Geophysical Research Abstracts
Vol. 14, EGU2012-2909, 2012
EGU General Assembly 2012

Cropland responses to extreme winter temperature events: results from a manipulation experiment in north-eastern Italy

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In the last years, several studies has focused on terrestrial ecosystem response to climate warming. Most of them have been conducted on natural ecosystems (forests or grasslands), but few have considered intensively managed ecosystems such as croplands despite of their global extension. In particular, extreme events, such as temperature changes outside the growing season (winter) when soil is not covered by plants, can have a strong impact on soil respiration, residues decomposition, yield and overall net biome production (NBP).

In this study, we investigated the response of soil respiration (total and heterotrophic), aboveground NPP, yield and NBP on a soybean crop (Glycine max (L.) Merr.) due to a manipulated warmer or cooler winter. The experiment was carried out in Beano (46°00' N 13°01'E, Italy). Soil albedo and soil temperature were manipulated by covering soil surface during late winter with a layer of inert ceramized silica gravel. We tested three treatments with three replicates each: cooling (Co; white gravel), warming (W; black gravel), mix (M; black and white 4:1 gravel) and control (C; bare soil). An automated soil respiration system measured continuously total soil CO_2 efflux across all the year and heterotrophic respiration after sowing in root exclusion subplots. Additionally, soil temperature profiles (0, 2.5, 5 and 10 cm depth), soil water content (between 5 and 10 cm depth) were monitored in each plot. After sowing, soybean phenological phases were periodically assessed and final yield was measured in each plot.

Results showed a significant change in upper soil temperature between gravel application and canopy closure (maximum of + 5.8 °C and – 6.8 °C in the warming and cooling treatments, respectively). However, warming had only a transient effect on soil respiration (increase) before sowing. Thereafter, as soon as fresh organic matter availability decreased, soil respiration rate decreased and annual budget was not significantly different from control. On the other hand, cooling showed an annual lower soil respiration in comparison to other treatments. Thus, these results highlight the higher sensitivity of fresh organic matter to extreme and short heat waves. We also observed an anticipation in seed germination in both W and M in comparison to C (-4 days) and a delayed germination (+3 days) in Co. Moreover, seed germination, plant density and growth were increased in W and M and reduced in Co.