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# Drought effects on soil carbon dioxide production in two ecosystems in Central Sulawesi, Indonesia

Oliver van Straaten

Georg-August-University of Goettingen, Buesgen Institute, Soil Science of Tropical and Subtropical Ecosystems, Goettingen, Germany (ostraat@gwdg.de, +49551393310)

Drought response on soil $CO_2$ production dynamics were examined in two tropical ecosystems in central Sulawesi, Indonesia. Large-scale throughfall displacement roofs were built in a cacao (*Theobroma cacao*) / *Gliricidia sepium* agroforestry plantation (560 m.a.s.l.) and in a sub-montane tropical rainforest (1050 m.a.s.l.) to simulate drought conditions. At each site, ecosystem drought responses from three roof plots were compared to three undisturbed control plots. Soil $CO_2$ production was measured spatially at the soil surface and vertically within the soil profile to 2.5 m depth every two weeks.

1. The cacao / *Gliricidia* ecosystem exhibited a mild drought response. Here, soil $CO_2$ production decreased by 13% in comparison to the control plots during the 13 month induced drought. The mild drought response is attributed to two reasons. First, soil $CO_2$ efflux exhibited an inverse parabolic relationship with soil moisture ($R^2$ = 0.32): soil $CO_2$ efflux peaked at intermediate moisture conditions, but was low when soil conditions became dry (in the induced drought plots), and when the soil became water saturated (in the control plots). This means that respiration differences between control and roof plots may have been masked when soil moisture conditions were saturated in the control and concurrently dry in roof plots. Secondly, the shallow rooted cacao understory grown next to the deeper rooted *Gliricidia* overstory created a favourable set of site conditions that enabled the ecosystem to mitigate serious drought stress. The experiment had a $CO_2$ neutral effect overall: emissions were initially reduced during the induced drought period but rebounded and surpassed the control during the five month rewetting phase, thus compensating for earlier declines.

2. In contrast, the sub-montane tropical rainforest experienced a severe decrease in soil $CO_2$ production. Here, soil $CO_2$ efflux decreased by an average of 39% in comparison to the control during the 24 month induced drought period. Soil moisture, the main variable controlling $CO_2$, exhibited a strong positive linear relationship with soil $CO_2$ production ($R^2$ = 0.72). A two phase ecosystem drought response was observed. During the first phase, which lasted nine months, leaf litter respiration declined while the total respiration from autotrophic and belowground heterotrophic sources remained relatively unchanged, although an upward shift from the subsoil to the soil surface was measured. During the second phase of the experiment, when drought conditions intensified further (the next 16 months), belowground $CO_2$ production from heterotrophic and autotrophic sources decreased at all soil depths. Leaf litter respiration remained negligible. Recuperation after the drought was slow in this ecosystem and did not rebound to control plot levels. In this ecosystem, the simulated drought resulted in a reduction in overall $CO_2$ emission.