INTERANNUAL VARIABILITY IN SOIL RESPIRATION OF FOREST, GRASSLAND, AND AGROECOSYSTEMS IN SUB-BOREAL ZONE OF RUSSIA

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ABSTRACT

Annual and seasonal dynamics of total soil respiration (TSR) of sandy Albeluvisols and clay Phaeozems under forest, grassland, and arable were studied in situ (Russia, Moscow Region). Measurements of soil CO_2 emission were carried out by closed chamber method from November 1997 through October 2003 weekly. The highest mean TSR (806 ± 86 g $C \cdot m^{-2} \cdot yr^{-1}$) was observed for sandy Albeluvisols under grassland. It significantly exceeded the annual CO_2 fluxes from soils of other ecosystems ($P < 0.1$). The lowest value of mean annual TSR was observed for arable clay Phaeozems (361 ± 55 g $C \cdot m^{-2} \cdot yr^{-1}$). It was reliably lower than in soils of the other cenoses ($P<0.5$). No significant differences were found between annual amounts of CO_2 emitted from Albeluvisols under forest and Phaeozems under forest and grassland. The interannual variability of TSR caused by the difference of weather conditions was 30% on average and ranged from 25-26% (forest and grassland ecosystems on Albeluvisols) to 37% (agroecosystem on Phaeozems). We found that TSR in natural ecosystems positively correlated with the total annual precipitation and sum of precipitation for the spring season ($R=0.73$-0.90, $P<0.1$). The share of the cold period (November-April) to the annual CO_2 flux was substantial and averaged 22-25% and 17% for natural and agricultural ecosystems, respectively. Therefore, emission of CO_2 during the cold period was an essential part of the annual CO_2 fluxes from soils of sub-boreal zone, which should be taken into account while calculating the carbon budget for the whole year.

INTRODUCTION

Soil respiration is a major flux in the global carbon cycle. Temperature and moisture availability have a strong impact on total soil respiration causing its interannual variability [*Davidson et al.,* 2000; *Raich et al.,* 2002]. Environment changes have also a strong potential to influence the rates of soil respiration. This study was aimed to assess the annual TSR by different land use in sub-boreal zone and its interannual variability based on long-term year-round monitoring.

MATERIALS AND METHODS

Experimental sites were located on sandy sod-podzolic soils (Albeluvisols Umbric), on the territory of Prioksko-Terrasny State Reserve (Moscow region, Russia, 54°50'N, 37°35'E), and on clay grey forest soils (Phaeozems Albic), 4 km west of Pushchino. Measurements were carried out in situ during 6 years under mature mixed forest and grassland (appr. 50 yrs) on Albeluvisols and under secondary mixed forest, grassland (appr. 20 yrs), and arable on Phaeozems. More detailed descriptions of sites and soils were carried out earlier [*Kurganova et al*., 2003]. Soil CO_2 emission rates were measured by the closed chamber method over the period from November 1997 through October 2003 at 7-10 days intervals. Measurements were carried out between 9 and 11 a.m., the number of replicates was 3 during the cold period (November – April) and 5 during the warm period (May – October). Chamber techniques for cold and warm seasons were also different [*Kurganova et al*., 2003].

RESULTS AND DISCUSSION

The total respiration of soils in sub-boreal zone has been found to range from 156 to 1155 g C $m^{-2} \cdot yr^{-1}$ depending on the ecosystem type and the weather conditions of particular year. The interannual variability of TSR caused by the difference of weather conditions was 30% on average and ranged from 25-26% (forest and grassland ecosystems on Albeluvisols) to 37% (agroecosystem on Phaeozems). Hence, the cultivated soils are more sensitive to the changes of weather conditions than those under natural cenoses. The annual TSR of Albeluvisols under grassland (mean value - 806 ± 86 g $C \cdot m^{-2} \cdot yr^{-1}$) was maximal and significantly higher than CO_2 effluxes from soils of other ecosystems. The TSR of cultivated Phaeozem was minimal among ecosystems studied (mean value - 361 ± 55g $C \cdot m^{-2} \cdot yr^{-1}$). Our estimations of TSR correspond to those obtained for other ecosystems of the boreal zone - 760±340 g C·m^{-2}·yr^{-1} [*Raich and Schlesinger*, 1992; *Janssens et al.*, 2001]. There was no close correlation between annual TSR of soils studied and mean annual temperature. *Janssens et al.* [2001] did not also found the significant correlation between the annual soil respirations and mean annual temperatures for 18 European forests. However, we observed the close positive correlation between the annual CO_2 fluxes from soils of natural ecosystems, sum of annual precipitation, and sum of precipitation for the spring season (R=0.73-0.90, P<0.1-0.15).

Table 1. Seasonal, annual CO_2 (g C·m^{-2}·period^{-1}) fluxes and their interannual variability (CV, %) in soils of different land use (mean±SE)

Period	Albeluvisols		Phaeozems		
	Forest	Grassland	Forest	Grassland	Cropland
Winter	70+14	77+18	52+9	49+9	17+1
Spring	114+16	163+27	114+17	101+19	61+6
Summer	281+33	378+41	234+31	255+32	179+32
Autumn	170+15	187+19	161+22	115+18	104+25
Cold season (November-April)	160+26	189+36	143+20	113+17	60+8
Warm season (May-October)	475+50	617+67	419+54	408+56	301+55
Annual flux	635+63	806+86	561+64	520+69	361+55
CV, %	24.5	26.3	27.7	32.6	37.1

The contributions from cold period (November-April) and calendar seasons to the annual CO_2 flux were estimated. The share of cold period in the annual carbon dioxide flux averaged 20-25% and its maximum amounted to 37-40% (2000-2001 yrs.). The CO_2 fluxes comprised approximately 42-49% in summer, 20-29% in autumn, 18-21% in spring, and 6-11% in winter of the total annual carbon dioxide flux. These shares of calendar seasons for the soils of ecosystems studied depended on the combination of climatic conditions during the year. Thus, our measurements showed that emission of CO_2 during the cold period is an essential part of the total annual emissions and should be taken into account while calculating the carbon budget for the whole year.

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