TEMPERATURE EFFECT ON CARBON BIOMASS IN SOILS FROM TROPICAL AND TEMPERATE REGIONS

C.A.Vasconcellos
CNPMS-Embrapa, C. P. 151, CEP: 35701-970 - Sete Lagoas, MG.

ABSTRACT: Four soils from various origins, (tropical and temperate regions) were amended with ^{14}C labelled glucose (1mg C.g^{-1} soil) and incubated at 15°C and 35°C to determine the temperature effect on the carbon turnover and on the microbial biomass. The temperature effect on the biomass increased with the glucose addition. The biomass mineralization rates were higher at 35°C than at 15°C and higher for Woburn and Pegwell soils (temperate region) than for Capinopolis and Janauba (tropical region). Specific respiration rate (SRR) of new biomass (from glucose) and old biomass showed different behaviors between soils. At 15°C, the turnover C was 207, 225, 115 and 141 days for Janauba, Capinopolis, Woburn and Pegwell soil, respectively. At 35°C, it was 92, 69, 69 and 33 days for the same soils. The residual ^{14}C in the soil was higher at 35°C. The final total biomasses at 15°C and 35°C were correlated with the initial soil carbon content. There was an average of 31 and 8 mg of biomass C.g^{-1} soil organic carbon, respectively at 15°C and 35°C. The initial carbon content was an important factor to explain the mineralization rate at 35°C.
Key Words: carbon biomass, organic carbon, soil, temperature, turnover

EFEITO DA TEMPERATURA SOBRE A BIOMASSA CARBONO EM SOLOS DE REGIÃO TROPICAL E TEMPERADA

RESUMO: Quatro solos de várias origens, (clima tropical e temperado), receberam glucose marcada com ^{14}C, na proporção de 1mg de C.g^{-1} de solo e foram incubados a 15°C e a 35°C com o objetivo de determinar o efeito da temperatura sobre a reciclagem do carbono orgânico e da biomassa microbiana do solo. O efeito da temperatura na biomassa e na taxa de mineralização foi mais evidente a 35°C de incubação. A 35°C, os solos Woburn e Pegwell, da região temperada, apresentaram uma taxa de mineralização maior do que a dos solos de Janaúba e Capinópolis, de região tropical. A taxa de respiração específica da biomassa formada pela adição da glucose e da biomassa antiga demonstrou comportamento diferencial entre solos. A 15°C a reciclagem do carbono foi de 207, 225, 115 e 141 dias para Janaúba, Capinópolis, Woburn e Pegwell, respectivamente. A 35°C, foi de 92, 69, 69 e 33 dias para os mesmos solos. O ^{14}C residual foi maior a 35°C. A quantidade de biomassa final a 15°C e a 35°C foi correlacionada com o teor de carbono inicial do solo. Houve uma média de 31 e 8 mg de biomassa C.g^{-1} de carbono orgânico, respectivamente a 15°C e a 35°C. O teor de carbono inicial foi um fator importante para explicar a taxa de mineralização a 35°C.
Descritores: biomassa carbono, carbono orgânico, solo, temperatura, reciclagem

INTRODUCTION

Soil microbial biomass is the living part of soil organic matter, other than living plant material and organisms greater than 500 mm^3 in volume. It is the agent of organic residue breakdown and can be considered as the

agent responsible for the cycling of plant nutrients. Estimation of biomass value as a percentage of total soil organic carbon varied from 0.8 and 4.0% as mentioned by Jenkinson & Ladd (1981) and Grisi (1997).

It is well known that soil organic matter is the key to successful and sustainable productivity of soils in the tropics. Soil organic matter affects positively structure, aggregation, cation exchange capacity, microbial activity and the water retention capacity. Furthermore, soil organic matter is the major nutrient storage site affecting the availability and mobility of macro- and micro-nutrients to the plants.

The transition from natural vegetation to agroecosystems resulted in an universal decline in total soil organic carbon. Henrot & Robertson (1994), measured the biomass-C in two humid tropical soils. Both soils showed a similar pattern in total soil organic matter and biomass carbon decline following vegetation removal; after 3 yr, total C and N were reduced by 20%.

Research is necessary on processes of organic matter decomposition and on the biomass activity to provide clues to improve the sustainability of the soil system. Our main aim in this work was to study the effects of incubation at different temperatures on the turnover time of the microbial biomass in four soils, two from temperate (i.e. United Kingdom) and two from tropical (i.e. Brazilian) climate.

MATERIAL AND METHODS

The soils used were surface samples (0 to 15 cm deep) and their characteristics, measured as Vettori (1969), are shown in TABLE 1.

TABLE 1 - Soil chemical characteristics and clay content.					
Soil	pH	Clay	C	C/N	Water holding capacity
		%			%
Janauba	5.2	25.4	1.27	18	42
Capinopolis	5.0	18.0	2.02	14	50
Woburn	6.8	16.7	1.51	11	54
Pegwel	7.1	20.0	4.04	13.5	54

The Janauba (Dystrophic Red Yellow Latosol) and the Capinopolis soil (Dystrophic Dark Red Latosol) were sampled from native vegetation on Minas Gerais State, Brazil. The Woburn soil (Haplic Arenosol) was sampled from the permanent grass plot at Rothamsted Experimental Station, Hapenden, Herts England and the Pegwell (Hapludalf) was sampled from a native site in Pegwell Bay, Ramsgate, East Kent , England.

After sampling and sieving (< 2 mm) the soils were stored at + 5°C until use. Twelve portions of each moist soil at 40% of water holding capacity (WHC, ca. 0.01MPa), each containing 20 g on an oven-dried soil (24h at 105°C) basis were weighed into 50 ml glass jars. A solution of ^{14}C -labelled glucose containing 1 mg C g^{-1} soil (sp. act. 11.1 KBq mg C) and $(NH4)_2 SO_4$ to give a C: N ratio 15 : 1 was added. The labelled - glucose was added into the soil with a syringe as described by Vasconcellos (1994).

The moist soils were placed separately in a brown wide - necked bottle with a vial of 20 ml of 1N NaOH and 30 ml of distilled water was added to the bottom of the bottle. The bottle was, then, closed with a rubber bung. The NaOH vials were replaced after 7-8 days.

After glucose addition the portions of soils were incubated for 25 days at 15°C. Then, six portions of each treatment were transferred to a 35°C room and randomly distributed within three blocks, each of which contained two replicates of each soil, one to be extracted before and one after fumigation.

Another six portions of each treatment were kept in 15°C and were also randomly distributed as above.

Biomass C was measured by fumigation-extraction (Vance et al. 1987; Jenkinson & Powlson 1976; Jenkinson & Ladd 1981; Wu et al.1990) was determined at 0, 20, 40, 60, 82 and 90 days for the soils incubated at 15°C and at 2, 9, 15, 30, 50 and 70 days for soils incubated at 35°C.

$CHCl_3$ fumigation of the soils was done in a large desiccator containing 30 ml of alcohol-free $CHCl_3$. A moist filter paper was left in the bottom of the desiccator. The moist soils were exposed for 24h at 25°C to $CHCl_3$, later removed by repeated evacuation. The soils biomass were then extracted by shaking for 30 min with 0.5 M K_2SO_4 (1:4 soil: solution ratio). The unfumigated control samples were extracted with 0.5 M K_2SO_4, as described before, at the time fumigation commenced.

K_2SO_4- extractable organic C was measured by an automated UV-persulphate oxidation, as described by Wu et al. (1990). Biomass C (BC), was calculated from the relationship:

$$BC = 2.22 Ec \text{ (Equation 1)}$$

Where Ec = [(organic C extracted by $K_2 SO_4$ from fumigated soil) - (C extracted by K_2SO_4, from non fumigated

soil)]

For biomass ^{14}C determinations, 0.75 ml aliquots of the K_2SO_4 soil extract solutions were placed into plastic scintillation vials with 20ml of Ultima Gold - TM (Packard Inst., Groningen, The Netherlands) as scintillation cocktail, sealed and mixed until clear. Samples were counted in a liquid scintillation counter (2500 TR Liquid Scintillation Analyser Packard) to a 2 Sigma value of 1.00 % or for 5 min. The counts detected (cpm) were converted to disintegration per minute (dpm) using a quench curve in the program for ^{14}C counting. The quench curve efficiency was 88.4%. Biomass ^{14}C was calculated as described above. The quantity of C- labelled biomass (^{14}C-Bc) synthesized from residual ^{14}C-labelled metabolities was calculated from equation 2, Wu (1990),

$$(BI)_s = \{[(BI)_o - (BI)_t]*(Bc)_t*(SA)_m\}/[(BI)_o*(SA)_g - (Bc)_t(SA)_m]$$

(Equation 2)

Where:

t = the incubatiom time (days) (from day 25 onwards);
$(Bc)_t$ = Total biomass C measured at day t;
$(BI)_o$ = [14]C - Bc measured at the start (day 25, t=0);
$(BI)_t$ = [14]C - Bc measured at day t;
$(BI)_s$ = The amount of [14]C - Bc which was synthesised from the residual [14]C - labelled metabolites in the total[14]C - Bc measured at day t.
$(SA)m$ = the [14]C - specific activity of the metabolite fraction available for synthesis of new biomass. This was taken to be the same as the ^{14}C-specific activity of the K_2SO_4-extractable organic - C in the unfumigated soil.
$(SA)g$ = the [14]C- specific activity of the glucose originally added.

The Biomass specific respiration rates were calculated from total CO_2-C evolved during the incubation within the different time intervals divided by the average of the amounts of biomass carbon measured at the first and last day of the interval and divided by the total of days in each interval period.

The mean separation was done by Duncan's Multiple test at 5% of probability.

RESULTS AND DISCUSSION

The biomass development: The biomass (^{12}C, total [12+14]C and ^{14}C) in the end of incubation time at 15°C and 35°C and their variation during the incubation period are shown in TABLE 2 and Figure 1.

Soil	Unamended Soil		Amended Soil					
	12C		12C	12C+14C	14C	12C	12C+14C	14C
	15°C	35°C		15°C	35°C			
Janaúba	112	64	92	212	120	11	45	34
Capinopolis	305	145	92	309	217	19	112	93
Woburn	187	62	100	248	148	9	51	42
Pegwell	654	449	167	839	672	7	228	221

TABLE 2 - Final amounts of biomass after incubation at 15oC and 35oC for 90 and 70 days respectively. Biomass C µg/g dry soil
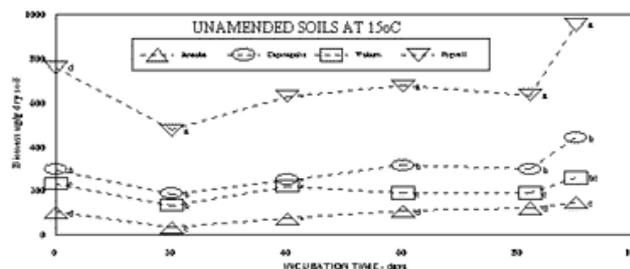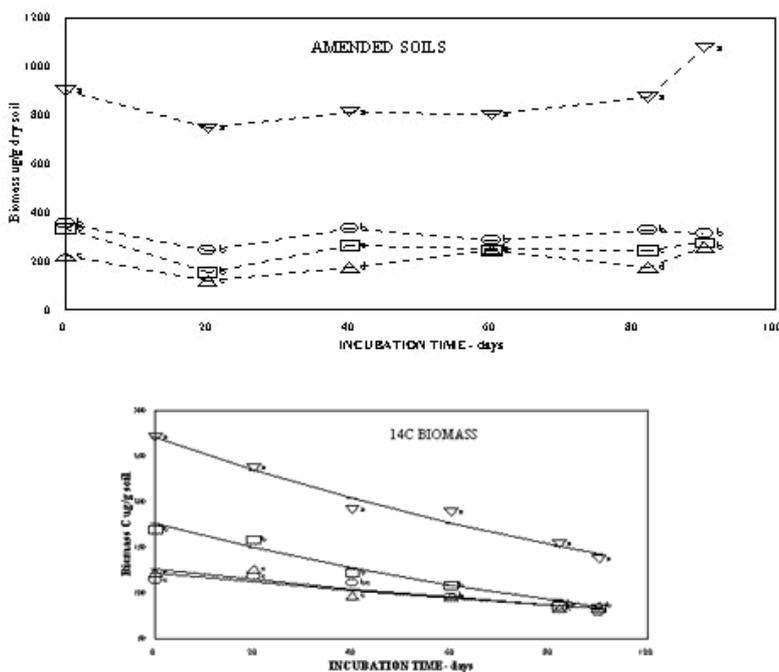
Figure 1 - Biomass C variation at 15°C as incubation temperature. Symbols are for experimental points and complete lines to fitted points. Biomass value for each individual soil followed by different letters are significantly different, (Duncan p < 0.05).

The biomasses decreased as the temperature increased. With glucose, the total $^{12+14}$C biomass decreased by 79%, 64%, 79% and 73%, for Janauba, Capinopolis, Woburn and Pegwell soils respectively, following incubation at 35°C . Without glucose, the ^{12}C biomass decreased only 43%, 52%, 67% and 31%.

The new biomass formed with the glucose addition, represented by ^{14}C biomass decreased 72%, 57%, 72% and 67% when the temperature increased for Janauba, Capinopolis, Woburn and Pegwell soils. Thus, the biomass which developed following glucose addition seemed more sensitive to higher temperatures than the original biomass. Joergensen et al. (1990), also, showed declining of biomasses in temperate soil, when the incubation was done at 35°C.

The changes in the pattern of microbial biomass could affect the N mineralization and immobilization processes of each soil during the plant development.

At 15°C, with glucose, the Janauba and Pegwell soils showed the same biomass pattern from native organic C; Capinopolis and Woburn soils decreased the biomass native organic ^{12}C, (TABLE 2). The same behaviour was reported by Anderson & Domsch (1985) and Brookes et al. (1987). The corresponding decline at 25°C was 16-45%.

Broadbent (1953) reported an increase in the rate of decomposition of native organic matter when addition of plant material was made, i.e., there was a positive priming effect.

Thus, the soil priming effect following glucose addition seemed to have different behaviour at 15°C. After an initial fluctuation, soil microbial biomass apparently drifted slowly upward at 15°C only for Woburn and Pegwell soil in unamended and amended soil. It could be said that no significative variation was observed after 20 days of incubation. After this period, Janauba and Capinopolis soils, from tropical regions, apparently increased in a linear pattern (Figure1) probably in consequence of the cryptic growth of the microbial population.

For a given cohort of biomass, the ^{14}C decay can be expressed by the first-order equation:

$$BCt = BCo* e^{-k't}, \text{ (Equation 3)}$$

Where

BCo = the initial amount of biomass ^{14}C at time = 0;
BCt = the amount remaining after time t;
k' = the decay constant rate per day of initial biomass;

For this system,

$$T \text{ (turnover) } = 1/k' \text{ (Equation 4)}$$

These equations, as mentioned by Wu (1990) are true only for a biomass cohort which do no replenished as the organism die and it is necessary to correct the decay constant rate (k value).

At 15°C there was a decline in ^{14}C biomass as described by the equations:

R^2 % Half-live($t_{1/2}$)

Janauba B- $^{14}C = 126.5 * e^{-(0.0047 \pm 0.0008)*t}$ 89 *** 147 days

Capinopolis B- $^{14}C = 122.7 * e^{-(0.0042 \pm 0.0008)*t}$ 87*** 165 days

Woburn B- $^{14}C = 175.9 * e^{-(0.0008 \pm 0.0007)*t}$ 98*** 87 days

Pegwell B- $^{14}C = 270.4 * e^{-(0.007 \pm 0.0006*t)}$,   97 *** 97 days

At 35°C the ^{14}C biomass were fitted to the following equations:

R^2 % Half-live($t_{1/2}$)

Janauba B- $^{14}C = 90.01 * e^{-(0.0305 \pm 0.0036)*t}$,   83*** 23 days

Capinopolis B- $^{14}C = 104.6 * e^{-(0.0241 \pm 0.002)*t}$,   96*** 29 day

Woburn B- $^{14}C = 148.4 * e^{-(0.0409 \pm 0.0019)*t}$,   99*** 17 days

Pegwell B- $^{14}C = 196.4 * e^{-(0.0485 \pm 0.006)*t}$,   92*** 14 days

At 35°C the total amended biomass (BCt) showed a decline as described by:

R^2 % Half-live($t_{1/2}$)

Janauba BCt = $159.07 * e^{-(0.018 \pm 0.003)*t}$ 84*** 39 days

Capinopolis BCt = $320.05 * e^{-(0.0149 \pm 0.0149)*t}$ 86*** 47 days

Woburn BCt = $361.40 * e^{-(0.028 \pm 0.0045)*t}$ 88*** 25 days

Pegwell BCt = $749.95 * e^{-(0.017 \pm 0.003)*t}$ 90*** 41 days

From these equations it is possible to make some observations as the temperature effect on biomass. The k'values were higher at 35°C than at 15°C. For the ^{14}C biomass, the k values indicate higher mineralization rates for temperate Woburn and Pegwell soils, and smaller ones for tropical Janauba and Capinopolis. However, the Co values (initial ^{14}C biomass) were higher for Woburn and Pegwell. It means that the reserve of microbial carbon and available energy was greater in English soils than in the Brazilian ones, emphasising the observation of the sensibility of biomass from temperate soils to high temperatures (Jenkinson et al. 1991, Gris 1997).

The half-life was calculated from **t(1/2) = ln2/k'**

When an energy source is added to the soils, normally the micro-organisms multiply rapidly until the substrate is nearly exhausted and then decrease again. The CO_2 evolution must have the same pattern. However, the pattern seen in these experiments was different as shown by the specific respiration rate - (mg CO_2 evolved. * g^{-1} * biomass * day^{-1}), TABLES 3 and 4. The data for CO_2 evolved are in Vasconcellos (1994).

Table 3 - Biomass specific respiration rates at 15°C.				
Soil	Incubation period	Specific respiration rate mg CO2*g-1*biomass*day-1		
	(Days)	Unamended	Amended	
			14C + 12C	14C
Janauba	20	43	19	44
	40	44	16	39
	60	22	15	38
	80	15	15	37
	90	12	15	36
Capinopolis	20	8	26	58
	40	7	22	47
	60	5	21	44
	80	4	20	43
	90	3	20	45
Woburn	20	34	14	48
	40	28	13	45
	60	21	13	47
	80	20	13	49
	90	15	14	52
Pegwell	20	15	9	42
	40	13	8	39
	60	10	8	38
	80	8	8	37
	90	6	8	41

Table 4 - Biomass specific respiration rates at 35°C.				
Soil	Incubation period (Days)	Specific respiration rate mg CO2* g-1*biomass*day-1		
		Unamended	Amended	
			14C + 12C	14C
Janauba	2	408	339	122
	9	156	117	52
	15	87	84	52
	30	116	74	60
	50	-	75	71
	70	96	88	68
Capinopolis	2	212	235	125
	9	75	80	45
	15	50	56	35
	30	73	48	34
	50	-	46	39
	70	74	51	47
Woburn	2	299	281	103
	9	116	101	41
	15	87	78	38
	30	89	76	45
	50	64	91	68
	70	57	129	97
Pegwell	2	227	225	73
	9	77	77	33
	15	51	55	38
	30	50	48	54
	50	64	48	99
	70	44	55	124

Either for unamended soils at 15°C, the specific respiration rate (SRR) had decreased - not in a linear pattern, throughout of incubation time, - from **43 to 12**, **8 to 3**, **34 to 15** and **15 to 6** mg CO_2/g of biomass per day for Janauba, Capinopolis, Woburn and Pegwell soil, respectively.

The Janauba and Capinopolis biomass showed an increasing pattern; Woburn and Pegwell a constant biomass pattern, (Figure 1).

The SRR was constant, during the incubation period, for amended soils at 15°C. The SRR for Janauba were 39 and 16 mg CO_2/g of total and ^{14}C biomass per day, respectively; for Capinopolis, 47 and 22 mg of CO_2/g per day, for Woburn, 48 and 13 mg of CO_2/g per day and for Pegwell 39 and 8 mg of CO_2/g of biomass per day. In a sharp contrast, biomass ^{14}C felt during the incubation period. The biomass at 35°C did not show a specific SRR pattern in unamended soils. For amended soil without the first point as initial temperature adaptation, the SRR showed constant values from 15 to 70 days. For Capinopolis it was 57 and 41 mg of CO_2 g^{-1} total biomass and ^{14}C biomass per day.

Janauba, (88 mg.g^{-1}.day^{-1}), Woburn (95 mg.g^{-1}.day^{-1}) and Pegwell (57 mg.g^{-1}.day^{-1}) showed constant values for total biomass and a significant linear increase for ^{14}C biomass (new biomass). The slope b values from fitted linear equations were 0.313 ($\pm$ 0.08), 0,95 ($\pm$ 0.155) and 1,57 ($\pm$1.57) mg of CO_2.$g^{-1}C$ biomass.day^{-1}, respectively.

As pointed out by Santruckova & Straskraba (1991) the increase of specific respiration could be due to effect of stress. But, the water content of the soils at 15°C varied from 50 to 46% of WHC; at 35°C the range was 50% to 31% of WHC. However, during the last week of incubation period the water content was corrected by weight. By another way it is possible that energy for biomass maintenance and CO_2 evolved is coming from various sources (carbon inputs, organic matter, dead microbial cells, endocellular reserve, etc) as showed by Grisi (1997).

As point out by Jenkinson et al. (1991) changes in the climate pattern can alter the total carbon storage in soil. In this way, there is a characterisation of vicious cycle, global warming will accelerate the decomposition of soil organic matter, the CO_2 thus formed further increasing global warming and decreasing the soil biomass microbiology.

These results also emphasise the importance of management practice on soil organic carbon and with the possibility to quantify the organic matter quality, mainly knowing that continuous crop (and plowing processes) cause losses in the natural reserves of organic matter (Zadorin &Yumagulova, 1983).

The biomass turnover: As point out by Jenkinson & Parry (1989) the internal recycling of biomass metabolites can affect the estimate of turnover time. In consequence the uncorrect rate (k') or the degra-dation of ^{14}C-Biomass C was first obtained by fitting a first- order regression equation to the residual ^{14}C-Biomass C as shown in the equations above.

The true rate constant of ^{14}C-Biomass C degradation (k) in the soils can be obtained from measured ^{14}C-Biomass C subtracted from the ^{14}C-Biomass C synthesised from metabolities as shown in TABLE 5. The ^{14}C-biomass synthesised was calculated by the equation 2 with the specific activities data in TABLE 6.

TABLE 5 - Synthesis of 14C biomass metabolites and its effects on the estimation of degradation constant.				
Measured 14C biomass carbon				
Soil	Calculated 14C - BC synthesized from metabolites mg C* g-1 soil1		Correct Rate Constant of 14C - BC degradation mg (14C -BC.g-1 soil.day-1)	
	15°C	35°C	15°C	35°C
Janauba	3.4	1.9	4.82*10-3	33*10-3
Capinopolis	5.9	5.6	4.43*10-3	27.9*10-3
Woburn	2.9	1.0	8.65*10-3	42.7*10-3
Pegwell	9.4	9.3	7.1 *10-3	81.1*10-3

Biomass value for each individual soil followed by a different letter are significantly different (p < 0.05).
1The BC synthesized from metabolites were calculated from 20-90 for 15°C and from 0-70 days.

TABLE 6 - Data required to calculate the 14C -biomass carbon synthesized. Incubation temperature at 15°C and 35°C.												
Soil	Specific activity of biomassC at 15°C							Specific activity of 0.5 M K2S04 at 15°C				
	dpm.g-1 C							dpm.g-1 C				
							days					
	0	20	40	60	82	90		20	40	60	82	90
Janauba	367	677	365	259	314	225		30	30	28	21	21
Capinopolis	213	321	221	224	181	166		36	40	33	28	27
Woburn	335	670	305	288	233	200		12	16	15	14	14
Pegwell	200	212	157	157	117	85		12	15	14	10	12
Specific ativity of biomass C at 35°C								Specific activity of 0.5 M K2S04 at 35°C				
	dpm g-1 C							dpm.g-1 C					
	0	2	9	15	30	50	70	0	2	9	15	30	50	70
Janauba	367	463	406	234	179	229	163	44	36	24	22	27	18	20
Capinopolis	213	261	217	164	137	120	136	64	38	43	36	38	32	32
Woburn	335	323	278	189	108	124	158	22	17	18	18	18	17	16
Pegwel	200	189	115	123	43	35	26	25	14	44	30	19	12	8

The declines in total biomass C during the incubation period was faster in amended soils than in unamended control soils. As Wu (1990) has pointed out, it means that with new energy source the turnover of biomass C would be faster than in unamended soil. The faster decline of total biomass C with glucose is due to the enhanced turnover of biomass due to the residual effects of glucose incorporation. The rate of biomass C turnover in unamended soils can be calculated from the following formula:

$$\Delta P = e^{-kt} - e^{-kut} \text{ (Equation 4)}$$

Where

D P - is the proportion of the total biomass C that declines between the incubation period in the glucose-amended treatment minus the proportion of the total biomass C that declines in the unamended treatment. k and ku are the rate constants of biomass turnover in amended and unamended soils, respectively at a specific time (t) in days. The ku value is determined by solving the equation above.

Unfortunately, at 15°C, the results observed for the biomass C in unamended treatments were not consistent. During the incubation period the microbial population could use the soil organic matter as substrate for its development (Grisi, 1997).

In the amended treatments, after a decline from time 0 to time 20, the total biomass showed an increasing linear pattern for all soils, except for Capinopolis, which showed no specific biomass variation.

At 35°C, the corrected constant rate of Biomass C turnover for unamended soil are given in TABLE 7 and Figure2. The biomass in the Janauba and Capinopolis soils had turnover times (**1/ku**) of 92 and 69 days; Woburn and Pegwell, 69 and 33 days. Thus, biomass C in the Pegwell soil was most sensitive to temperature.

Soil	Declines in BC (% 0-70 days)			Corrected rate for unamended soils
	Amended	Unamended	Differences	ku*10-3
Janauba	78	41	37	10.8
Capinopolis	71	49	22	14.5
Woburn	89	58	31	14.6
Pegwell	71	59	12	29.9

TABLE 7 - Decline of biomass C (BC) in glucose - amended and unamended soil and constant rates of Biomasss C turnover in unamended soil at 35oC
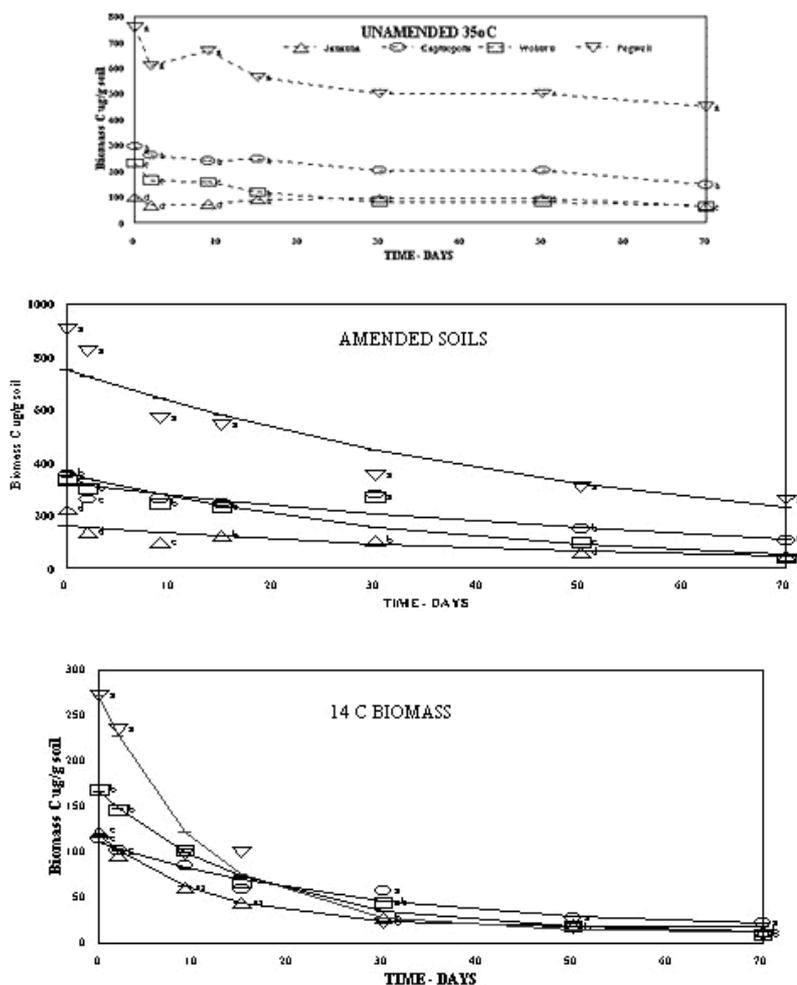
Figure 2 - Biomass C variation at 35°C as incubation temperature. Symbols are for experimental points and complete lines to fitted points. Biomass value for each individual soil followed by different letters are significantly different, (Duncan p < 0.05).

It can be calculated from ku values in TABLE 7 that, at 35°C, about 19% (100 * (1 - $e^{-ku* 20}$)) of the biomass C

is replaced during turnover in 20 days in Janauba unamended soil, 25% in Capinopolis, 25% in Woburn soil and 45% in Pegwell soil. Van Veen et al. (1981) showed that clay soils have a greater capacity to preserve microbial biomass than sandy soils. In our experiment, the clay content did not vary widely (16.7% to 25.4%).

At 15°C, for amended soils, the turnover time were 207 days for Janauba, 225 day for Capinopolis, 115 days for Woburn and 141 days for Pegwell . According to Jenkinson et al. (1987), the air temperature conversion factor is 3.81 at 25°C. If that factor is used to convert the turnover times of biomass C obtained in the laboratory to those expected under field conditions, the following values are obtained at 15°C: Janauba, 2.2 years; Capinopolis 2.3 years; Woburn, 1.2 years and Pegwell 1.5 years. Wu (1990) showed biomass C turnover times of 1.3 years in the Woburn soil, and 1.8-2.2 years in a range of soils from Rothamsted.

TABLE 8 gives the ^{14}C balance. Probably because biomass activity was lower at 35°C the ^{14}C remaining was higher at 35°C. It is necessary to note that the total ^{14}C evolved at 15°C and at 35°C was very close.

Soil	Biomass			CO2 evolved			Residue	
	15°C	35°C		15°C	35°C		15°C	35°C
	mg.g -1 de soil							
Janauba	92	11		640	683		268	306
Capinopolis	92	19		714	705		194	276
Woburn	100	9		734	795		166	196
Pegwell	167	7		606	691		225	302

TABLE 8 - 14C distribution in biomass carbon and CO2 evolved at the end of incubation period. The residual 14C was calculated from the difference from the total added.

Biomass and Correlations: Final total biomass at 15°C and 35°C were very close correlated with initial soil carbon content, (r values were 0.982 and 0.992, respectively), but not with the clay content. There was an average of 31 and 8 mg of biomass C.g^{-1} of C, respectively at 15 and 35°C . The residual ^{14}C was closely correlated with clay content at 15°C. No correlation were found at 35°C. There was correlation between the decomposition rate at 35°C and the initial soil organic carbon.

CONCLUSIONS

- The biomass mineralization rates were higher at 35°C than at 15°C and higher for Woburn and Pegwell (soils from temperate region) than for Janauba and Capinopois (soils from tropical region).

- The specific respiration rate of new biomass from glucose and old biomass showed different behaviour between soils, but not between temperate and tropical region;

- At 15°C, the turnover C was 207, 225, 115 and 141 days for Janauba, Capinopolis (soils from tropical regions), Woburn and Pegwell (soils from temperate regions) respectively. At 35°C, it was 92, 69, 69 and 33 days for the same soils. These results emphasised the effect of global warming on soil biomass and on the stability of the soil quality.

- The residual ^{14}C remaining in the soil was higher at 35°C.

- The final total biomasses at 15°C and 35°C were correlated with the initial soil carbon content. There was an average of 31 and 8 mg of biomass C.g^{-1} soil organic carbon, respectively at 15°C and 35°C.

- The initial carbon content was an important factor to explain the mineralization rate at 35°C being important for soil management practice to improve the soil organic matter and the sustentability of food production

ACKNOWLEDGEMENTS

REFERENCES

ANDERSON, T.H.; DOMSCH, K.H. Determination of ecophysiological maintenance carbon requirements of soil microorganisms in a dormant state. **Biology and Fertility of Soils**, v.1, n.1. p.81-89, 1985.   [Links]

BROADBENT, F.E. The soil organic fraction . **Advances in Agronomy**,v.5, p.153-183,1953.   [Links]

BROOKES, P.C.; NEWCOMBE, A.D.; JENKINSON, D.S. Adenylate energy charge measurements in soils. **Soil Biology and Biochemistry**, v.19, p.21-217,1987.   [Links]

GRISI, B.M. Temperature increase and its effect on microbial biomass and activity of tropical and temperate soils. **Revista de Microbiologia** , v.28, p.5-10, 1997.   [Links]

HENROT, J; ROBERTSON, G.P. Vegetation removal in two soils of the humid tropics: Effect on microbial biomass. **Soil Biology and Biochemistry**, v.26 n.1,p 111-116. 1994.   [Links]

JENKINSON, D.S.; LADD, J.N. Microbial biomass in soil: measurement and turnover. In Paul, E.A.; Ladd, J.N. **Soil Biochemistry**. New York: Marcel Dekker,1981. v.5, p.4l5-471.   [Links]

JENKINSON, D.S.; HART, P.B.S.; RAYNER, J.H.; PARRY, L.C. Modelling the turnover of organic matter in long-term experiments at Rothamsted . **Intecol. Bull**., n.15, p.1-8. 1987.   [Links]

JENKINSON, D.S.; PARRY, L.C. The nitrogen cycle in the Broadbalk wheat experiment: a model for the turnover of nitrogen through the soil microbial biomass. **Soil Biology and Biochemistry**, v.21, p.535-541, 1989.   [Links]

JENKINSON, D.S.; POWLSON, D.S. The effects of biocidal treatments on metabolism in soil. V. A method of measuring soil biomass. **Soil Biology and Biochemistry**, v.8, p.209-213, 1976.   [Links]

JENKINSON, D.S.; ADAMS, D.E.; WILD, A. Model estimates of CO_2 emissions from soil in response to global warming. **Nature**, v.351, p.304-306,1991.   [Links]

JOERGENSEN, R.G.; BROOKES, P.C.; JENKINSON, D.S. Survival of the soil microbial biomass at elevated temperatures. **Soil Biology and Biochemistry**, v.22, p.1129-1136, 1990.   [Links]

SANTRUCKOVA, H.; STRASKRABA, M. On the relationship between specific respiration activity and microbial biomass in soils. **Soil Biology and Biochemistry**, v.23, p.525-532, 1991.   [Links]

VANCE, E.D.; BROOKES, P.C.; JENKINSON, D.S. An extraction method for measuring soil microbial biomass C. **Soil Biology and Biochemistry**, v.19, n.6, p.703-707, 1987.   [Links]

VAN VEEN, J.A.; PAUL, E.A. Organic carbon dynamics in grassland soils. 1. Background information and computer simulation. **Canadian Journal of Soil Science**, Ottawa, v.6l, n.2, p.185-201, 1981.   [Links]

VASCONCELLOS, C.A. Temperature and glucose effects on soil organic carbon: CO2 evolved and decomposition rate. **Pesquisa Agropecuária Brasileira**, v.29, n.7, p.1129-1136, 1994.   [Links]

VETTORI, L. **Métodos da análise do solo** . Rio de Janeiro: EPE, 1969. 24p (Boletim Técnico, 7).   [Links]

WU, J.; JOERGENSEN, R.G.; POMMEREMING, B.; CHAUSSOD, R.; BROOKES, P.C. Measurement of soil microbial biomass C. by fumigation - extraction - an automated procedure. **Soil Biology and Biochemistry**, v.22, p.1167-1169, 1990.   [Links]

WU, J. The turnover of organic C in soil Reading : Reading, 1990. p.236. Thesis (Ph.D) Reading University.   [Links]

ZADORIN, A.D.; YUMAGULOVA, A.N. Dynamics of humus during crop rotations in different regions of Kazakhstan. Soviet Agricultural Science, v.2, n.5/8, 1982. Resumo 8709 em **Soil & Fertilizer**, v.46, n.9, p.909, 1983.

Scientia Agricola

**Av. Pádua Dias, 11
13418-900 Piracicaba SP Brazil
Tel.: +55 19 3429-4401 / 3429-4486
Fax: +55 19 3429-4401**

e-Mail

scientia@esalq.usp.br