Potato Scenario Description March 2006

At the Vienna EMRAS conference in the fall of 2005, it was decided to initiate a scenario for C-14 transfer in crops based on unpublished data contained in a thesis from Imperial College. The crops investigated were cabbage, beans and potatoes. We decided to start the scenario with potatoes because they are widely used.

Experimental conditions

Approximately two hundred potato tubers (*Solanum tuberosum* cv. Romano) were placed in dark storage on July 5 1995 and left to chit (sprout). Some tubers were split to produce sufficient plants to transfer three to each of one hundred pots on August 4 1995. Some of the plants were later thinned to two per pot. The pots had dimensions 40x40x40 cm and each was filled with Fison's Levington multi-purpose peat-based compost. The plants were cultivated in a walled garden at Imperial College.

The crops were exposed to ${}^{14}\text{CO}_2$ in the MAFF/CARE wind tunnel. This allowed the exposure to take place under realistic atmospheric boundary layer conditions, while providing adequate containment for the ${}^{14}\text{CO}_2$. The experimental layout is shown in Figure 1, where each pot contains four plants, as in experiments with cabbage and beans. In the potato experiment only 2-3 plants per pot were used.

The wind tunnel has the capacity to accommodate thirty pots. Twenty of these constitute the 'fetch' of the canopy and facilitate the build up of a turbulent boundary layer. The remaining ten pots provided the plant material to be sampled as part of the experiment, enabling a maximum of thirty potato plants to be sampled for each exposure (but generally 20 plants in the later development stage).

The potato plants were fumigated with ${}^{14}\text{CO}_2$ for approximately 10 hours within the wind tunnel at six stages (P1 – P6) of the crop's growth cycle. The schedule of fumigations is summarized in Table 1, which shows the number of days after sowing at which fumigation occurred (stage of development) and the fumigation date. The date of chitting of this crop was 5th July 1995 and the planting date was 4th August 1995. Following fumigation, samples were taken immediately to measure the activity concentration of ${}^{14}\text{C}$ fixed by the crop (harvest H1) and the plants were moved outside to the garden. Subsequent samples (H2 to H6) were taken at intervals that varied in number and frequency according to the age of the crop at fumigation, as given in Table 2.



Figure 1: Experimental canopy in wind tunnel side elevation (a) and plan view (b)

The air activity concentration for each exposure period was calculated as the total activity absorbed in the trapping solution divided by the total volume of air sampled. The air profiles presented in Figure 2 are plots of average air activity concentration during the sampling period plotted at the mid point of the sampling period for each of the exposure

experiments. These concentrations are given numerically in Table 3, and C-14 integrated air concentrations are given in Table 4. The ranges of temperature and photosynthetically active radiation (PAR) in the tunnel during each experiment are given in Table 5. The canopy was illuminated with a bank of six 450 W agricultural lights set to a sixteen-hour photoperiod. The temperature in the tunnel increased with time during the fumigation (Table 5) and the relative humidity increased by about 10%, with an average value of 55%. The average illumination was quite constant in P2-P5, and decreased slightly with time for P1 and P6. The illumination was not uniform on all plants and the range in Table 5 must be considered. The plants were under no water stress.

In experiment P1, 30 plants were used in the 10 sampling pots; 25 plants were used in P2 and 20 (2 per pot) in the rest of the fumigations.



Figure 2: C-14 activity concentrations in air in the wind tunnel during exposure

Code Nº of Experiment	Time of Fumigation	Fumigation date
	(Days after sowing)	(d/m/y)
P1	21	25/8/95
P2	33	7/9/95
P3	47	21/9/95
P4	61	5/10/95
P5	74	18/10/95
P6	89	2/11/95

Table 1: Fumigation schedule for experiments in which potato plants were exposed to $^{14}\mathrm{CO}_2$

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	Experiment											
Harvest	P1		P1 P2 P3		P4		P5		P6			
	Age [*]	T**	Age	Т	Age	Т	Age	Т	Age	Т	Age	Т
H1	21	0	33	0	47	0	61	0	74	0	89	0
H2	31	10	38	5	53	6	65	4	79	5	90	1
H3	38	17	44	11	58	11	72	11	83	9	93	4
H4	48	27	58	25	68	21	83	22	87	13	95	6
H5	72	51	79	46	83	36	90	29	93	19	97	8
H6	97	76	97	64	97	50	97	36	100	26	100	11

* days after exposure

Table 3: C-14 air concentration a	above the	potatoes
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	P1		P2		P3		P4	P5		P6	
Time	Air										
(min)	Conc										
	(Bq/m3)										
32	65121	32	47090	31	68339	31	55009	30	57453	30	30450
99	43715	99	29804	100	42376	98	34387	97	36612	96	21067
166	21521	166	16279	167	24373	165	18999	163	19576	162	12966
233	12095	233	8297	236	11749	230	10269	236	9906	228	7152
300	6577	301	4405	303	6361	294	5774	304	5028	295	4086
368	3667	369	2490	371	2983	360.5	3359	370	2858	361	2461
435	2325	438	1393	438	1827	430.5	1686	436	1646	426	1452
501	1460	505	801	504	839	496.5	985	501	954	492	900
569	701	570	565	570	694	567	651	568.5	607	566	507

Table 4: C-14 integrated air concentration (IAC)

Experiment	IAC
	MBq m ⁻³ min
P1	9.764
P2	6.983
P3	9.647
P4	8.089
P5	8.307
P6	4.774

Table 5: Range of temperature (T) (°C) and PAR (W/m²) during fumigation

Experiment	Tmin	Tmax	PARmin	PARmax
P1	23	27	70	150
P2	21	26	50	160
P3	20	23	40	160
P4	19	24	30	130
P5	19	23	30	130
P6	17	20	30	130

Biomass dynamics

The average dry weight of the roots, leaves, stems and tubers, together with standard deviations (based on 2-6 plants), in all experiments for every harvest time are given in Table 6 and Figure 4. The development of leaf area index (LAI) is given in Figure 3. The dry weight fractions for each harvest are given in Table 7.



Figure 3: Leaf area index development for potatoes, beans, cabbage

P1									
	Age	LEAVES	STDEV	STEMS	STDEV	ROOTS	STDEV	TUBERS	STDEV
H1	21	3.2	2.3	1.7	1	7.7	4.4	-	-
H2	31	10	8.4	7.5	7.1	1.3	1.1	-	-
H3	38	7	1.2	9.6	2.2	1.8	1.3	0.3	0
H4	48	15.5	9.4	15.5	8.6	2.7	1.4	11	8.3
H5	72	9.4	8.8	11.3	6	1.4	1.4	40.7	32.6
H6	97	6.8	8.3	14.7	6.1	1.3	1	78.3	87.2
P2									
H1	33	11.2	5.1	11.9	4.7	2.9	1.5	-	-
H2	38	5.4	2.9	8	4.5	1.1	0.6	-	-
H3	44	6.5	4.6	10.9	5.6	1.9	1.1	3.8	0.7
H4	58	15.6	1.6	18.4	3	3.4	1.7	12.5	3
H5	79	15.4	15.7	14.7	8.8	1.3	1.2	45.3	47.5
H6	97	5	4.8	7.1	2.4	0.9	0.4	30.2	8.7
P3									
H1	47	7.84	2.86	12.15	5.02	3.42	1.75	9.78	7.22
H2	53	12.77	4.9	11.98	5.08	2.76	1	13.29	11.2
H3	58	6.73	5.19	9.37	6.08	1.41	0.37	13.38	4.02
H4	68	6.33	5.38	11.95	9.77	1.59	0.91	16.34	12.73
H5	83	5.81	5.71	12.23	2.89	2.11	1.46	50.31	41.86
H6	97	2.74	1.75	8.66	0.54	0.7	0.08	46.46	19.1
F									
P4					1	r			1
H1	61	15.53	7.05	22.62	9.39	2.71	1.55	27.59	27.76
H2	65	12.07	8.38	9.12	5.25	2.66	0.62	42.27	20.06
H3	72	4.42	2.42	7.93	4.1	1.02	0.76	24.53	12.11
H4	83	3.08	2.18	9.51	5.85	0.76	0.55	32.33	18.72
H5	90	7.72	8.1	16.29	19.02	1.45	0.35	35.67	10.73
H6	97	0.56	0.13	47.35	1.85	0.51	0.66	49.99	2.21
P5		1							
H1	74	6	2.4	8.8	4.7	1.5	0.9	38.1	17.8
H2	79	4.2	2.2	8.2	2.6	0.7	0.3	24.3	18.9
H3	83	2.6	2.7	6.5	1.3	1.1	0.7	49.3	54.6
H4	87	4.3	2.4	8.2	2.1	1.6	0.6	75.8	25.8
H5	93	5.1	1.7	15.6	11.3	1.3	1	49.1	30.3
H6	100	2.2	1.9	14.7	2.6	1.6	0.8	76.9	6
P6					r	r		1	r
H1	89	6.21	6.76	14.03	14.9	0.99	0.36	36.66	14.17
H2	90	5.38	4.92	9.02	3.98	1.27	0.61	70.34	24.97
H3	93	6.9	4.96	17.02	7.57	0.69	0.44	48.18	9.43
H4	95	10.89	5.53	17.34	3.99	2.16	0.33	121.68	52.71
H5	97	7.52	8.28	17.08	10.93	1.18	1.47	77.58	68.4
H6	100	3.24	0.45	7.17	0.45	0.23	0.05	40.39	35.06

Table 6: Biomass dynamics for potatoes



Figure 4: Dry weights of potato leaves (a), stems (b), roots (c), tubers (d)

P1	Dry weight fraction							
	Age	leaves	stems	roots	tubers			
H1	21	0.06	0.02	0.07	-			
H2	31	0.09	0.03	0.05	-			
H3	38	0.06	0.04	0.07	0.12			
H4	48	0.07	0.04	0.08	0.12			
H5	72	0.08	0.04	0.07	0.16			
H6	97	0.12	0.1	0.09	0.22			
P2								
H1	33	0.08	0.04	0.08	-			
H2	38	0.05	0.03	0.06	-			
H3	44	0.06	0.04	0.06	0.31			
H4	58	0.09	0.05	0.08	0.15			
H5	79	0.09	0.05	0.06	0.18			
H6	97	0.07	0.06	0.06	0.17			
P3								
H1	47	0.06	0.05	0.08	0.13			
H2	53	0.08	0.03	0.07	0.13			
H3	58	0.09	0.04	0.05	0.13			
H4	68	0.08	0.04	0.06	0.15			
H5	83	0.09	0.05	0.06	0.17			
H6	97	0.13	0.13	0.07	0.18			
P4								
H1	61	0.08	0.04	0.07	0.15			
H2	65	0.07	0.02	0.06	0.16			
H3	72	0.09	0.05	0.07	0.18			
H4	83	0.08	0.06	0.05	0.19			
H5	90	0.17	0.07	0.06	0.16			
H6	97	0.25	0.6	0.07	0.2			
P5								
H1	74	0.08	0.04	0.05	0.18			
H2	79	0.1	0.05	0.06	0.2			
H3	83	0.14	0.04	0.07	0.18			
H4	87	0.15	0.04	0.06	0.17			
H5	93	0.16	0.08	0.08	0.19			
H6	100	0.08	0.07	0.08	0.15			
P6	1	1						
H1	89	0.14	0.06	0.07	0.17			
H2	90	0.12	0.04	0.06	0.18			
H3	93	0.41	0.07	0.06	0.19			
H4	95	0.47	0.08	0.07	0.28			
H5	97	0.6	0.13	0.09	0.21			
H6	100	0.7	0.17	0.1	0.19			

Table 7: Dry weight fractions

Calculation Endpoints:

Modelers are asked to calculate the following:

- 1) the carbon concentration in the leaves at each sampling time (H1 to H6) for each experiment (P1 to P6) [Bq/gdm];
- 2) the carbon concentration in the tubers at final harvest (H6) for each experiment [Bq/gdm];
- 3) 95% confidence intervals on all predictions.

The Modelers are also asked to supply a fully documented model description following the EMRAS template.