Geophysical Research Abstracts
Vol. 17, EGU2015-4644, 2015
EGU General Assembly 2015

CO_2 balance of an intensively grazed temperate pasture during pasture renewal via cultivation or direct drilling

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The management practice of pasture renewal (PR, also referred to as 'restoration') of permanent pastures offers the opportunity to replace low producing pasture, remove weeds and pests, improve drainage, and introduce improved pasture varieties, thereby increasing pasture production. PR can consist of a range of practices including spraying existing pasture with herbicide, followed by direct drilling or full cultivation (ploughing). Although PR is common in some farming systems, little is known about the impact of PR of permanent pastures on soil C and CO_2 dynamics.

Here we report on the CO_2 balance following four PR events of intensively grazed permanent pastures in temperate New Zealand. Three events of PR followed the same method which included two herbicide sprays and a full cultivation (CULT). PR events took place in either spring or autumn, which meant soil moisture conditions varied greatly between PR events. For the fourth PR event, pasture was sprayed only once, and was not cultivated but instead seeds were directly drilled (DD) into the sprayed-off pasture. Chambers and the eddy covariance technique were used to measure the CO_2 exchange before, during and after PR. In addition to the direct loss of CO_2 measured during the PR events, we also quantified the 'net impact of PR' which we defined as the difference between net CO_2 exchange of the pasture that underwent PR and that of an undisturbed pasture which served as a control. This way, we also accounted for the temporary lack of photosynthetic carbon inputs when plants were absent during the PR events.

Both the rate of direct CO_2 respiratory losses and the 'net impact of PR' appeared highly dependent on soil moisture status, with the lowest rate of loss measured under severe drought conditions and the highest rate of loss measured in spring when ample moisture was present. Because the rate of CO_2 loss did not decrease over time during PR, the longer the soil was bare, the more CO_2 was lost. The duration of PR (here defined as the time between spraying and seedling emergence) varied between PR events and ranged from 15 to 79 days. The 'net impact of PR' of all four PR events ranged from 55 to 405 g C m^{-2} per PR event.

While cultivation is often thought to lead to enhanced CO_2 losses compared to no-till, data collected showed no evidence of lower CO_2 losses of direct drilling compared to the full cultivations. Possibly, in our systems physical disturbance caused by cultivation was less important than lack of C inputs by photosynthesis which occurred using either method (CULT and DD).

Therefore, if one aims to reduce C losses during PR, it is recommended to i) minimise the duration of the period between spraying the old pasture and establishment of the new pasture, and ii) renew pastures when conditions for soil microbial activity and photosynthesis are sub-optimal (in our case in autumn instead of spring because of lower soil moisture availability).