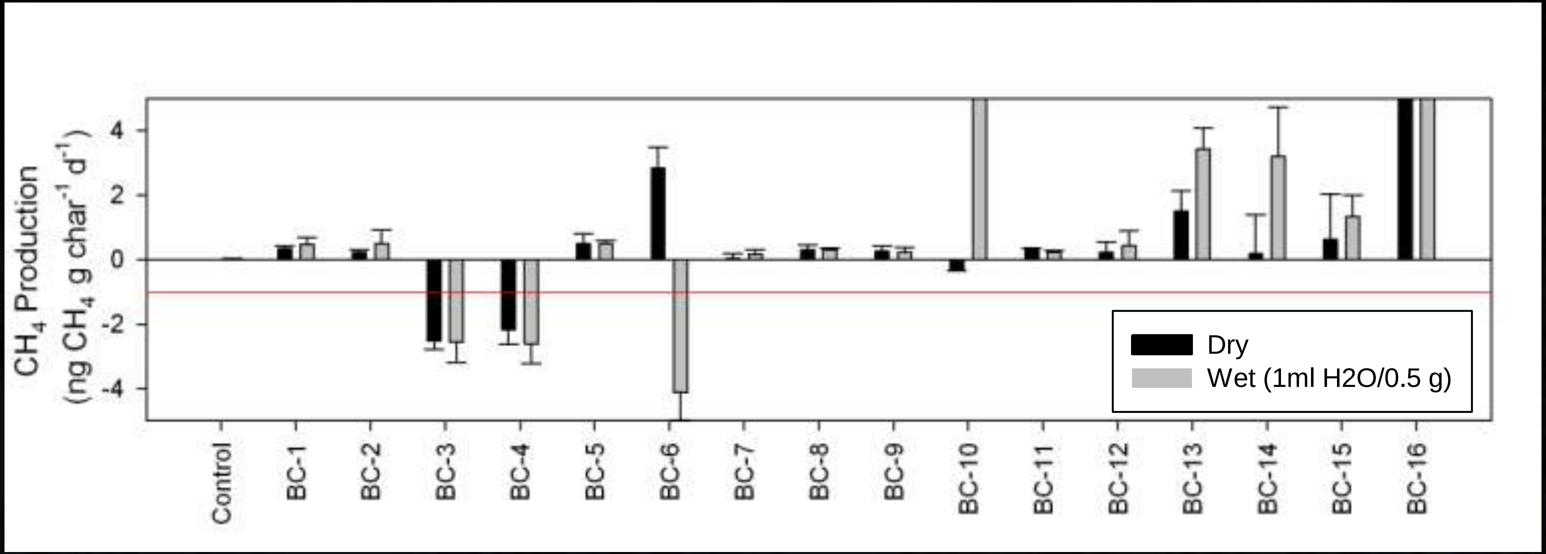


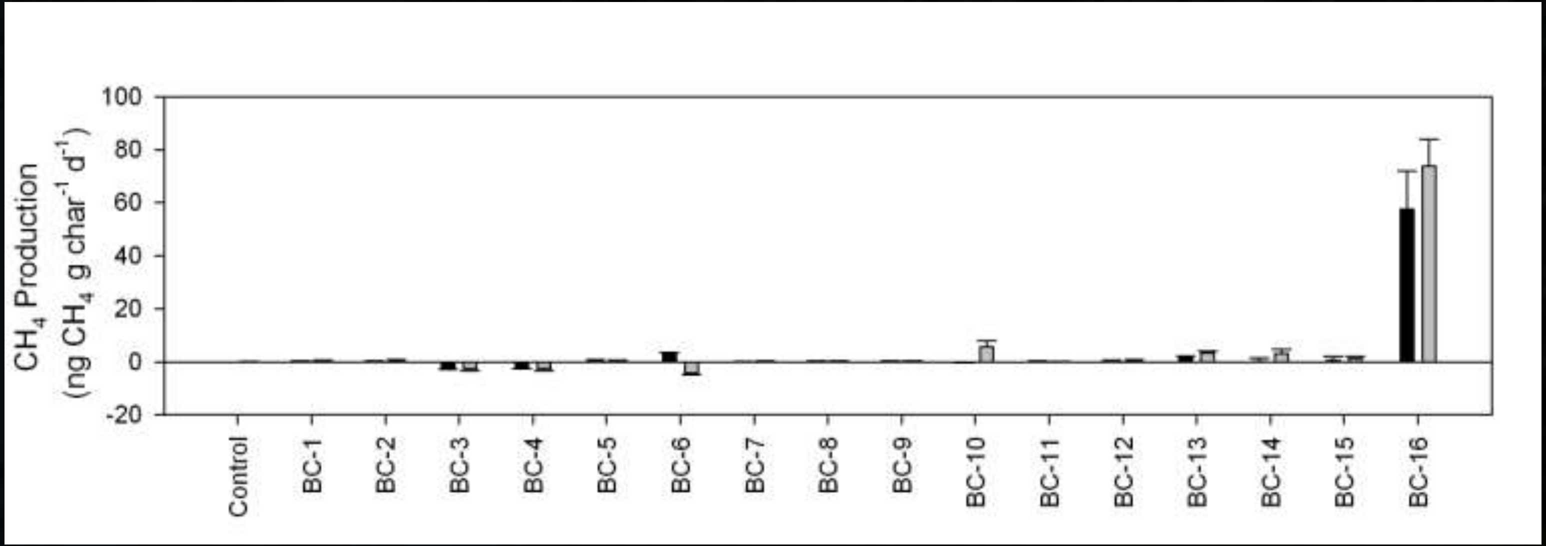
Biochar CO_2 Production



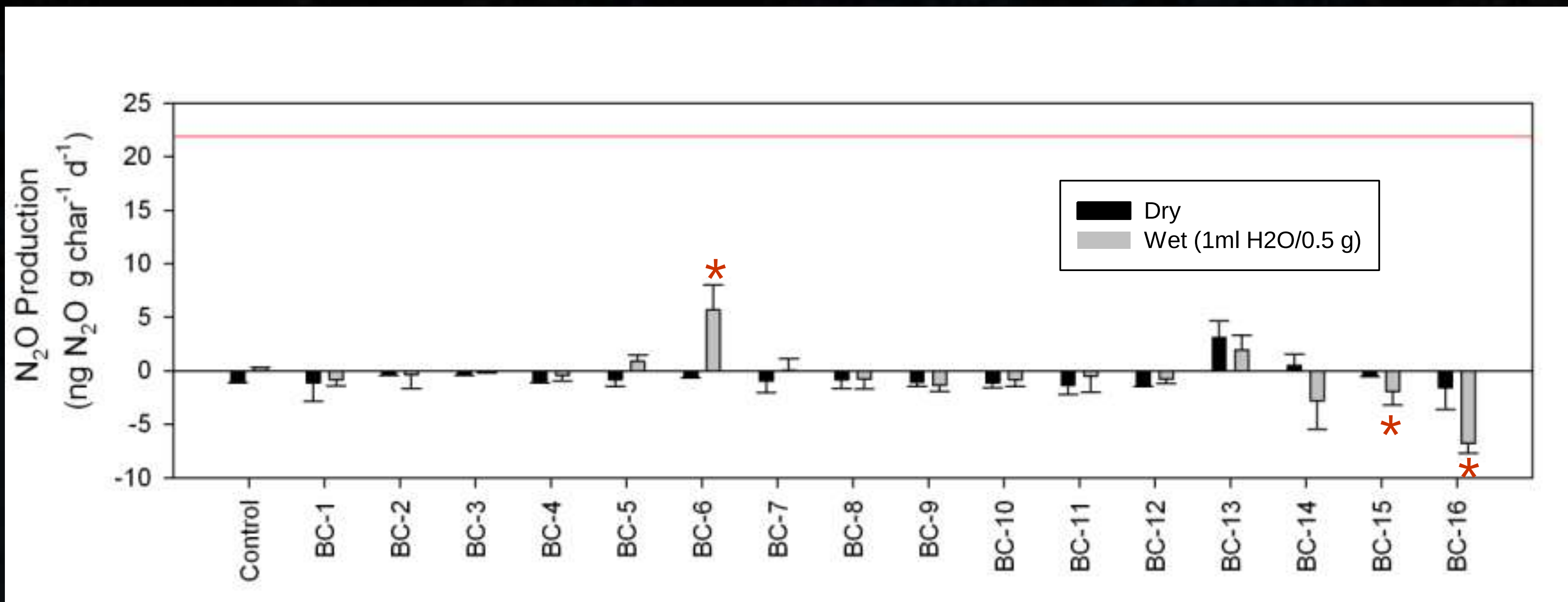
Red line represents average soil basal respiration (3 soils)
8 above; 7 below; and 1 no difference

Methane : Biochar alone





N_2O : Biochar alone



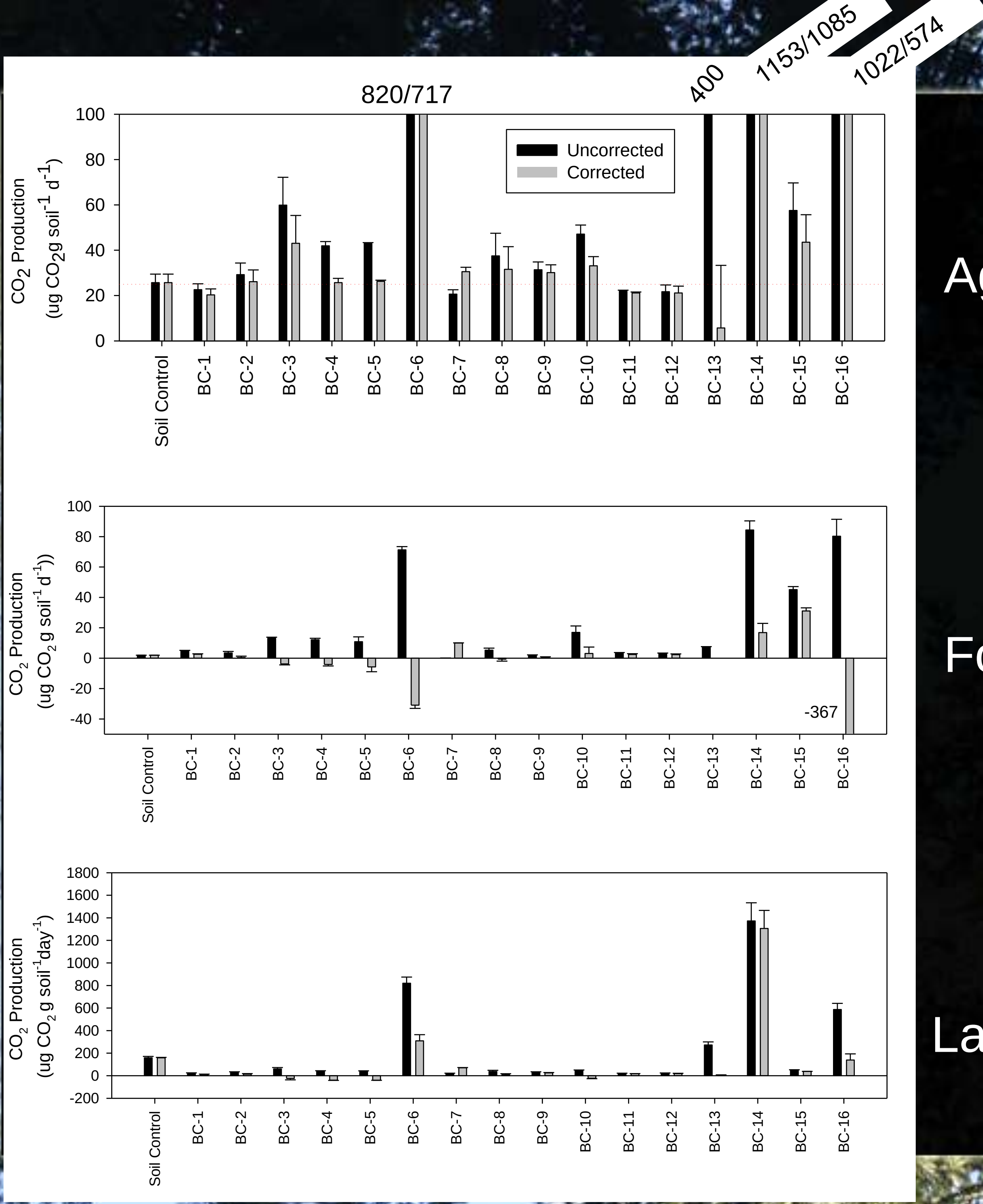
Only 3 biochars were significantly different than control (no char) – 1 produced N_2O and 2 consumed N_2O (sorption or denitrification?)

Ethane and Ethylene Production

BC-16 macadamia shell biochar

- Observable production of ethane and ethylene…as well as other hydrocarbons (not currently identified)
- Production rates:
  - Ethane: 200 ± 4.7 ng C_2H_6 g_{char}^{-1} d^{-1}
  - Ethylene: 82 ± 9.7 ng C_2H_4 g_{char}^{-1} d^{-1}
- In soils – reduced by 40 - 73%, potentially due to microbial oxidation

CO_2

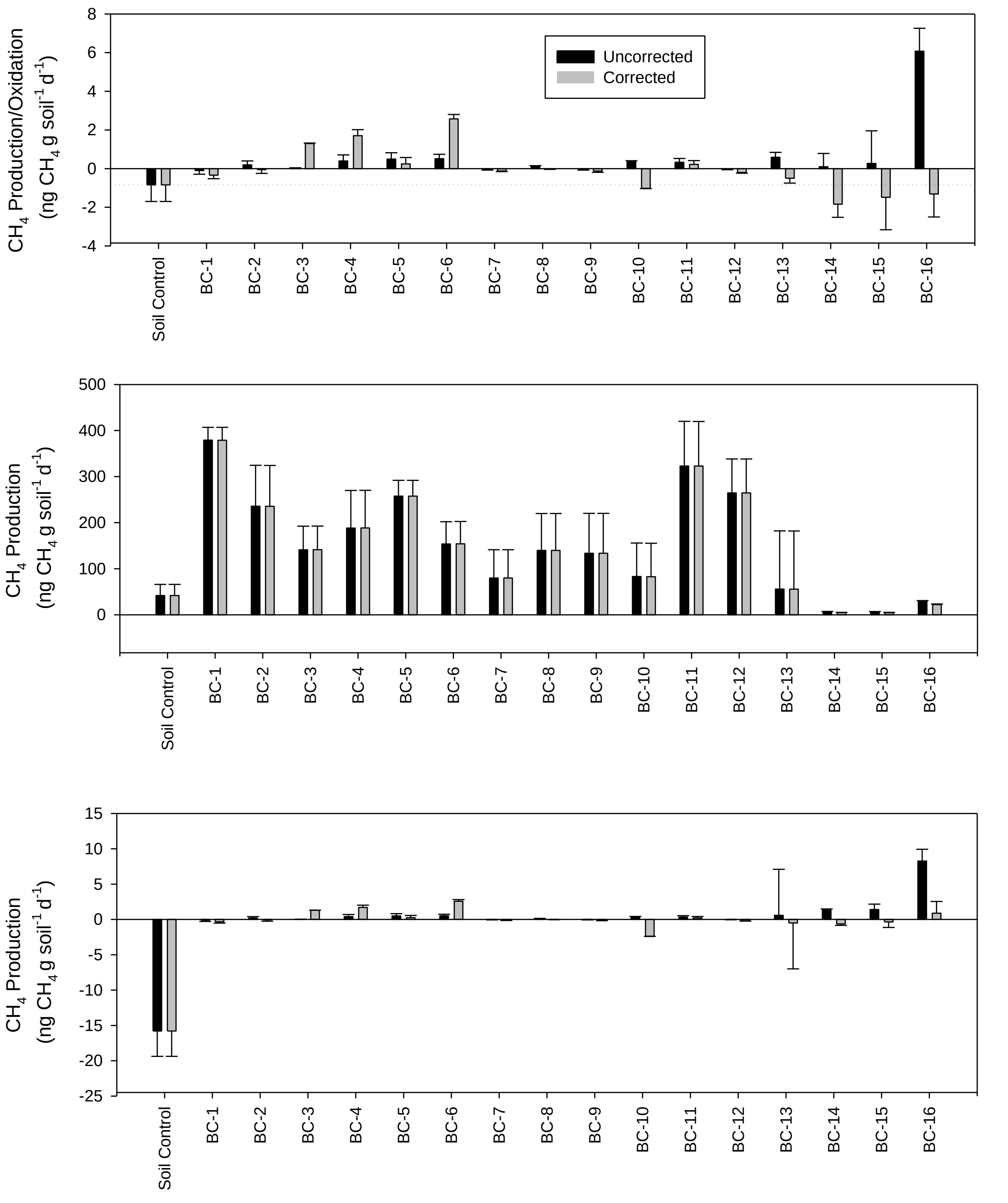


Agricultural Soil

Forest Nursery Soil

Landfill Cover Soil

CH_4



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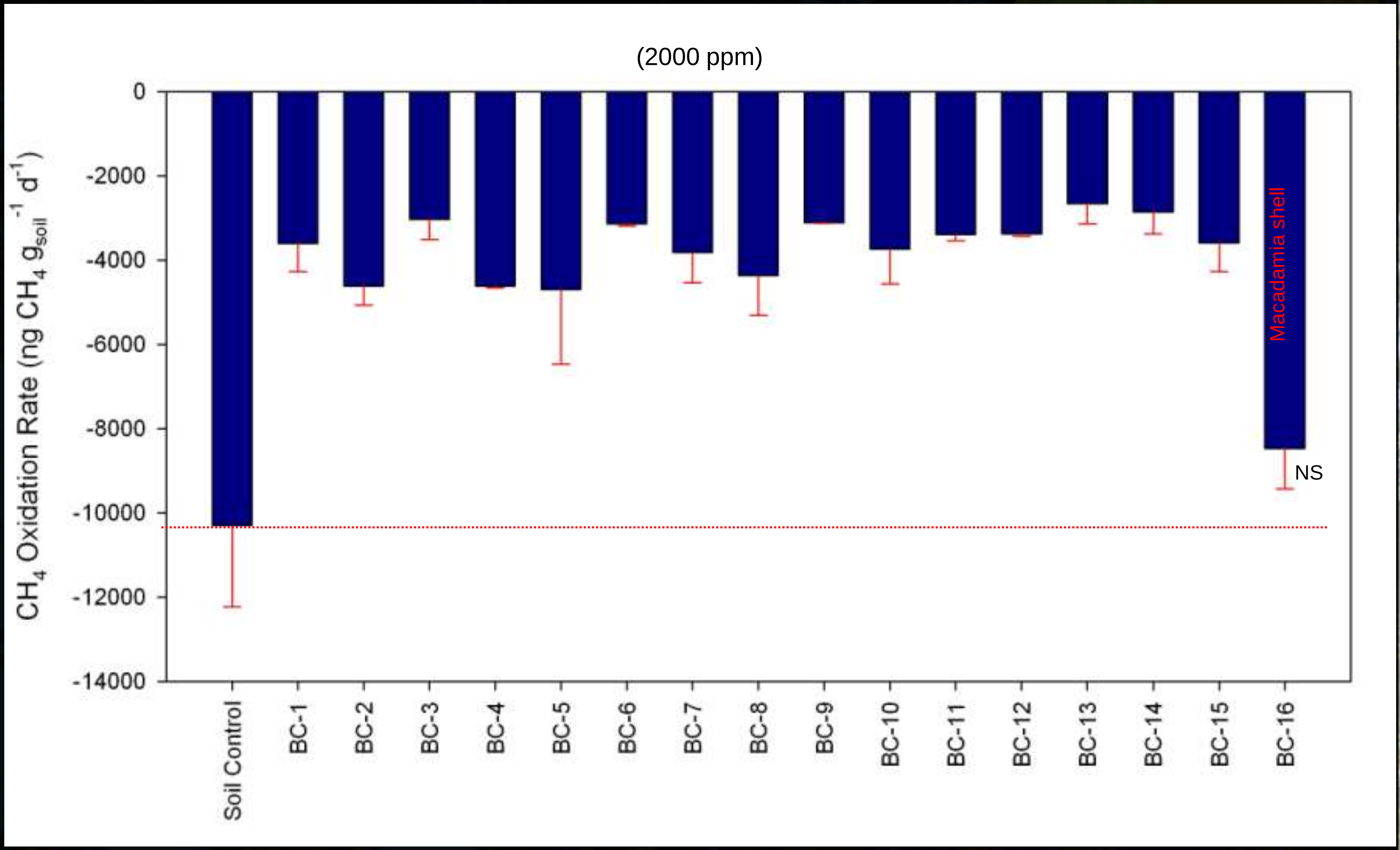
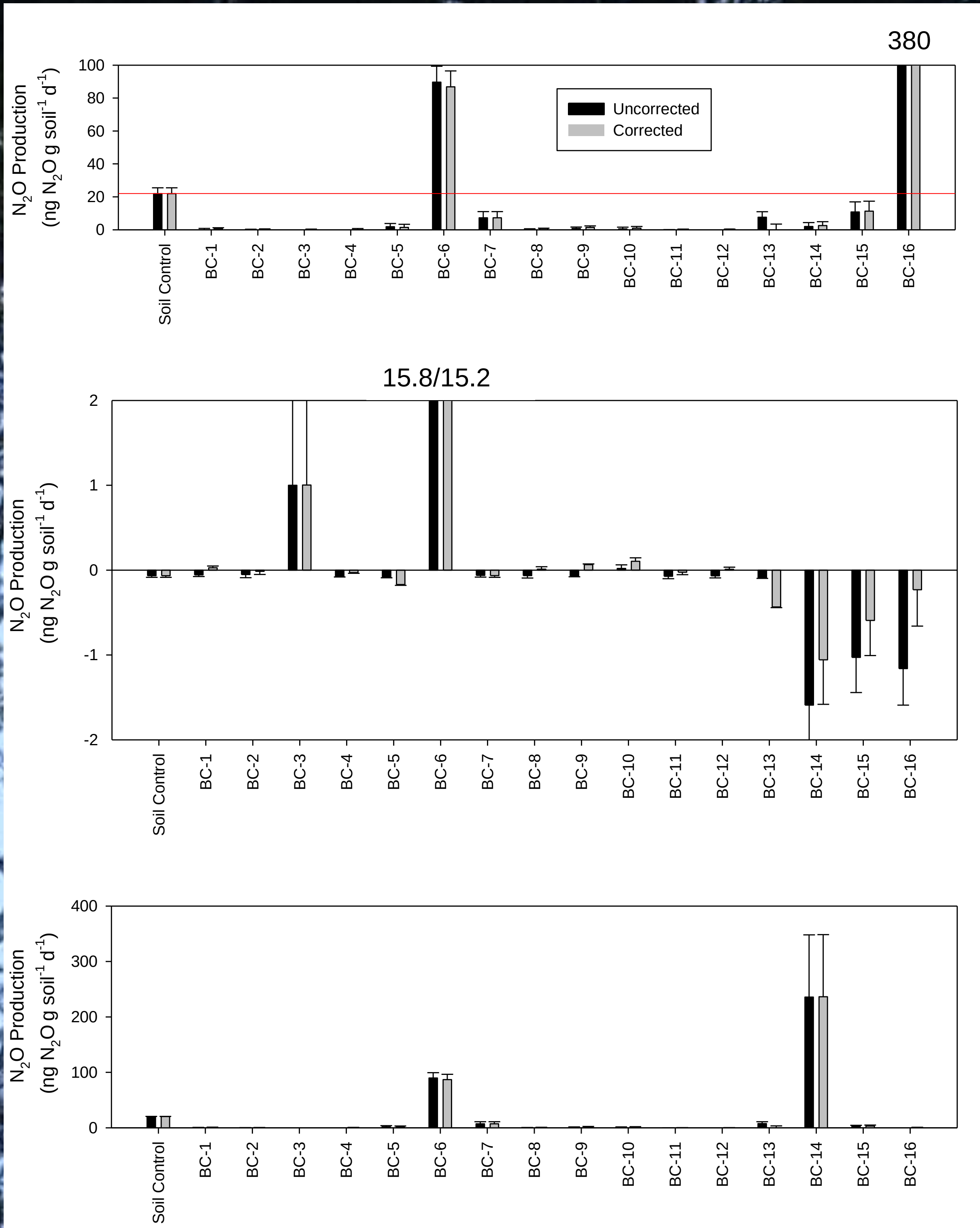
Landfill Cover Soil

Closer look at CH_4 oxidation
Landfill cover soil elevated CH_4 levels



15 biochars significantly reduced CH_4 oxidation; 1 non-significant decrease.

N_2O



Agricultural Soil

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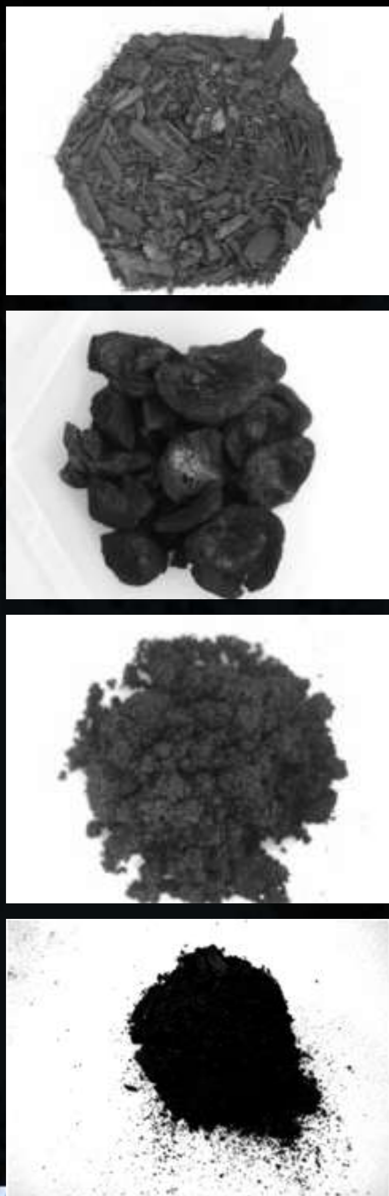
Conclusions

- Positive effect observed so far in laboratory
  - Reduction in N_2O production potential
- No consistent trends in CO_2
  - Majority reduced basal CO_2 respiration
- Majority of biochars reduce CH_4 oxidation activity
  - Soil methanotrophs are the only known biological sink for atmospheric methane
- Preliminary lab results – field plot research is ongoing…

Conclusions



→ Not all biochars are the same:
Creation process, original feedstock, temperatures, etc..

→Greenhouse gas production:
Complicated by biochar production, release, or sorption – this is particularly important for CO_2

→Overall, greenhouse gas impacts function of both <u>char and the soil</u>

Acknowledgements

We would like to acknowledge the cooperation:

Dynamotive Energy Systems – Fast pyrloysis char through non-funded CRADA agreement

Best Energies – Slow pyrolysis char through a MTA agreement

Biochar Brokers , Chip Energy and David Laird for their assistance in acquiring various biochars.

Martin duSaire, Tia Phan, Lindsey Watson, and Lianne Endo for technical assistance.