



Biochar carbon stability and priming effect in contrasting soils of Australia

Yunying Fang¹, Balwant Singh¹, Bhupinder Pal Singh², Evelyn Krull³

¹ Faculty of Agriculture & Environment, The University of Sydney, Sydney, Australia.

² NSW Department of Primary Industries, Sydney, Australia.

³ CSIRO Land and Water, Adelaide, Australia.


Materials and Methods

Wood biochars were produced at 450 and 550°C by slow pyrolysis (5-10°C/min heating rate and 40 min residence time at Pacific Pyrolysis, Australia) from a ¹³C-depleted (-36‰) woody biomass of *Eucalyptus saligna*.



Property	Biochar 450	Biochar 550
pH (1:5 H ₂ O)	8.64	9.96
EC (1:5 mS/m)	89.4	112.7
δ ¹³ C ‰	-36.3	-36.5
Total carbon (%)	67.4	73.2
Total nitrogen (%)	0.5	0.6
CEC (mmol _c /kg)	11.4	54.0
SSA (m ² /g)	191	228
Pore volume (cm ³ /g)	57	68

Physico-chemical properties of the experimental soils

Property	 WA	 SA	 Qld	 NSW
pH (1:5 H ₂ O)	5.70	8.77	7.89	5.65
EC (1:5 mS/m)	8.2	24.5	13.0	15.0
Clay (%)	1.3	21.5	44.2	44.1
CEC-AgTU	24	99	265	120
Organic C (%)	0.95	2.53	2.25	4.39
Inorganic C (%)	-	6.01	-	-
δ ¹³ C (‰)	-28.2	-14.1	-17.3	-21.4
Total N(%)	0.07	0.16	0.16	0.43
Clay minerals	Kaolinite, quartz, illite	Illite, kaolinite, calcite	Smectite, kaolinite	Goethite, gibbsite, kaolinite, hematite

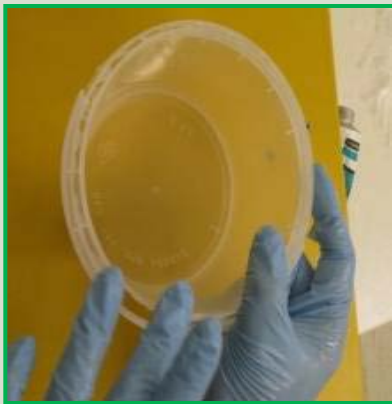
Experimental procedures



- Biochars (450°C and 550°C, 2% w/w) was mixed with 300 g (oven dry basis).
- Nutrient solution
- Microbial inoculum
- Moisture at 70% WHC
- 4 replications

Experimental procedures

- The soil samples with or without biochar were incubated in sealed containers for 12 months at **20°C, 40°C and 60°C**.
- Gas sampling and analysis ($^{13}\text{CO}_2\text{-C}$ and total $\text{CO}_2\text{-C}$) performed at 2, 4, 8, 16, 32, 60, 90, 120, 183, 231, 263, 311, 365 days to evaluate the oxidation of biochar-C.



Quantifying C source in the respired CO₂ by the mass balance approach

$$C_{\text{Biochar}} (\%) = \frac{(\delta^{13}\text{C}_T - \delta^{13}\text{C}_S)}{(\delta^{13}\text{C}_B - \delta^{13}\text{C}_S)} \times 100$$

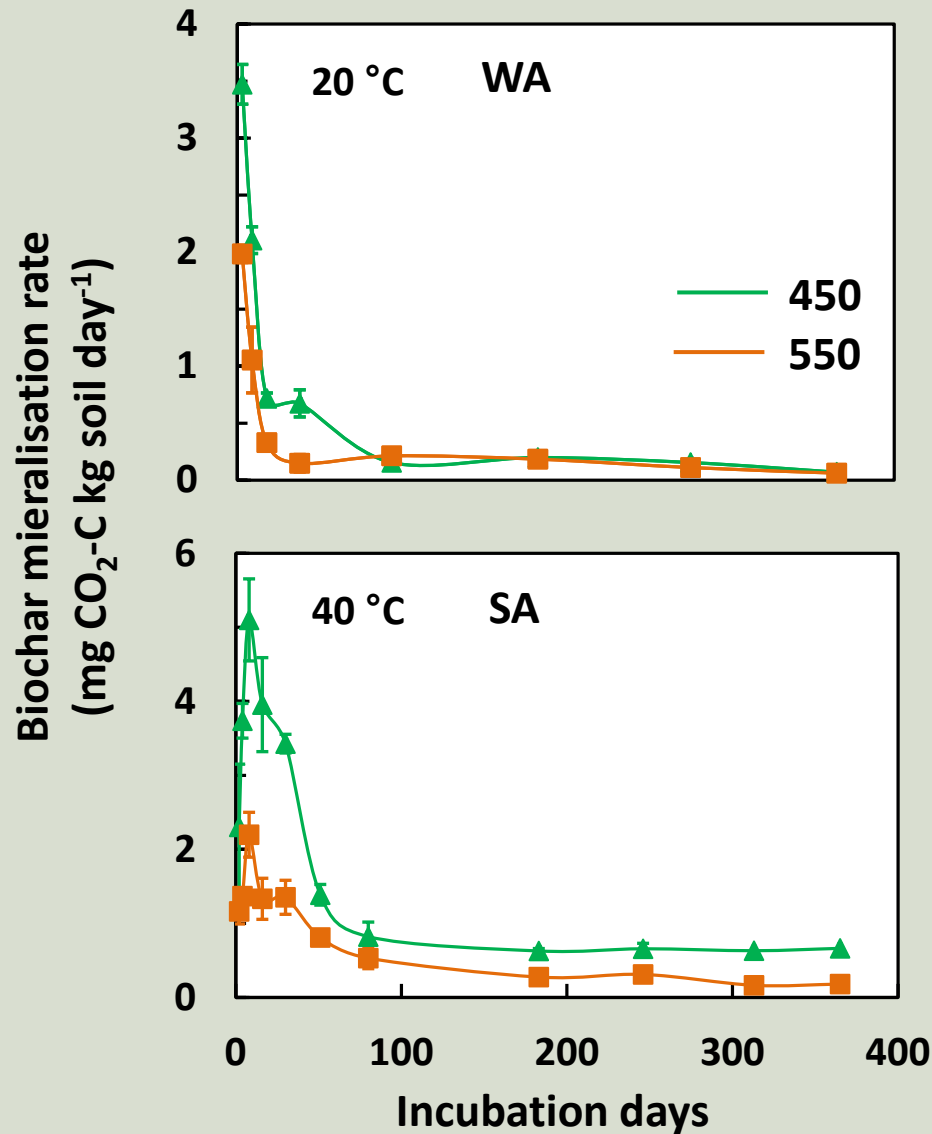
$C_{\text{Biochar}} (\%)$ = Fraction of biochar-derived C

$\delta^{13}\text{C}_T$ = $\delta^{13}\text{C}$ signature of total respired CO₂ from biochar-amended soil

$\delta^{13}\text{C}_B$ = $\delta^{13}\text{C}$ signature of ¹³C-depleted-biochar

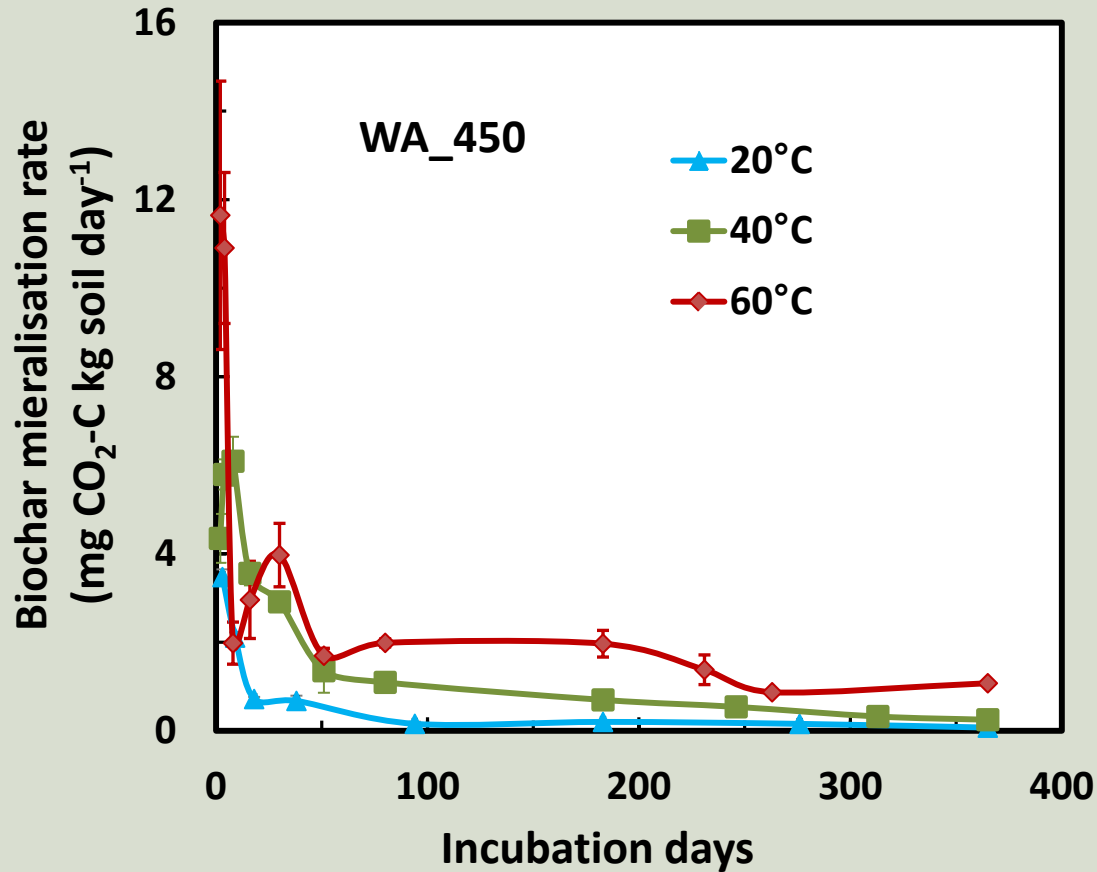
$\delta^{13}\text{C}_S$ = $\delta^{13}\text{C}$ signature of control soil-C

Biochar pyrolysis temperature



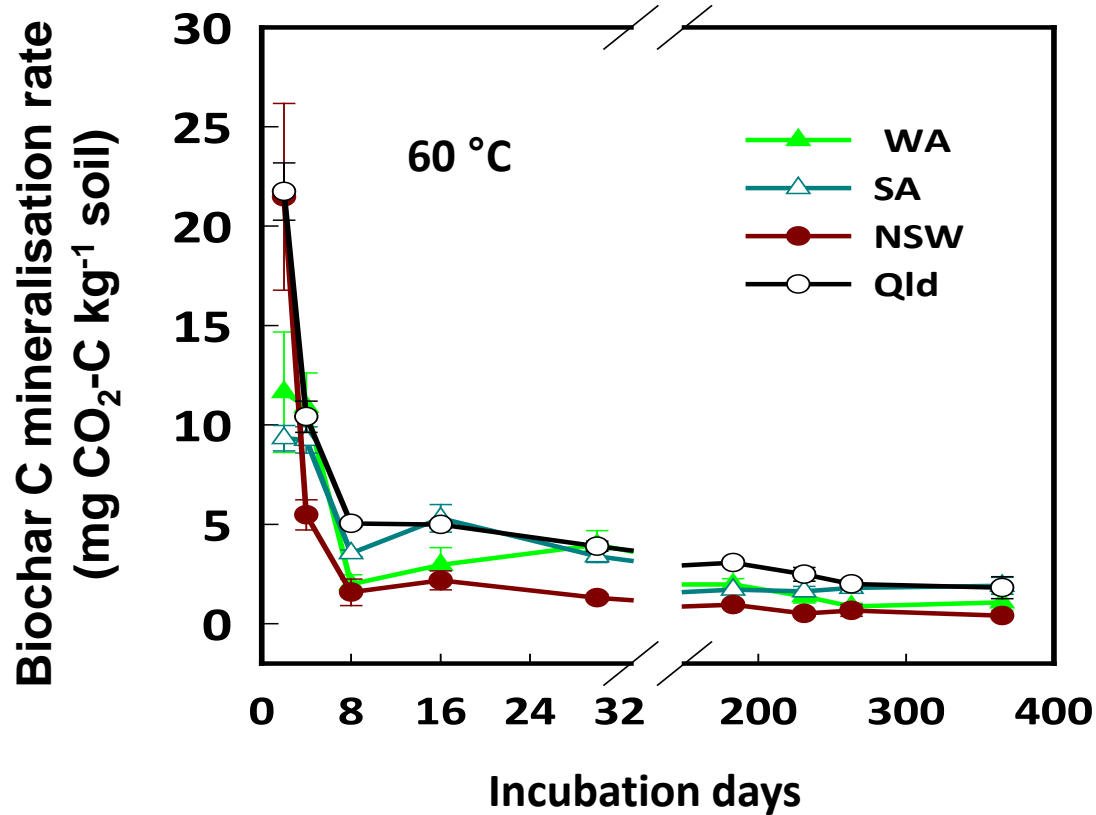
- 450°C > 550°C
- Stabilized after 3 weeks

Incubation temperature



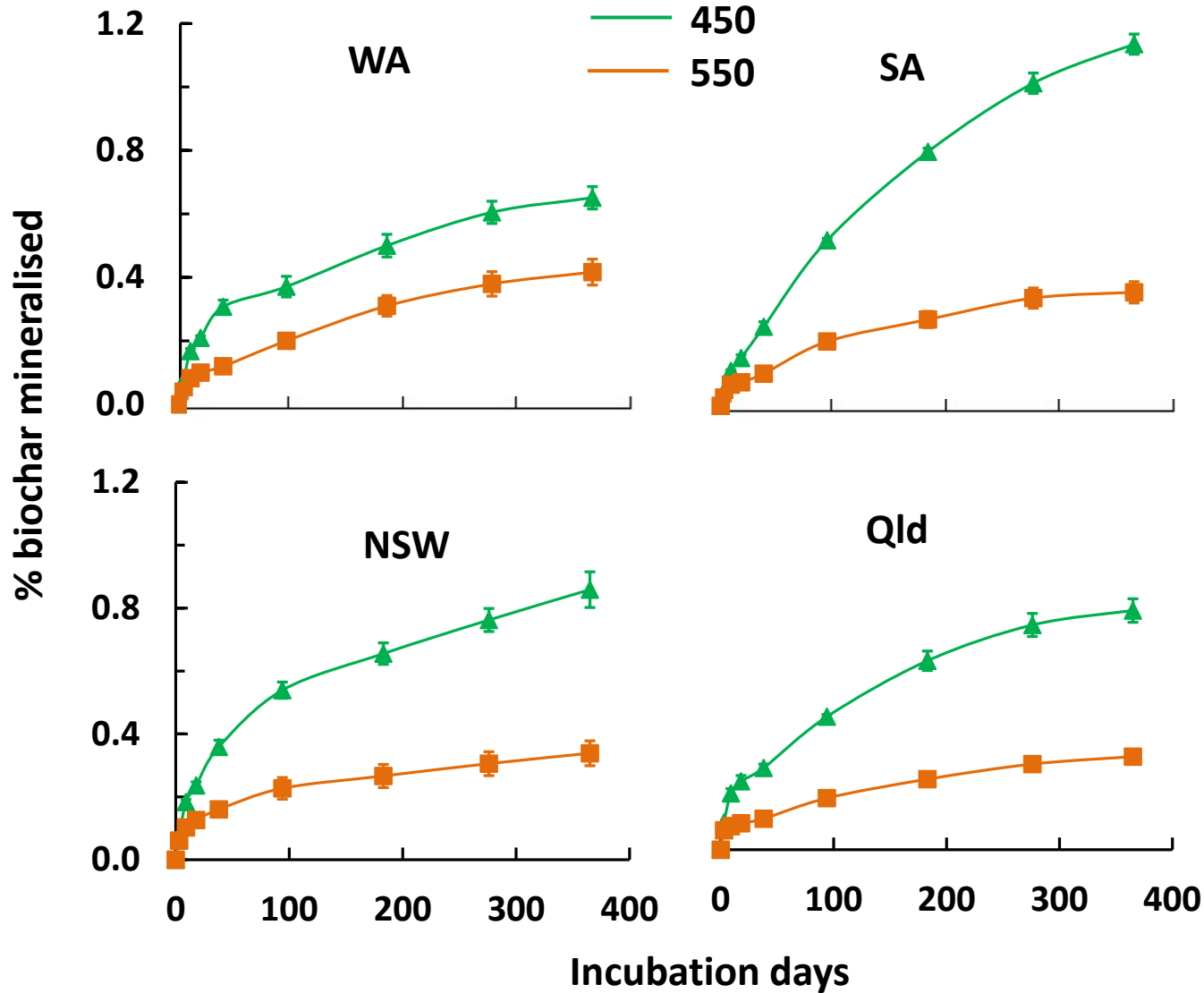
Biochar mineralized rate increased with increasing incubation temperature
20°C < 40°C < 60°C

Soil properties

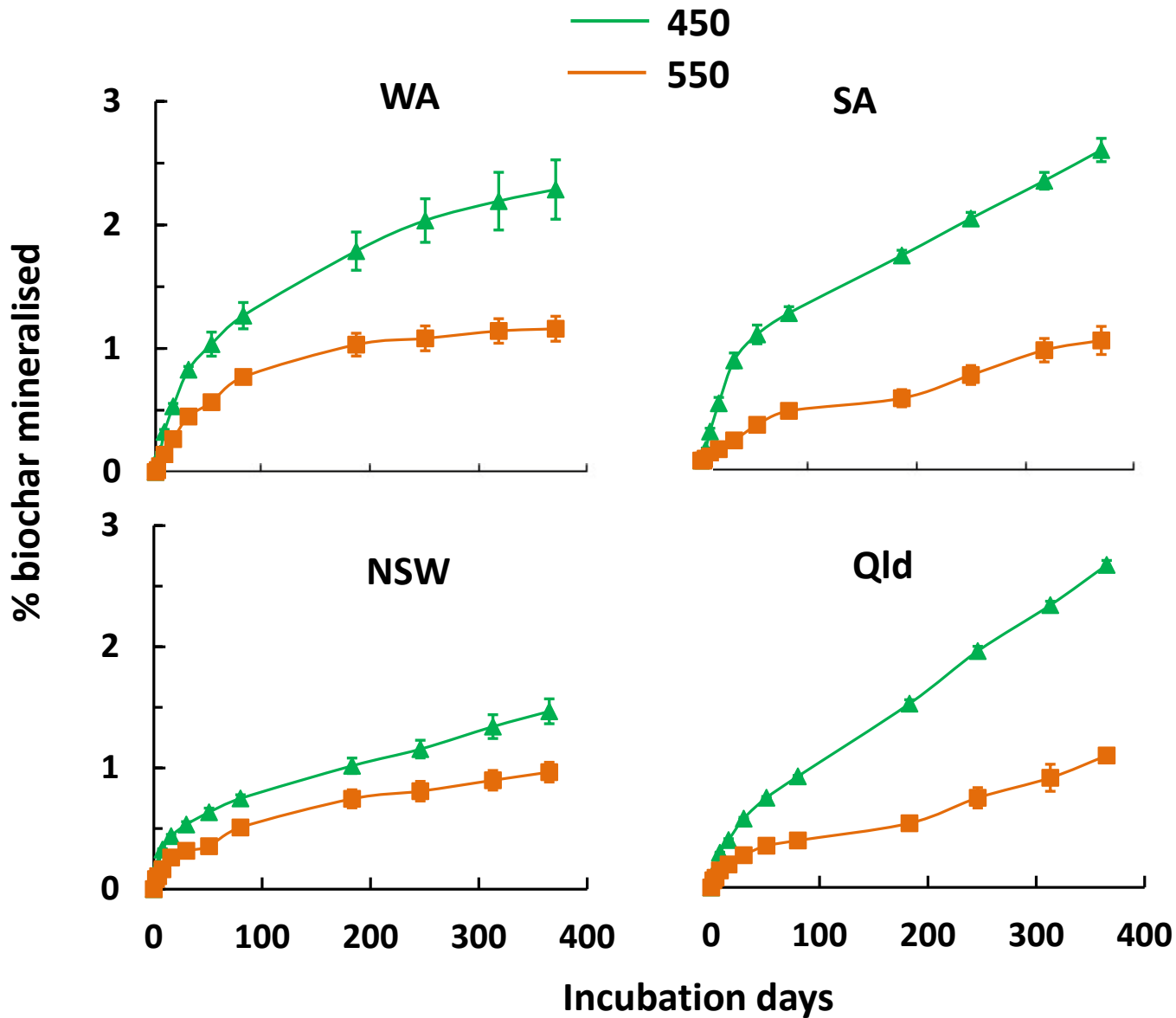


Biochar had the higher initially mineralization rate in the NSW and Qld soils at day 2, then the lowest in the NSW soil after day 4

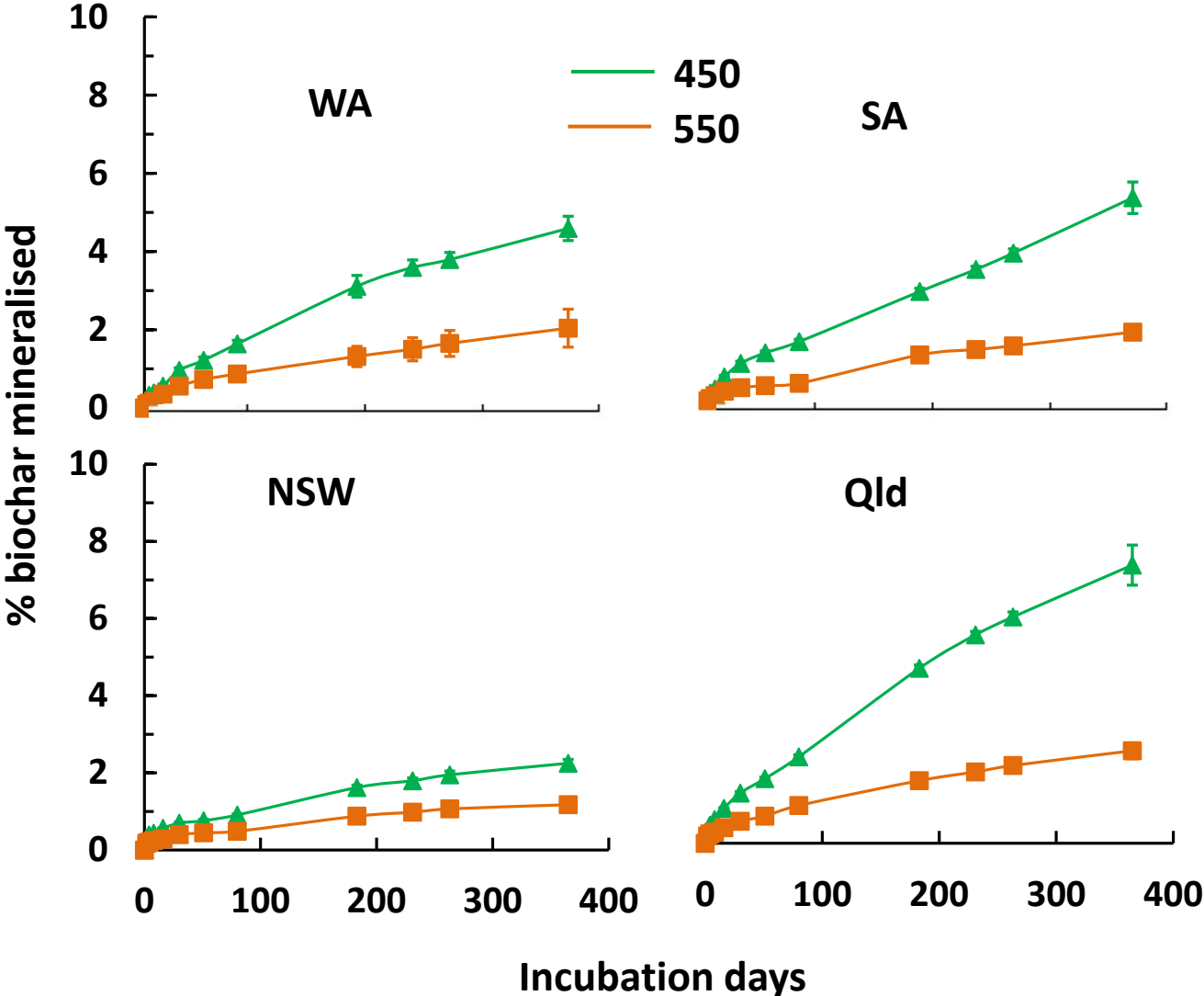
Biochar mineralised at 20°C



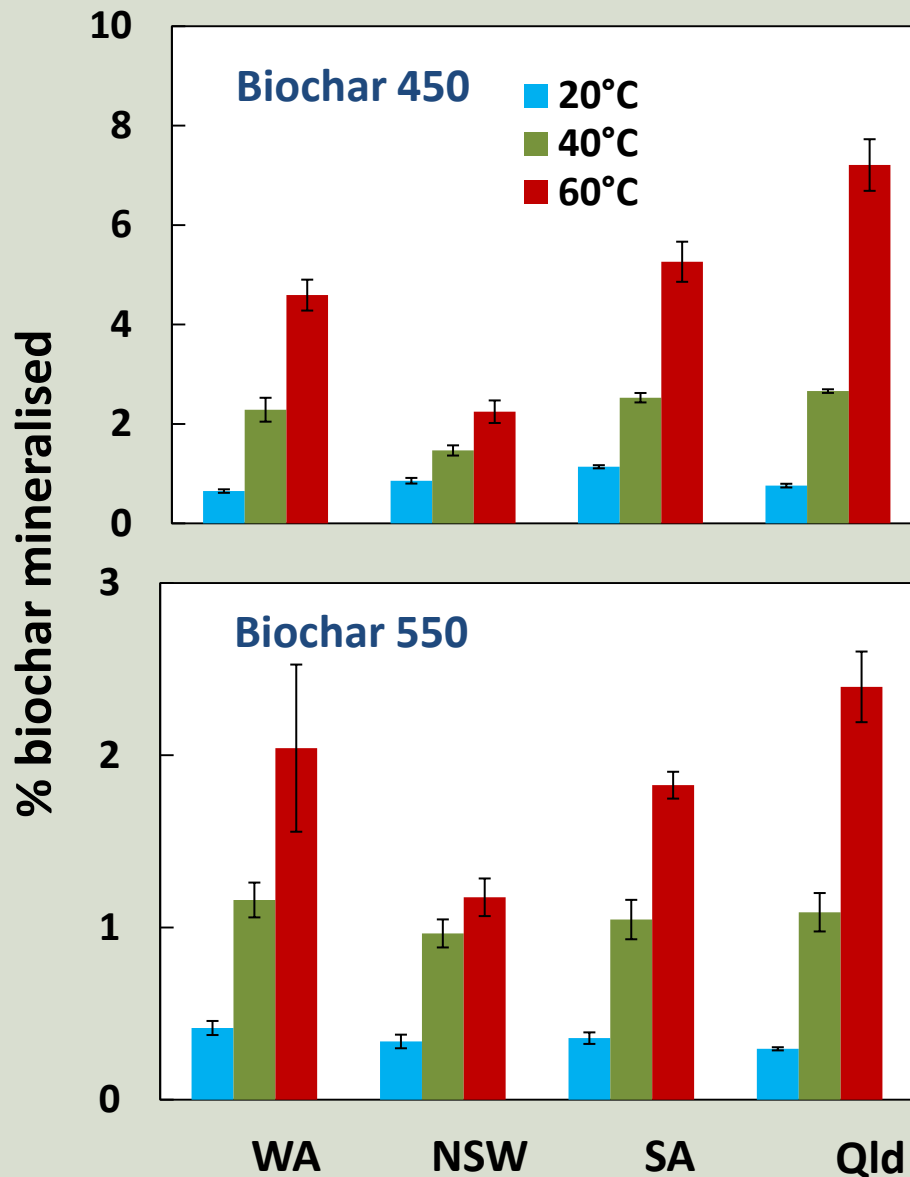
Biochar mineralised at 40°C



Biochar mineralised at 60°C

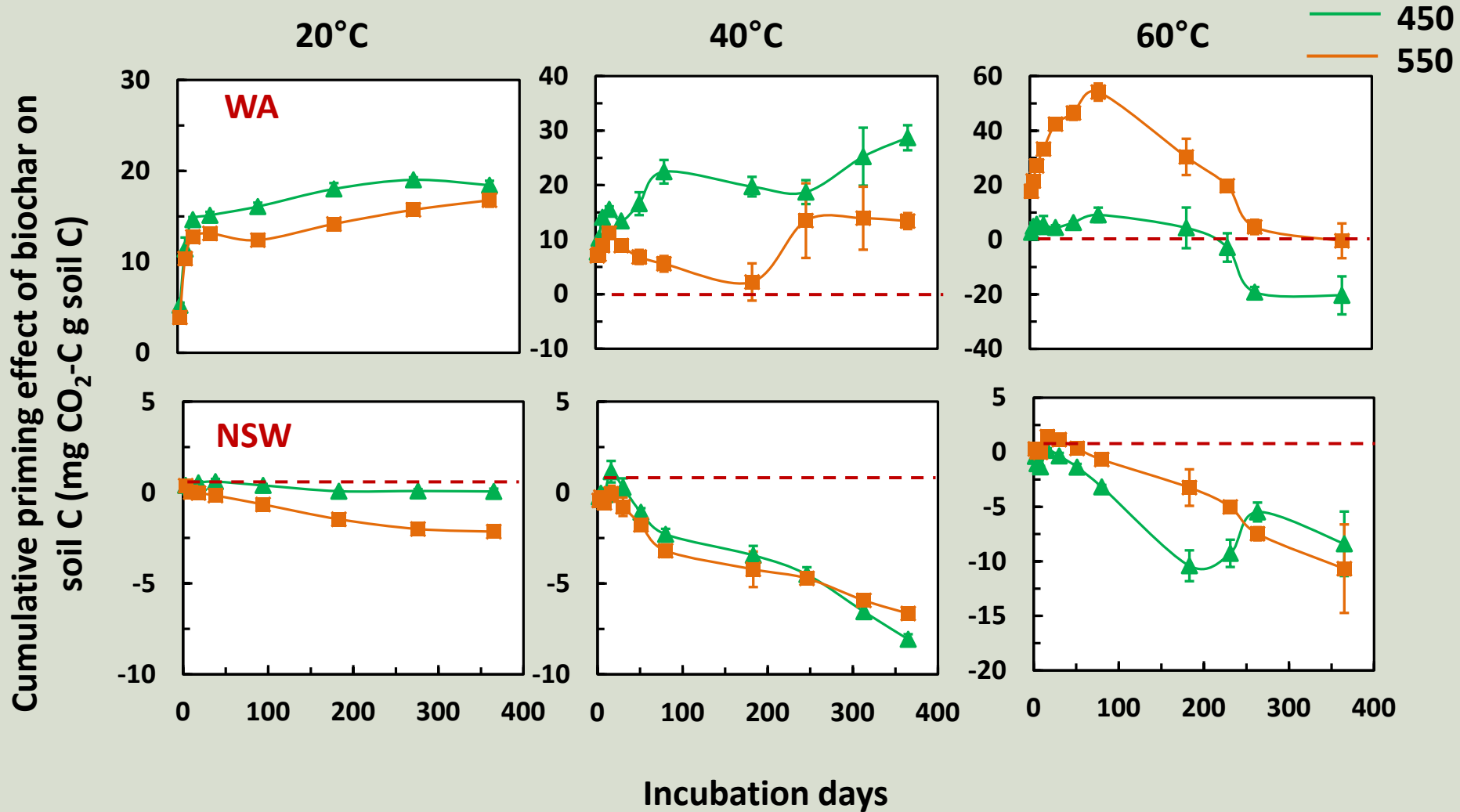


Proportion of biochar mineralised after one year

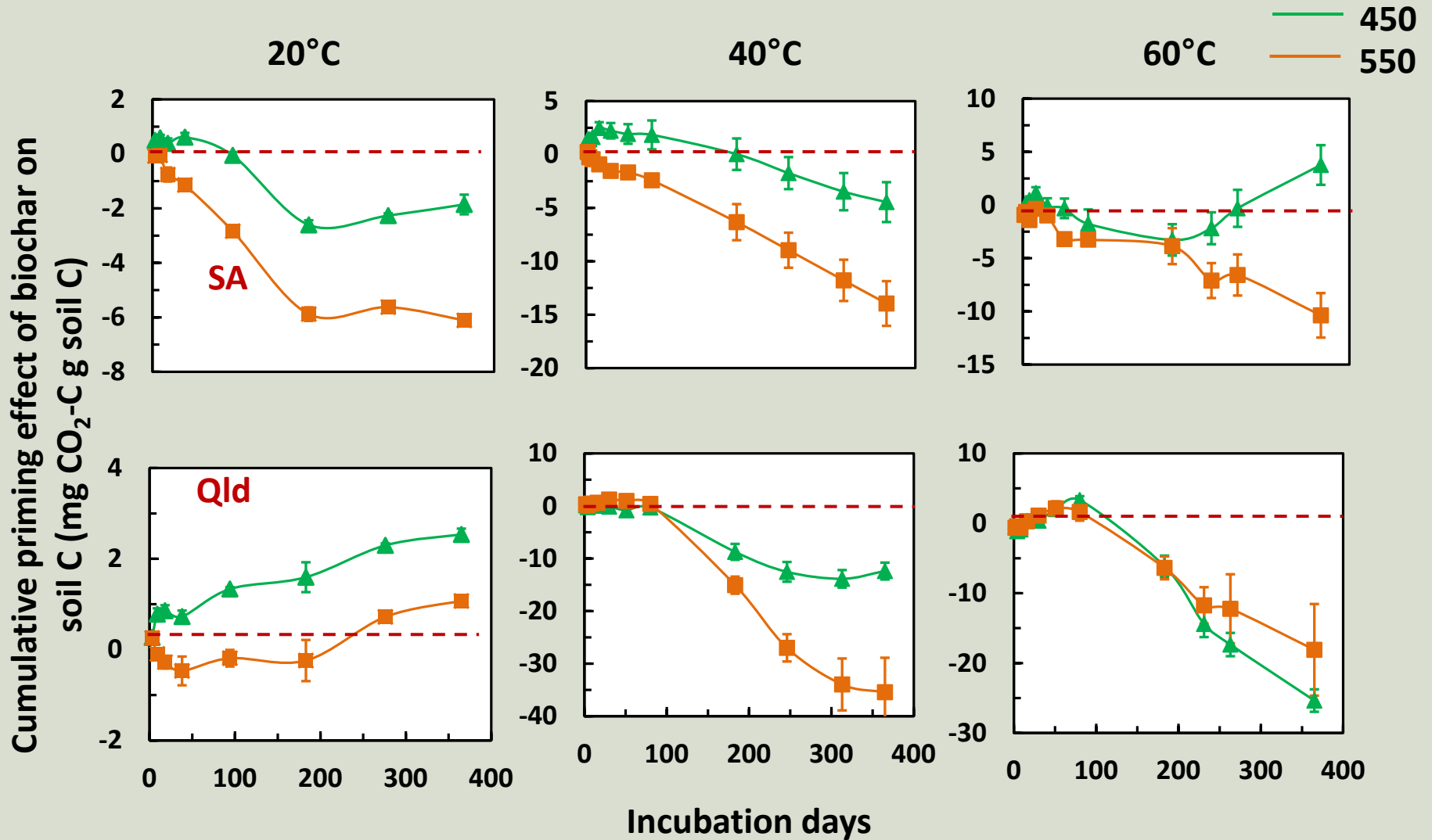


- Biochar 450°C in soils:
 - 20°C: Lowest in Qld and WA
 - 40°C: NSW
 - 60°C: NSW
- Biochar 550°C in soils:
 - 20°C: no difference
 - 40°C: no difference
 - 60°C: Lowest in NSW

Cumulative priming effect of biochar on SOM



Cumulative priming effect of biochar on SOM



Summary

- Variable proportion of biochar-C (0.3-7%) was mineralised in soils.
 - Pyrolysis temperatures: **B550 > B450**
 - Incubation temperatures : **20°C > 40°C > 60°C**
 - Soil properties
 - At 20°C: B450°C mineralisation had the lowest in the Qld and WA soils.**
 - At 40°C and 60°C: Increased stability of biochars in the NSW soil.**
- Priming effect: **positive priming effect of biochar on native SOC in the WA soil, and negative priming effect of biochar in the other soils.**

Acknowledgements

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