Supplementary Materials

10.1071/CP15260_AC
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Supplementary Material: *Crop & Pasture Science*, 2016, 67(8), 812–822.

Cradle-to-farmgate greenhouse gas emissions for 2-year wheat monoculture and break crop–wheat sequences in south-eastern Australia

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Supplementary Table 1. Greenhouse gas emissions (kg CO_2-e/ha and kg CO_2-e/t grain) for canola in the grains region of south-eastern New South Wales

Grain yield of canola was 2 t/ha, grown after wheat in the previous season

	inputs/ha	CO_2-e kg/ha	CO_2-e kg/t	%
Pre-farm				
Production of urea (46% N)	185 kg	121.08	60.54	14.4
Production of MAP (10% N, 21.9% P)	150 kg	129.11	64.55	15.3
Mining of lime, 95% purity	263 kg	10.94	5.47	1.3
Production of glyphosate 450 g/L	4.25 L	20.81	10.40	2.5
Production of surfactant 1000 g/L	460 g	0.89	0.45	0.1
Production of other herbicides and pesticides[1]		9.48	4.74	1.1
Transport urea	0.185 tkm	8.78	4.39	1.0
Transport MAP	0.15 tkm	7.12	3.56	0.8
Transport pre-crop (7.21 kg) and in-crop (0.74 kg) herbicides and pesticides	0.00795 tkm	0.39	0.19	<0.1
Transport lime	0.263 tkm	9.21	4.61	1.0
Production and transport of diesel		13.19	6.60	1.6
Canola seed purchased	3 kg	1.99	1.00	0.2
Embodied energy for tractors and other machinery[2]	0.00293 t	10.8	5.4	1.3
Pre-farm subtotal		344	172	41
On-farm				
Background soil N_2O emissions	0.251 kg	74.86	37.43	8.9
N_2O emissions directly from urea	0.267 kg	79.6	39.80	9.5
N_2O emissions directly from MAP	0.047 kg	14.00	7.00	1.7
N_2O emissions indirectly from urea	0.027 kg	8.05	4.03	1.0
N_2O emissions indirectly from MAP	0.005 kg	1.40	0.70	0.2
CO_2 emissions from urea	136 kg	135.66	67.83	16.1

CO_2 emissions from lime	104 kg	104.50	52.25	12.4
N_2O emissions from burning 10% residues	0.00044 kg	0.13	0.07	<0.1
CH_4 emissions from burning 10% residues	0.0215 kg	0.54	0.27	0.1
Combustion of tractor and equipment diesel[3]	0.25–6.12 L	78.61	39.31	9.3
On-farm subtotal		497	249	59
Total pre-farm + on-farm emissions		841	421	100

[1] Production of other herbicides and pesticides: triclopyr herbicide 600 g/L, applied @ 120 mL/ha; solvent for triclopyr (DGME), applied @ 24 g/ha; trifluralin 480 g/kg, applied @ 1.8 L/ha; aromatic solvent for trifluralin 560 g/l, applied @ 1.0 kg/ha; haloxyfop 520 g/l, applied @ 100 mL/ha; DGME solvent for haloxyfop (45%), applied @ 45 mL/ha; clopyralid 500 g/L, applied @ 300 mL/ha; surfactant 1000 g/L used with haloxyfop and clopyralid, applied @ 200 g/ha; fungicides: J 167 g/L, G 600 g/L, applied @ J 60 mL/ha and G 12 mL/ha; glycerine for fungicide G at 124g/L fungicide, applied @ 1.49 g/ha; insecticide 250 g/L, applied @ 30 mL/ha; solvents for fungicides and insecticide, applied @ 27.1 g/ha.

[2] Embodied energy of 57 kW tractor and sprayer, used for 3 runs during pre-crop fallow and for 2 runs in-crop depreciated over 10 years across 2000 ha/year, plus embodied energy of 135 kW tractor and 4 t lime spreader, used during pre-crop fallow once in 10 years across 2000 ha, plus embodied energy of windrower, harvester and 135 Kw tractor with air seeder, grain bin depreciated over 10 years, or fertiliser spreader over 5 years, all used in-crop across 2000 ha/year.

[3] Included 5 runs spraying, 3 pre-crop and 2 in-crop @ 4.5 L/ha, lime spreading (pre-crop) @ 0.25 L/ha, sowing @ 6.12 L/ha, in-crop fertiliser spreading @ 6.1 L/ha, harvesting @ 6.02 L/ha and grain collection @ 1.8 L/ha.

Supplementary Table 2. Greenhouse gas emissions (kg CO_2-e/ha and kg CO_2-e/t grain) for field pea in the grains region of south-eastern New South Wales

Grain yield of field pea was 1.8 t/ha, grown after wheat in the previous season

	inputs/ha	CO_2-e kg/ha	CO_2-e kg/t	%
Pre-farm				
Production of MAP (10% N, 21.9% P)	100 kg	86.07	47.82	16.3
Mining of lime, 95% purity	263 kg	10.94	6.08	2.1
Production of glyphosate 450 g/L	4.25 L	20.81	11.56	3.9
Production of surfactant 1000 g/L	460 g	0.89	0.50	0.2
Production of other herbicides and pesticides[1]		16.78	9.32	3.1
Production of inoculum	405 g	<0.01	<0.01	<0.01
Transport MAP	0.10 tkm	4.75	2.64	0.9
Transport pre-crop and in-crop herbicides, pesticides and inoculum (kg)	0.0115 tkm	0.57	0.33	0.1
Transport lime	0.263 tkm	9.21	5.12	1.7
Production and transport of diesel emissions)		10.90	6.05	2.0
Pea seed grown	90 kg	32.57	18.10	6.2
Embodied energy for tractors and other machinery[2]	0.002987 t	10.98	6.10	2.2
Pre-farm subtotal		204	114	39
On-farm				
Background soil N_2O emissions	0.251 kg	74.86	41.6	14.0
N_2O emissions directly from MAP	0.031 kg	9.29	5.13	1.7
N_2O emissions indirectly from MAP	0.003 kg	0.89	0.50	0.2
N_2O emissions from field pea residues	0.235 kg	70.18	39.0	13.1
CO_2 emissions from lime	104 kg	104.50	58.05	19.5
Combustion of tractor and equipment	0.25–6.12 L	65.30	36.28	12.2

diesel[3]			
On-farm subtotal	325	181	61
Total pre-farm + on-farm emissions	530	294	100

[1] Production of other herbicides and pesticides: triclopyr herbicide 600 g/L, applied @ 120 mL/ha; solvent for triclopyr (DGME), applied @ 24 g/ha; pendimethalin 330 g/L, applied @ 2.5 L/ha; aromatic solvent for pendimethalin 578 g/L, applied @ 1.445 kg/ha; haloxyfop 520 g/l, applied @ 100 mL/ha; DGME solvent for haloxyfop (45%), applied @ 45 mL/ha; Metribuz (Sencor), applied @ 0.4 L/ha; Uptake paraffinic oil 66% used at 0.5 L/ha, applied @ 290 g/ha; Pnonionic surfactant 34% in Uptake at 0.5 L/ha, applied @ 120 g/ha; alpha-cypermethrin 100 g/L, applied @ 160 mL/ha; aromatic solvent for alpha-cypermethrin (741.9 g/L), applied @ 119 g/ha; surfactant 1000 g/L used with alpha-cypermethrin, applied @ 4 g/ha; lambda-cyhalothrin 9.6% w/w, applied @ 36 mL/ha; aromatic solvents for lambda-cyhalothrin (320 g/L), applied @ 12.4 g/ha; diquat dessicant 200 g/L, applied @ 2.25 l/ha.

[2] Embodied energy of 57 kW tractor and sprayer, used for 3 runs during pre-crop fallow and for 5 runs in-crop depreciated over 10 years across 2000 ha/year, plus embodied energy of 135 kW tractor and 4 t lime spreader, used during pre-crop fallow once in 10 years across 2000 ha, plus embodied energy of harvester and 135 Kw tractor with air seeder, grain bin depreciated over 10 years, or fertiliser spreader over 5 years, all used in-crop across 2000 ha/year.

[3] Included 8 runs spraying, 3 pre-crop and 5 in-crop @ 4.5 L/ha, lime spreading (pre-crop) @ 0.25 L/ha, sowing @ 6.12 L/ha, harvesting @ 4.02 L/ha and grain collection @ 1.2 L/ha.