A cotton farm's carbon and greenhouse footprint

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Introduction

The principal sources of greenhouse gas emissions on mixed cotton farming enterprises include CO_2 from decomposition of crop residues added to soils and native soil organic matter, and the combustion of fuels. Nitrous oxide (N_2O) with a Global Warming Potential (GWP) of 296 (i.e. one N_2O molecule is equivalent to 296 CO_2 molecules in terms of its ability to warm the atmosphere) is also produced during transformation of both mineral (fertiliser) and organic (legume) nitrogen applied to soils. The latter also includes the decomposition of crop & pasture residues.

Nitrous oxide is also produced in smaller quantities in association with atmospheric deposition of nitrogen and nitrate leaching (the latter usually restricted to irrigated soils or high rainfall regions). Where urea is applied, CO_2 is also released to the atmosphere. In the case study outlined in this paper, urea based fertilisers were not applied. If animals are included in the farming enterprise, methane emissions (CH_4) also need to be included. Methane has a GWP of 23.

Methodology

The Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks 2006 – Agriculture; and the Factors and Methods Workbook (2007) are produced by the Department of Climate Change (DCC), (formerly known as the Australian Greenhouse Office). These documents are the primary sources for calculations and emission factors used in Australia. These documents have been developed in accordance with the 2006 IPCC (Intergovernmental Panel on Climate Change) Guidelines for Greenhouse Gas Inventories.

The majority of emissions in this case study were estimated using these inventory methods, except for the emissions of CO_2 released from agricultural top soils (0-30 cm) (which been calculated using the SOCRATES simulation model) and tree carbon sequestration (if applicable). Estimates of soil C change using SOCRATES (Grace et al., 2006) are compatible with estimates of soil carbon change provided by the Roth C model which underpins the Australian National Carbon Accounting System (NCAS).

A per annum average change in soil carbon during a 10 year rotation is presented (Table 1). For irrigated systems, a cotton-sorghum-cotton-sorghum-fallow rotation was employed. For dryland systems, a continuous summer sorghum crop was simulated. The SOCRATES model provides a more detailed assessment of soil carbon change than would be possible using the current Australian or IPCC Tier 1 methodologies.

During the past 4 years, the Cotton Research and Development Corporation, along with the DCC, have funded extensive research in the production of greenhouse gas emissions from soils under cotton, particularly N_2O which has definitive information for producing accurate greenhouse gas inventories.

All emissions (CO_2, CH_4 (methane) and N_2O) are expressed are CO_2 equivalents – CO_2(e), an internationally recognised single “currency” to be used in development of inventories and emissions reduction strategies. Methane emissions from cotton soils are not common, however data is currently being collected in cotton systems to confirm the role of CH_4.

Results

The emissions outlined in the inventory table are for a 416 ha Darling Downs farm and its particular mix of farming activities, in this case the inclusion of animals. Additional sources of emissions may need to be included for other enterprises, e.g. CO_2 from urea based fertilisers, N_2O from manure applications. On-line greenhouse gas inventory tools for both cotton and mixed farming enterprises are available on line at www.isr.qut.edu.au

In calculating direct emissions of N_2O from fertiliser applied to cotton growing soils, we have used the new Australia emission factor of 0.5%, which has been recommended by the DCC. This replaces the more commonly used default value of 1.25% of N lost as N_2O. The reduced emission value for cotton systems has been approved by the DCC as a direct result of data produced in the CRDC greenhouse gas experimental program and if confirmed through continued experimentation, will have a significant (beneficial) impact on the carbon footprint of a cotton farming enterprise.

The SOCRATES simulations suggest that carbon in the topsoil of the dryland cropping system is declining under conventional tillage. Annual CO_2 emissions from the irrigated soils are higher due to the accelerated decomposition (as a result of increased water availability during the season) and soil C under pastures is relatively unchanged. Annual emissions may be less than specified as the simulation of irrigated cotton system still has a number of uncertainities.

Nitrous oxide emissions from the management of the pasture system are also dependent on management (removal) of residues.

Table. 1 Estimated Annual Greenhouse Gas Emissions – Darling Downs, Qld

Category	Source	CO_2(e) (kg/ha)	Area (hectares)	Total CO_2(e) (tonnes)
Residue N_2O[a]	Pastures	0	100	0
	Dryland	94	100	8.9
	Irrigated cereal	199	100	19.0
	Irrigated cotton	112	100	7.1
Other N_2O	Atmos. Deposit			12.3
	Leaching			3.5
	Urine and faeces			12.6
Fertiliser N_2O	Direct loss[b]			61.0
Soil CO_2[c]	Dryland	191	100	8.2
	Irrigated	676	200	58.2
Fuel/power CO_2[d]	Electricity			0.2
	Petrol			10.8
	Diesel			106.4
CH_4	Animals			138.0
Sinks CO_2[e]	Trees	-1958	12	-47
TOTAL[f]				**399.5**

[a]N_2O produced on decomposition of organic materials (e.g. crop residues).

[b]2.5 tonnes N applied per annum. If the default emission value of 1.25% is used, an additional 92 tonnes CO_2(e) is emitted.

[c]If urea based fertilisers were used, an additional 40 tonnes CO_2(e) is emitted per annum.

[d]Electricity consumption emissions do not include power plant generation emissions.

[e]Negative value indicates carbon sequestration.

[f]For comparison average urban residential emissions = 40 tonnes CO_2/annum