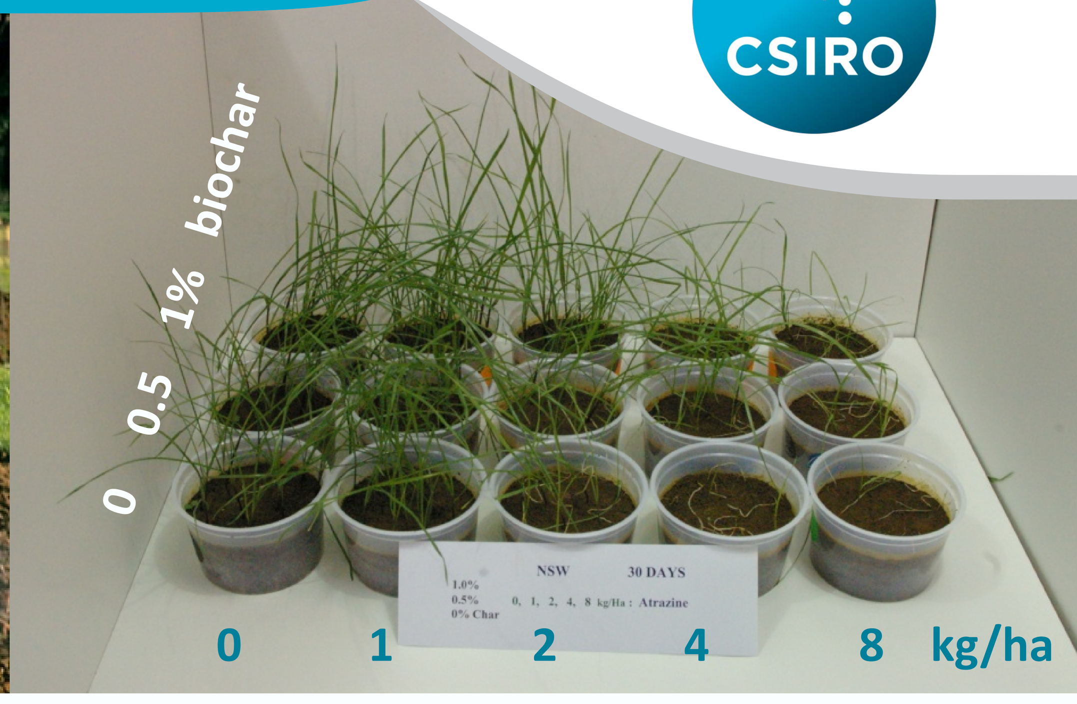
Biochar Application to Soils:
The Implications for Pesticide Fate and Efficacy

Rai S. Kookana*, S.K. Nag, X-Y Yu and G-G Ying

CSIRO LAND AND WATER, PMB 2, GLEN OSMOND, ADELAIDE, AUSTRALIA 5064
www.csiro.au



- Soil amendment with biochar is attractive for climate change mitigation and soil fertility enhancement perspectives.
- Little is understood of some of the unintended consequences of biochar addition to soil (Kookana et al. 2011).
- Some biochars have extra-ordinary capacity to bind and deactivate pesticides.
- We studied the effect of biochar addition to soil on persistence, plant uptake and efficacy of pesticides.

Experimental

- Batch sorption-desorption experiments on pesticides in soil (Alfisol) with varying amounts of biochars in soil (0-1% w/w)
- Plant uptake by spring onion (*Allium cepa*) grown in biochar-amended soil (Alfisol) and measuring pesticide residues in plant and soil.
- Glasshouse experiments to assess the efficacy of two contrasting pre-emergent herbicides (atrazine and trifluralin) for weed control in biochar (0-1%) amended soils (Ferrosol and Calcarosol).

Results and discussion

- In soils amended with biochars, pesticide sorption increased markedly and the release back in soil solution was hindered with increasing biochar contents in soil (Yu et al. 2006).
- Pesticide residues in biochar-amended soils after 30 days were higher by about 40 % than in control soil (Figure 1).
- The plant uptake of two insecticides (carbofuran and chlorpyrifos) decreased with increasing amounts of biochar in soil (Figure 2).
- Biochar amendments to soils significantly reduced the bioavailability to plants and hence the efficacy of pesticides (Figures 2 & 3).
- We found that up to 3 times higher than normal rates of herbicide application may be needed to gain an effective weed control in biochar-amended soils (Table 1).

Implications

- Pesticide applications rates may need to be increased in biochar-amended soils.
- Reduced efficacy of pesticides may facilitate the development of pest and weed resistance in biochar treated soils.
- The aging of biochar with time in soils may moderate its ability to deactivate pesticides.
- Field studies on efficacy of pesticides in biochar-amended soils are urgently needed prior to adoption of the biochar technology.

References

1. Kookana RS, A Sarmah, L Van Zwieten, E Krull and B Singh (2011). Adv. Agron. 112:104-144.
2. Nag, SK, RS Kookana, L Smith, E Krull, LM Macdonald, G Gill (2011). Chemosphere 84: 1572-1577.
3. Yu XY, GG Ying and Kookana RS (2006) J Ag Food Chem. 54: 8545-8550.
4. Yu XY, GG Ying and Kookana RS (2009) Chemosphere 76: 665-6671.

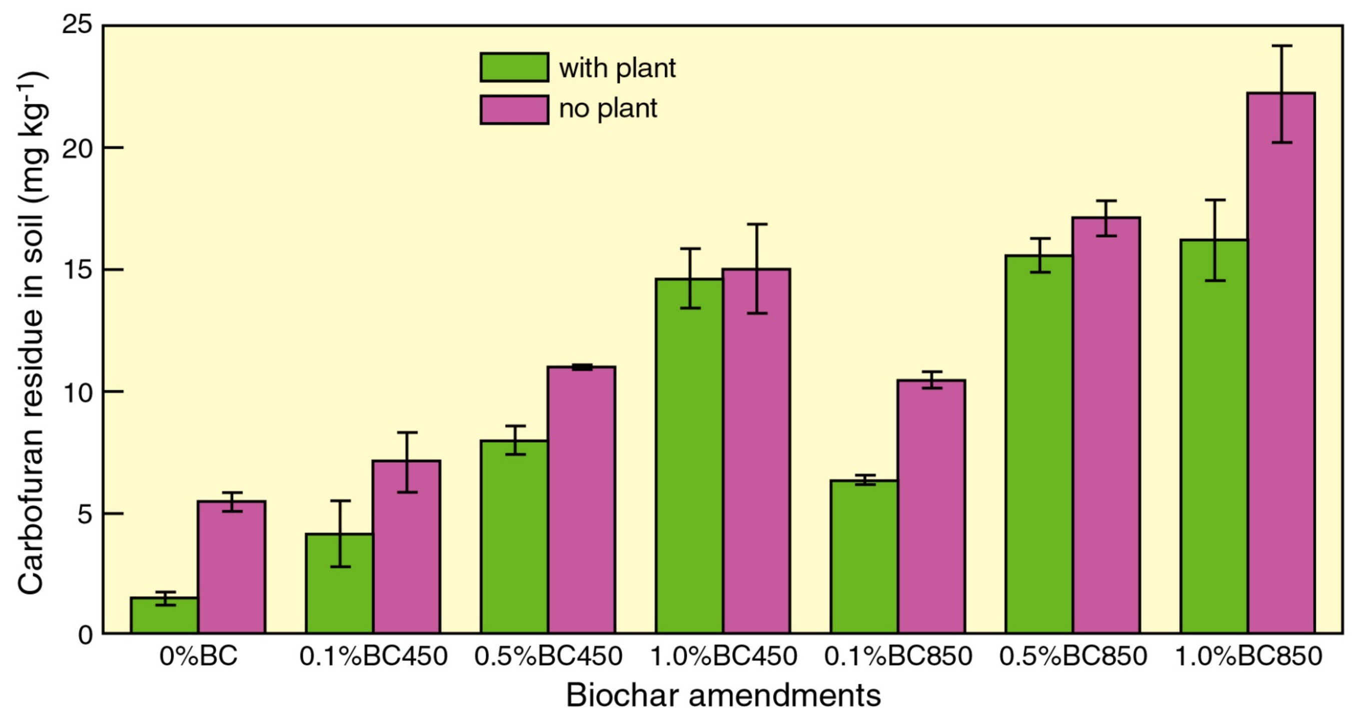


Fig 1. Carbofuran residue in soil (after 30 days) in presence of two biochars. BC450 and BC850 represent biochars produced from wood at 450 °C and 850 °C, respectively. (Yu et al. 2009).

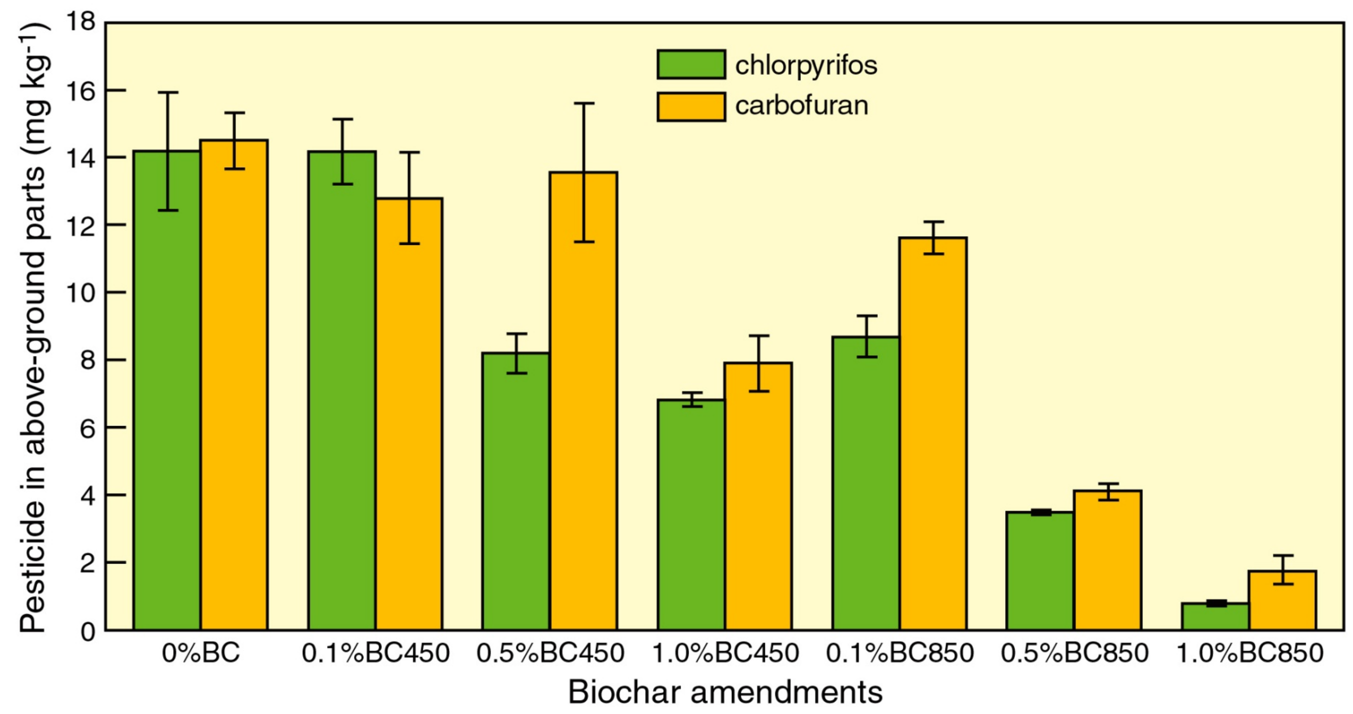


Fig 2. Pesticide residues in plants grown in soil amended with two biochars. BC450 and BC850 represent biochars produced from wood at 450 °C and 850 °C, respectively. (Yu et al. 2009).

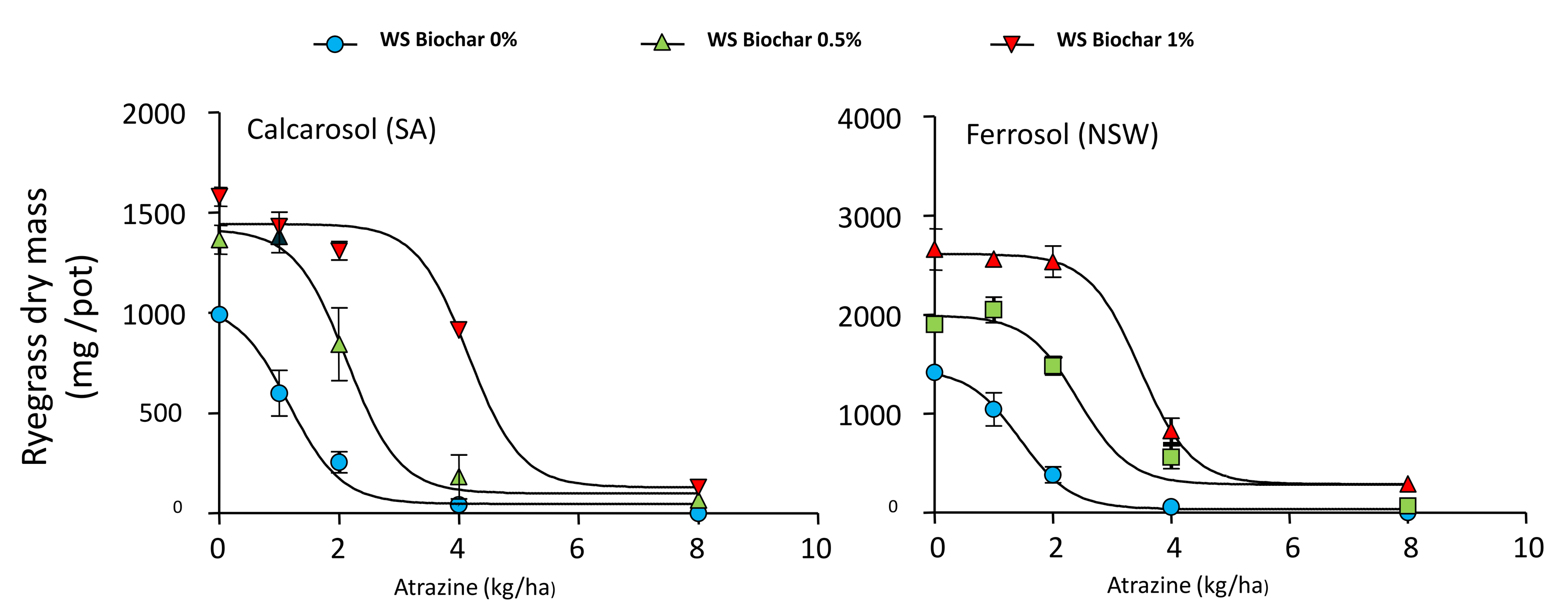


Fig 3. Dose response curves of atrazine for ryegrass weed control in two soils amended with a biochar (450 °C) , made from wheat straw (Nag et al. 2011).

Table 1. Herbicide application rates (kg/ha) needed for a 50% control of weeds in two soils amended at different rates of wheat straw biochar (450 °C).

Biochar (t/ha)	Atrazine	Atrazine	Trifluralin	Trifluralin
	Calcarosol	Ferrosol	Calcarosol	Ferrosol
0	1.17	1.45	1.36	1.00
5	2.13	2.43	1.35	1.31
10	4.16	3.48	1.48	1.59

FOR FURTHER INFORMATION

Dr. Rai Kookana
Chief Research Scientist
e Rai.Kookana@csiro.au
w www.csiro.au

ACKNOWLEDGEMENTS

This work was funded by CSIRO's Sustainable Agriculture Research Flagship and the Department of Agriculture, Forestry and Fisheries (DAFF), Government of Australia. Supports by Australian, Indian and Chinese governments for visiting fellowships to SK Nag and X-Y Yu are greatly appreciated.