Long –Term Effect Of Fertilizer Microdosing On Soil Fertility In Sahelian West Africa

Alexis Adams, Adam Gillespie, Koala Saidou, Anthony Kimaro, Badiori Outtara, Jeff Schoenau, Derek Peak

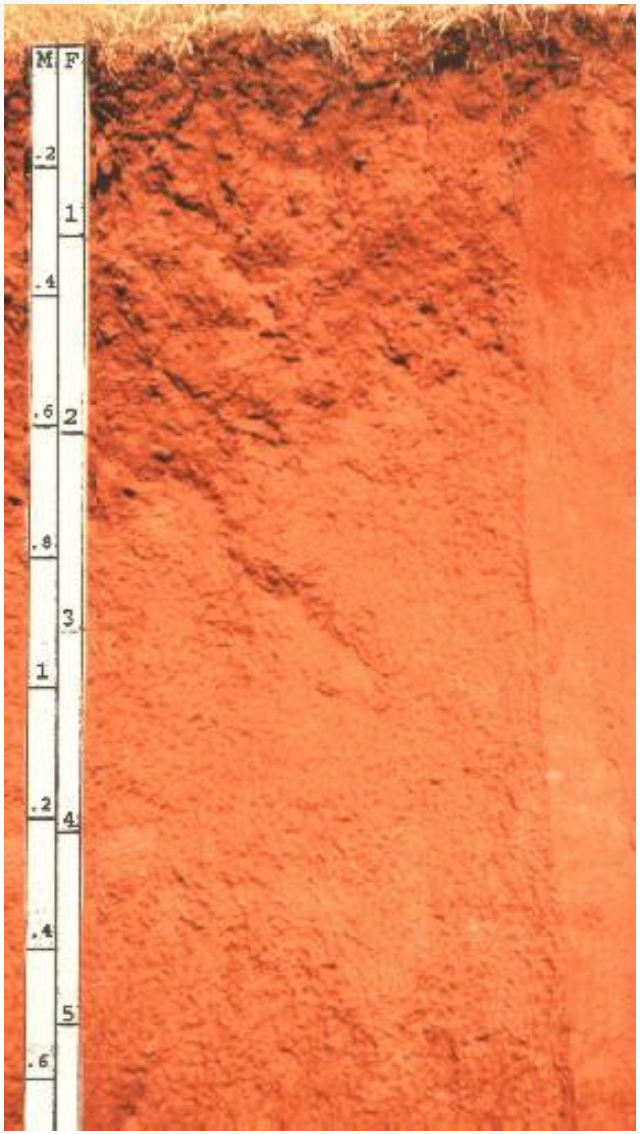
Sahel and Food Security

- Highest population food insecure people globally
- Population in Sahel increasing at rate of 3.1% per year
- Crop production increasing at only 1% per year
  - 24% Canada's avg cereal yield

http://mapsof.net/map/map-sahel

Why is Crop Production So Low?

- Unstable climate
- Low inherent soil fertility
- Competition for organic inputs
  - Feed, fuel, building materials
- Low fertilizer use



http://urbanext.illinois.edu/soil/orders/soiord.htm

Low Fertilizer Use: Less than 10 kg/ha!

- Fertilizer expensive
  - 4x Canada's prices
- Smallholder farmers
  - Low access to capital
  - Risk averse
- Difficult to access
  - Weak infrastructure and input sector

E. Bachmann

Microdosing: Step in Intensification

- **Microdosing**
  - **Reduced rate** of fertilizer, applied more precisely

http://www.idrc.ca

Microdosing Research

- **Focus** on short term yield response
- **Lack of focus** on sustainability
  - No long-term research
  - Few studies measure soil properties

D. Peak.

Research Objective

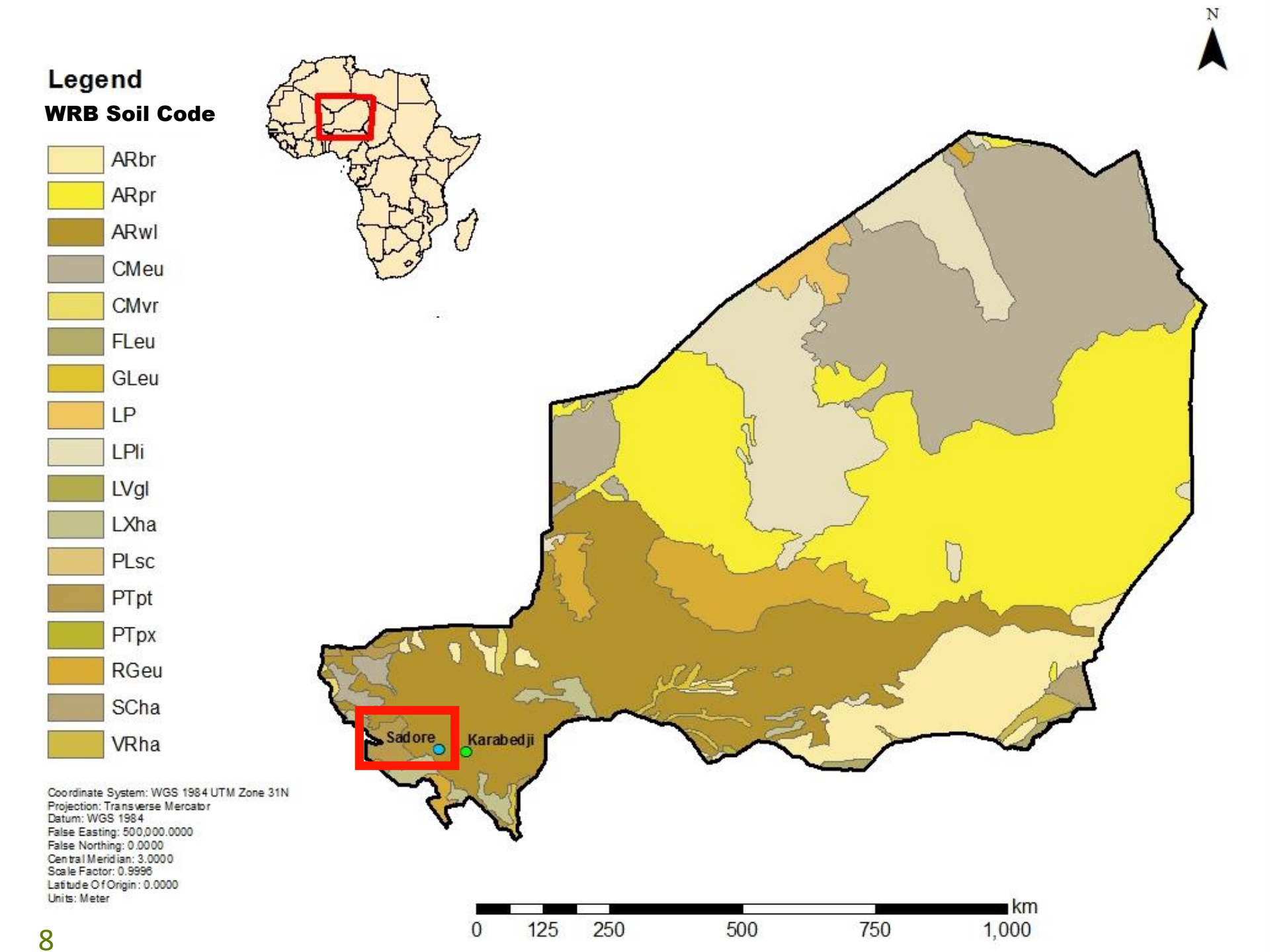
- Determine sustainability of microdosed ***rate*** of fertilizer by analyzing:
  - Yield trends
  - Soil chemical properties
  - Carbon speciation
- Explore sustainability of soil management practices as a whole

Effect of Rates: Sadore Long-Term Research Site

- Yield data from 1998 to 2013
- Continuous millet
- No difference between high and low fertilizer rate in application

http://www.dmpafrica.net/

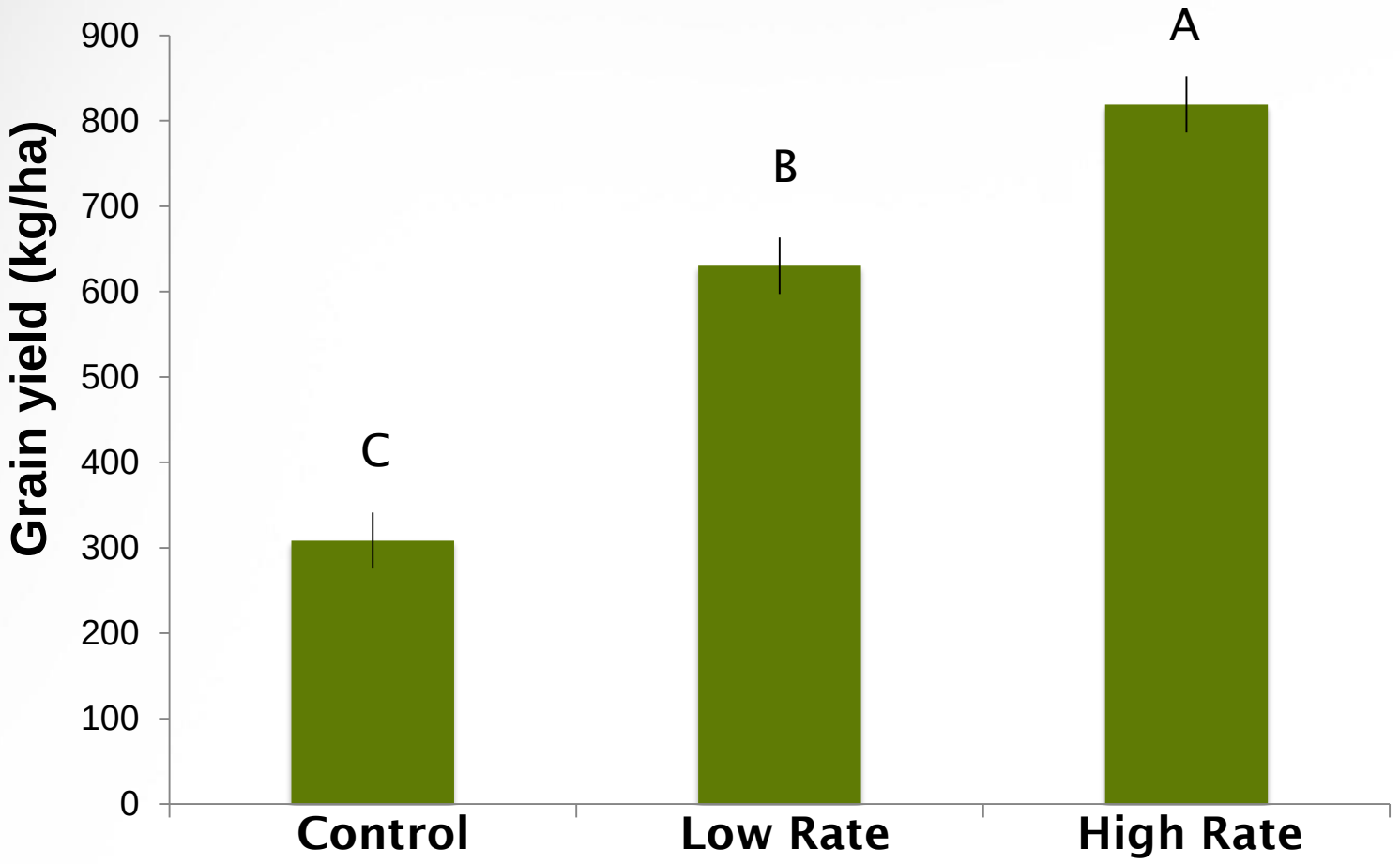
Rate	Fertilizer	Manure	Crop residue
	kg/ha	kg/ha	kg/ha
Control	0N, 0P	300	300
Low	15N, 4.4P	900	900
High	30N, 13.2P	2700	2700


Legend
WRB Soil Code
ARbr
ARpr
ARwl
CMeu
CMvr
FLeu
GLeu
LP
LPli
LVgl
LXha
PLsc
PTpt
PTpx
RGeu
SCha
VRha
N
Sadore
Karabedji
Coordinate System: WGS 1984 UTM Zone 31N
Projection: Transverse Mercator
Datum: WGS 1984
False Easting: 500,000.0000
False Northing: 0.0000
Central Meridian: 3.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter
0
125
250
500
750
1,000
km

http://www.oneacrefund.org

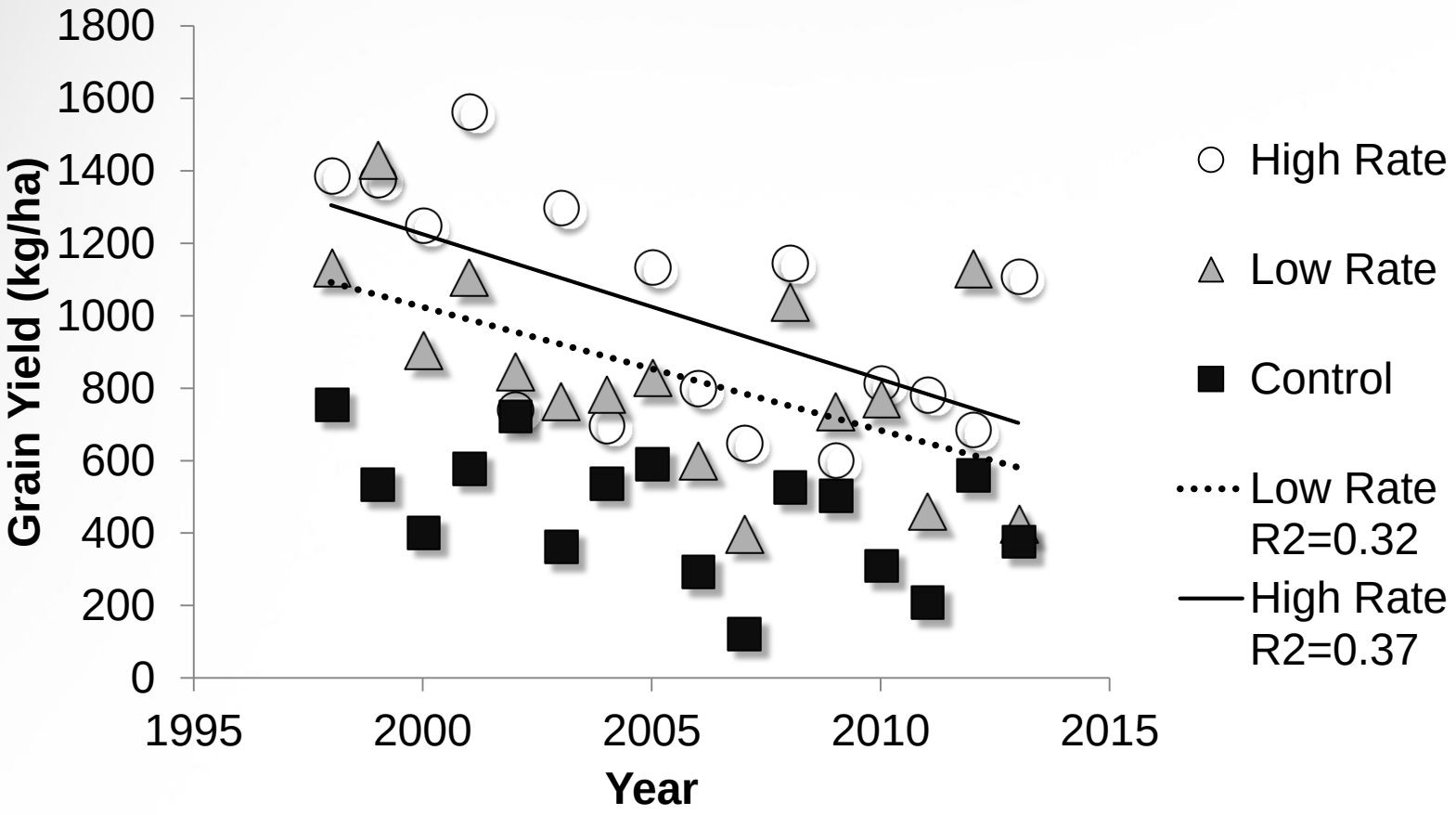
SUSTAINABILITY OF REDUCED RATE OF FERTILIZER

Figure 1. Average yield 1998-2013 by fertilizer rate



Yield Regression over Time

Figure 2. Yield Trend by Fertilizer Rate



Fertilizer Rates and Soil Properties

Table 1. Effect of fertilizer rate on soil properties at Sadore

Fertilizer Rate	**pH**	Electrical Conductivity	Organic Carbon	Total P	Available P	Total N	CEC
		mS/cm	%	mg/kg	mg/kg	mg/kg	cmolc/kg
Control	**5.3a**	0.048	0.24b	144.1c	5.9c	96.1c	0.7
Low Rate	**5.1b**	0.053	0.26a	161.8b	10.9b	104.5b	0.6
High Rate	**5.0c**	0.052	0.27a	172.9a	22.9a	127.0a	0.6
SEM	*0.02*	*0.0048*	*0.005*	*2.76*	*0.88*	*2.7*	*0.04*

$p<0.05$, SEM= standard error of mean

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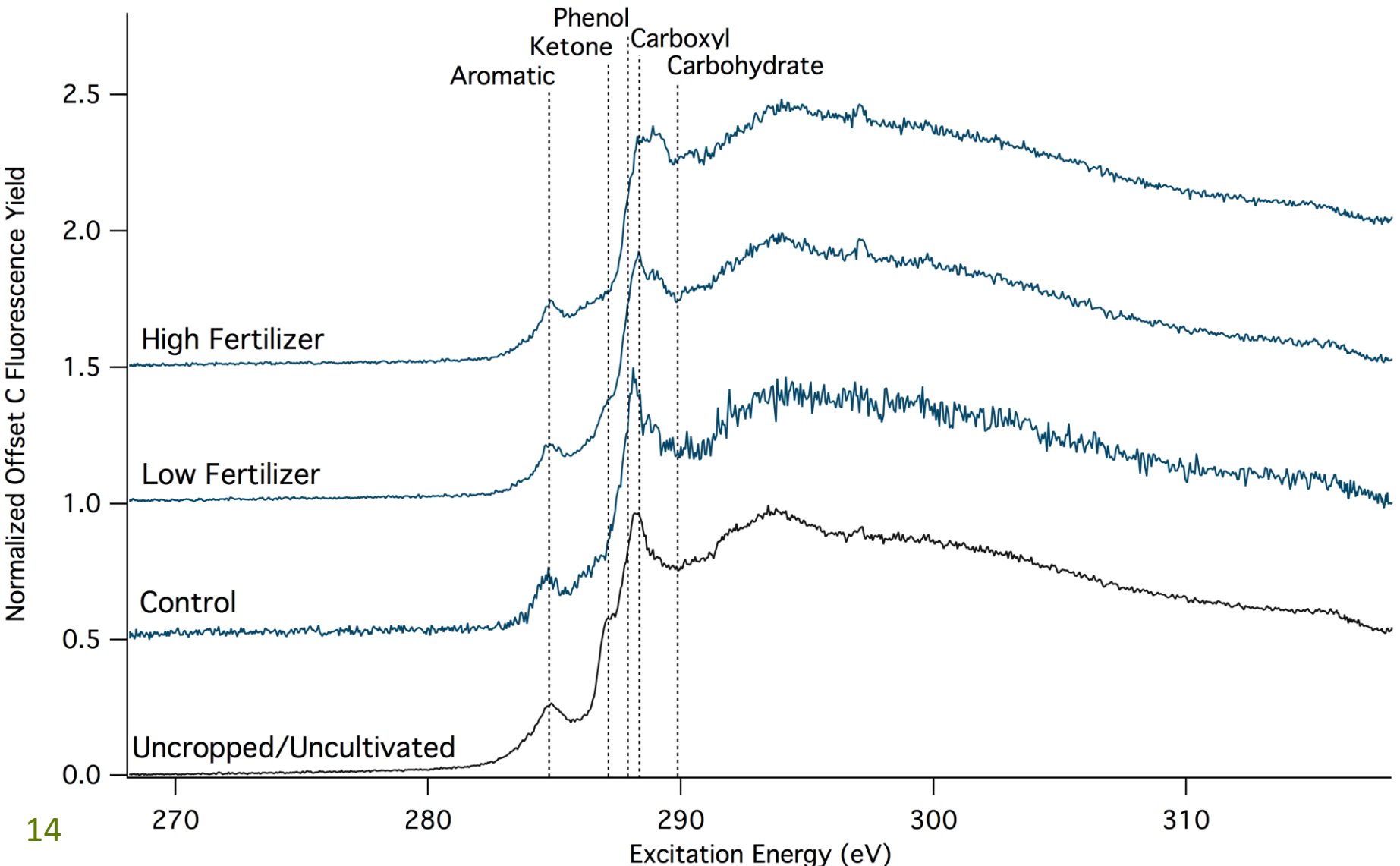
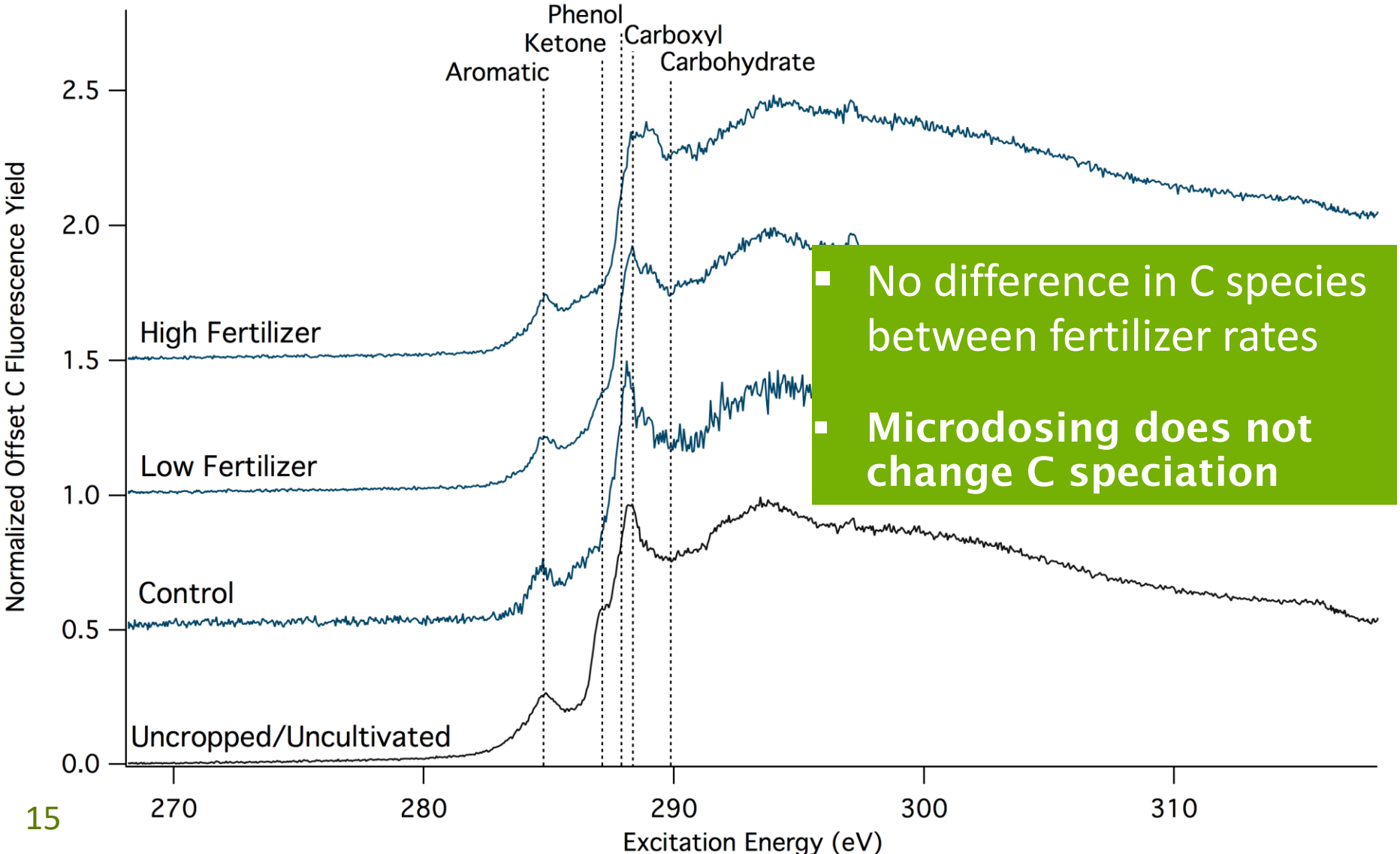
Carbon Speciation



Carbon Speciation



- No difference in C species between fertilizer rates
- **Microdosing does not change C speciation**

Sustainability of Microdosed Rate

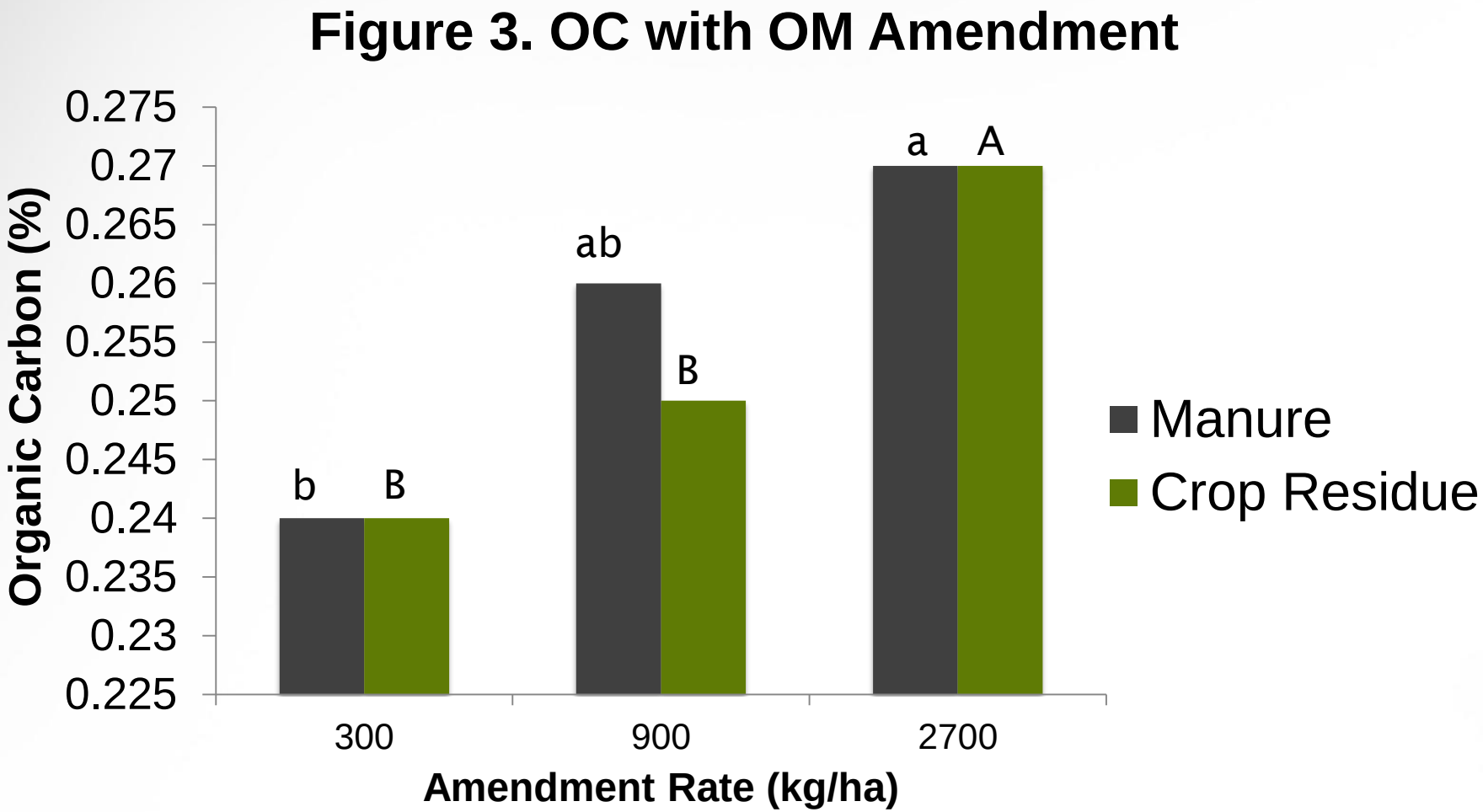
Compared to the high rate, the microdosed rate has:

- Lower average yield but similar rate of yield decline over time
- No indication mining N or P
- No difference in amount or type of organic C

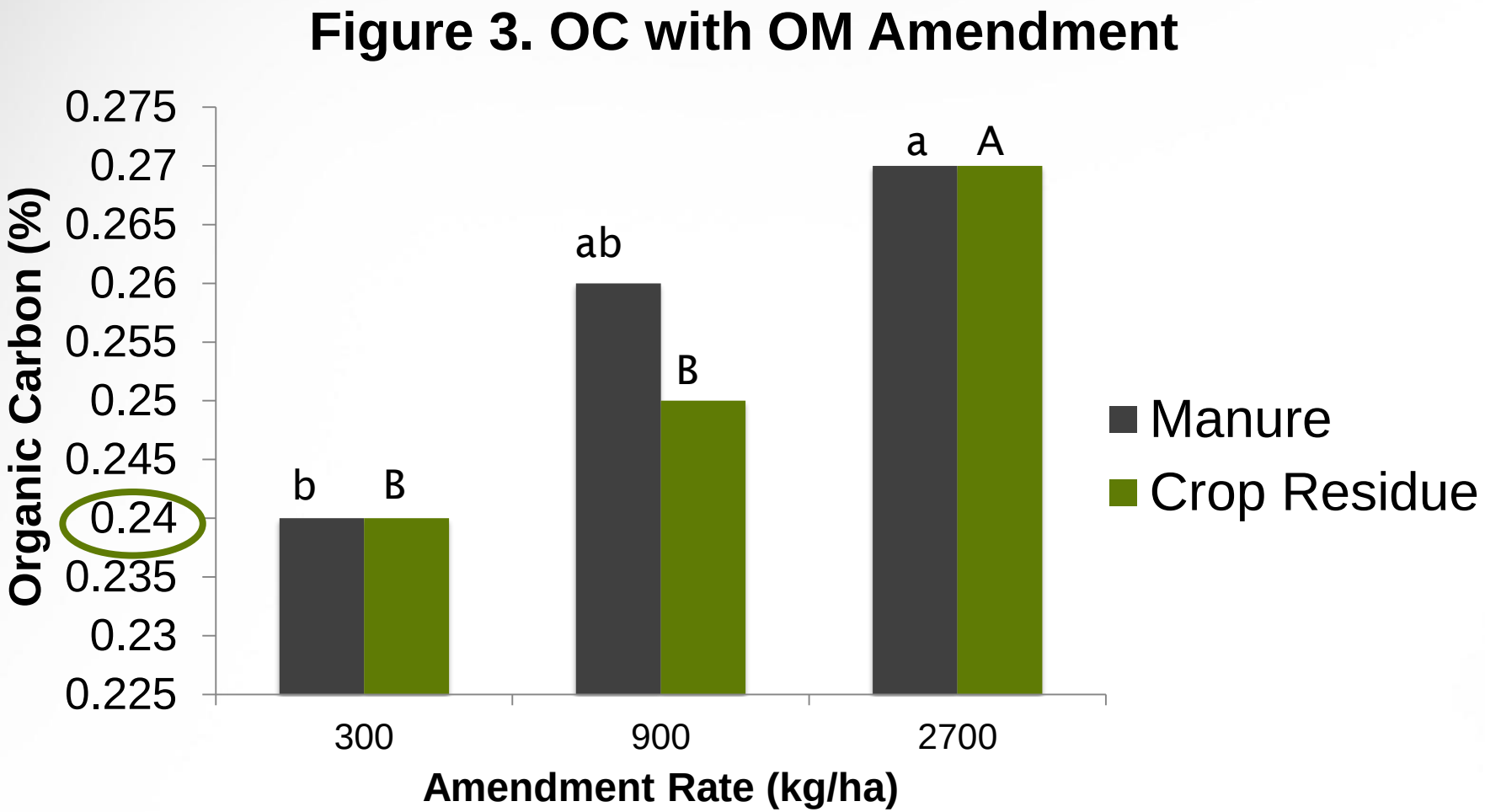
http://agra-alliance.org

SUSTAINABILITY OF SOIL MANAGEMENT PRACTICES

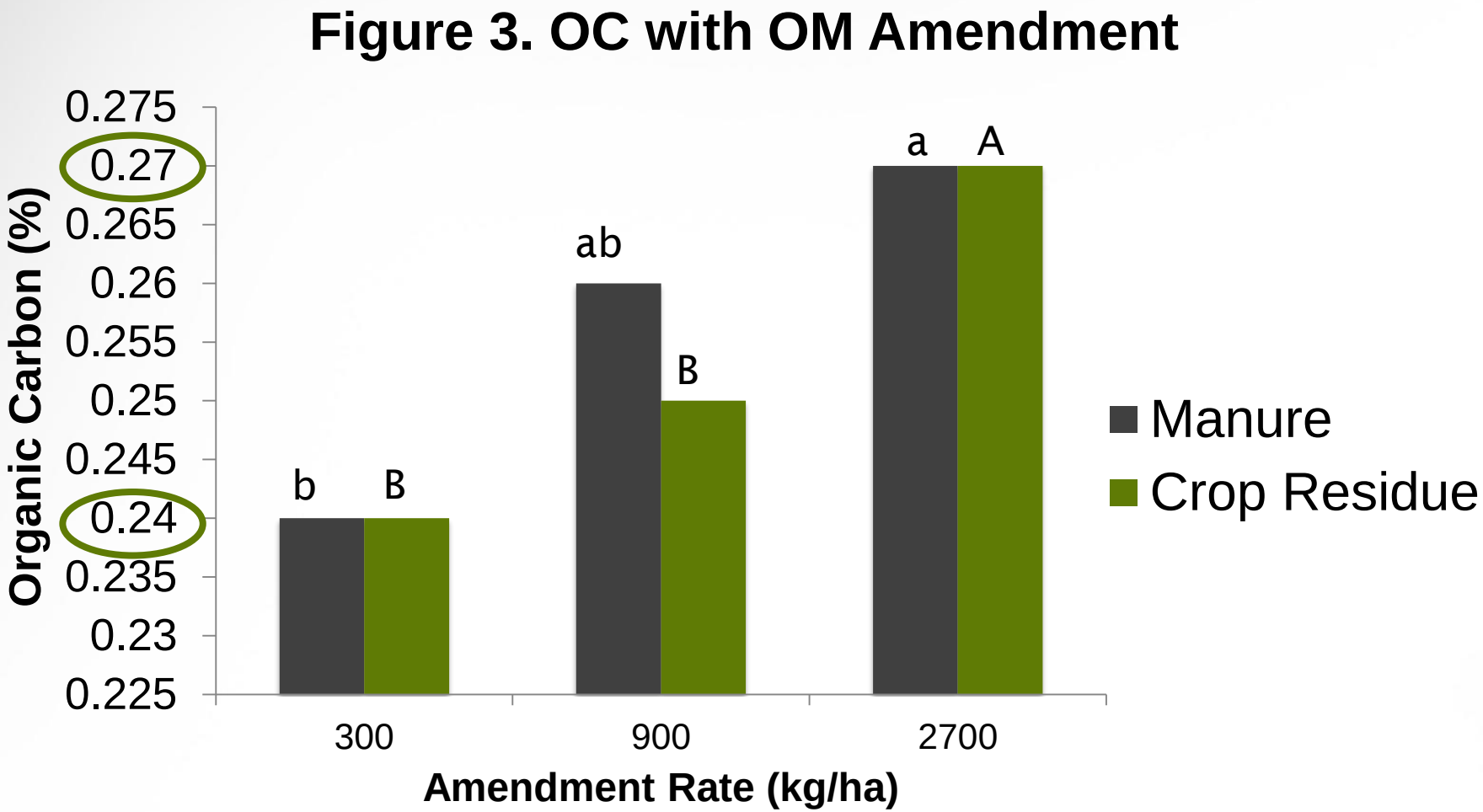
Improving Organic Carbon



Improving Organic Carbon



Improving Organic Carbon



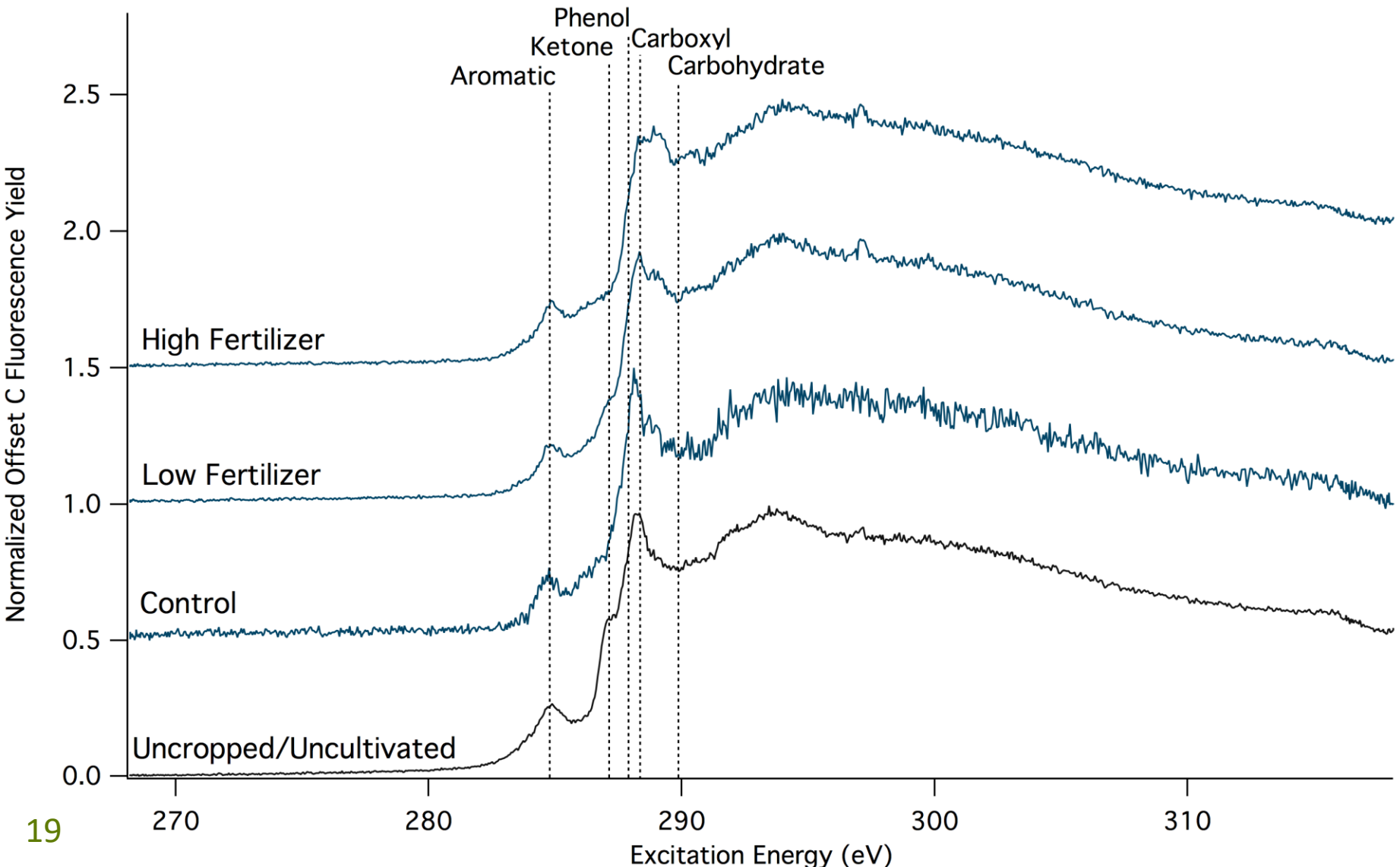
Fertilizer, Cropping, and Cultivation Effect

Table 4. Effect tillage, cropping, and fertilizer application on soil properties

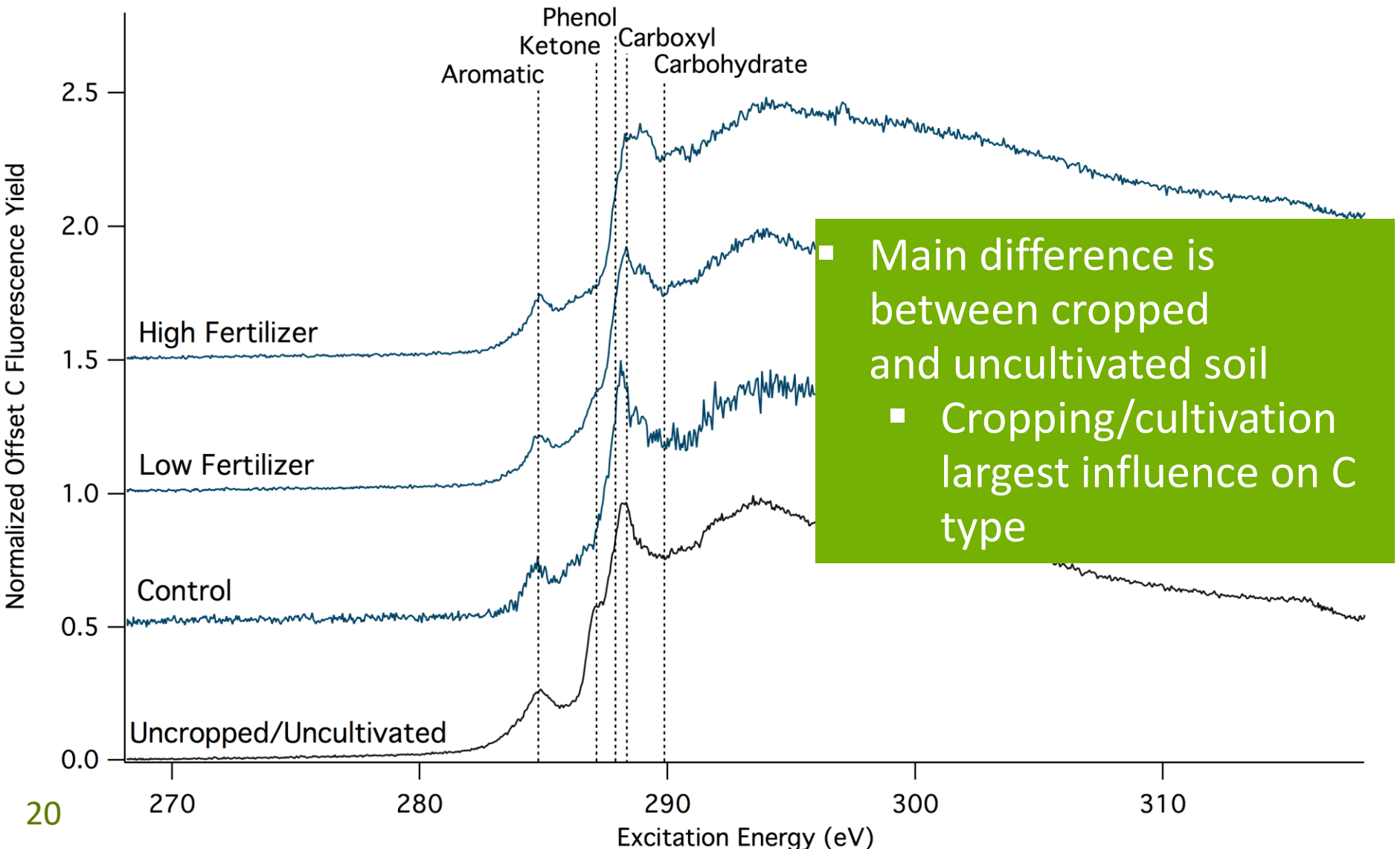
Treatment	pH	Electrical Conductivity	**Organic Carbon**	Total P	Available P	**Total N**	CEC
		mS/cm	%	mg/kg	mg/kg	mg/kg	cmolc/kg
Control	5.5a	0.035	**0.26**	163.0a	4.0bc	**79.4b**	0.4b
Low Fertilizer	5.2ab	0.045	**0.26**	190.2a	6.8b	**89.8b**	0.3b
High Fertilizer	5.3ab	0.043	**0.26**	194.4a	24.5a	**133.9a**	0.5b
SEM	*0.14*	*0.0239*	*0.028*	*9.82*	*0.77*	*9.51*	*0.06*
Uncultivated	5.0b	0.052	**0.21**	82.3c	3.0c	**131.0a**	0.8a
SEM	*0.09*	*0.0147*	*0.017*	*6.01*	*0.47*	*5.82*	*0.04*

$p<0.05$, SEM=standard error of mean.

Carbon Speciation



Carbon Speciation



- Main difference is between cropped and uncultivated soil
  - Cropping/cultivation largest influence on C type

Conclusion

- Nutrients required in these soils
- Microdosed rate of fertilizer no less sustainable than recommended rate at Sadore

- Is the cropping system as a whole sustainable?
  - Overall yield decline
  - Little OC buildup even with OM amendment
  - Loss of total N with cultivation
  - Cultivation changing C type
- Recommendations:
  - Combine no-till, microdosing, and OM amendment

Solution must fit in socioeconomic context to be effective

ACKNOWLEDGEMENTS

- Supervisors: Derek Peak and Jeff Schoenau
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- Augustine Osei and Gourango Kar for lab work
- Canadian Light Source
- Peak Lab Group

IDRC CRDI
International Development Research Centre
Centre de recherches pour le développement international

Foreign Affairs, Trade and Development Canada

Canadian Light Source
Centre canadien de rayonnement synchrotron

NSERC CRSNG