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Recording trace gases

Air-conditioned Perspex chambers for measurement of soil respiration and trace gases in undisturbed growing plants

The most different anthropogenic causes play a part in the increase of the greenhouse effect. Carbon dioxide from cropping plays an important role in this. A chamber system is normally used for quantifying CO₂ from plant-soil interactions. Problems are caused hereby by chamber effects making themselves felt, above all, through temperature increases and reduction of photosynthetic-active light. This led to a measurement system being developed in order to minimise these effects.

The trace gas carbon dioxide is around 50% responsible for the global greenhouse effect. Within the last 250 years the CO₂ content in the atmosphere has risen from 280 ppm to the current 355 ppm. The latter value can vary regarding location and time [1]. The most important anthropogenic causes for this change in concentration are the clearing of forests, burning of fossil fuel and intensification of agriculture. There still remains a considerable need for research, especially in the quantifying of CO₂ emissions from farmland [4]. Because of this, a field trial looking at two different factors in improving equipment was prepared near Hohenheim University as part of the DFG project "Measurement, Reduction and Modelling of Trace Gases from Farming Systems". There, different land-use systems were investigated with regard to their various CO₂ flows. For measurement of gas concentration, the chambers were closed for 10 minutes six times daily every four hours with measurements then taken every minute. The CO₂ concentrations under each hood were determined on-the-spot through infrared gas analysers. Problems in the measuring with such chambers were caused by the chamber-effect – this meant the creation of a microclimate within the chamber. The most important chamber effects are the rise in temperature and air moisture content as well as the reduction of photosynthetic-active light. During measurements with the chamber made of polyethylene, a stronger rise in temperature and a stop to

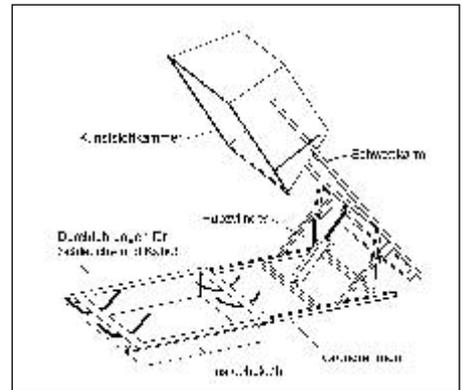


Fig. 1: Hohenheim Chamber

assimilation were observed within a few minutes. Through this, the measurement of soil respiration was falsified. This led to the modification of the measurement chamber so that the above-mentioned chamber effect was strongly curtailed.

Figure 1 shows the construction of the chambers used. A detailed description is available under [2]. Up until now, polyethylene hoods have been exclusively for such measurement chambers [3]. These led to substantial influencing of the measurements, above all in the case of carbon dioxide (fig. 2).

Initially, a reduction in CO₂ concentration can be seen, e.g., assimilation occurs: CO₂ is absorbed by the plants. Directly after the

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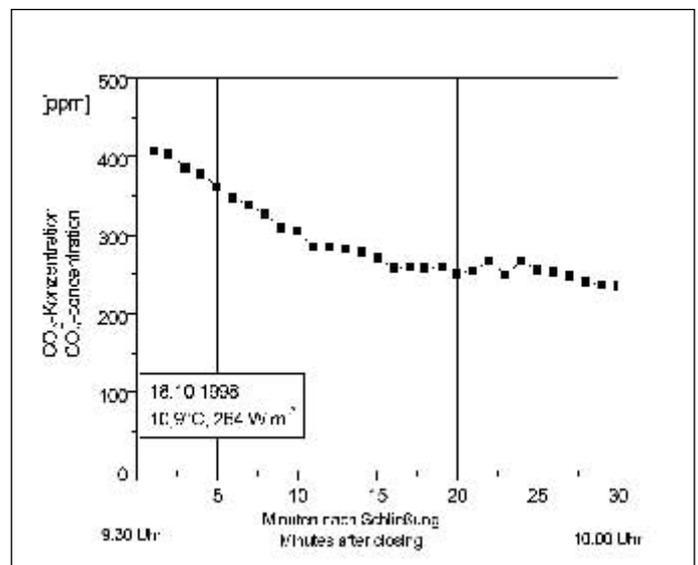


Fig. 2: Change of the CO₂-concentration after 30 min closing time (polyethylen chamber)

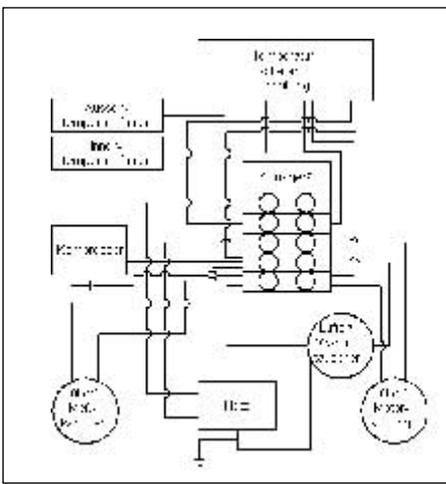


Fig. 3: Wiring of air-conditioner for temperature difference circuit

chamber is closed, the main limiting effect on assimilation is from the reduction in photosynthetic-active light, the gradually addition of the influence of rising temperature leads to a flattening out of the upward assimilation curve after about 10 minutes. Through this effect the plants are strongly limited in their photosynthetic performance and stop assimilation altogether if the chamber remains closed. After 15 minutes the increase is almost zero. As CO₂ absorption by plants is dependent on light as well as temperature, the construction of the hood material is of great importance for the plausibility of the measurement results. To ensure that the chamber effect does not effect measurements too strongly the follow points are important:

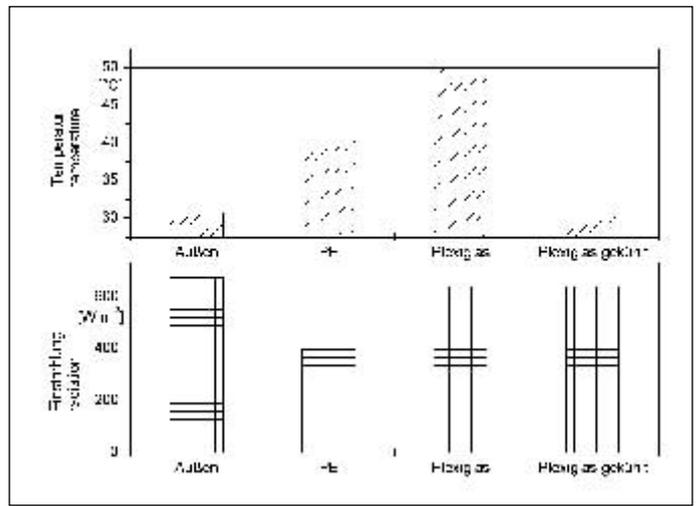
1. Hoods which are as far as possible transparent for radiation should be used, and
2. A temperature increase should be avoided through appropriate cooling.

Modifying the chambers

The chambers were modified by replacing PE by perspex which allows 90 to 96% of radiation through. This meant in turn that cooling was necessary and for this commercially available air conditioning was used.

Cooling of interior air was via temperature difference switch integrated into the air conditioning. This compared the ambient external temperature with that within the hood and, where the difference reached 2K (fig. 3), switched on the air conditioner. The temperature difference switch was activated 5 min before measurements began. At this point the hood interior temperature was given a desired value 2K under the actual reading of the exterior sensor. This led to the air conditioning being activated in advance thus being in a position to immediately delivered full performance when the hood was closed. The maximum measured difference between exterior and interior temperature (actual value) was 4K.

Fig. 4: Change of temperature and radiation under the chambers after a closing time of $t_s = 10$ min



Results

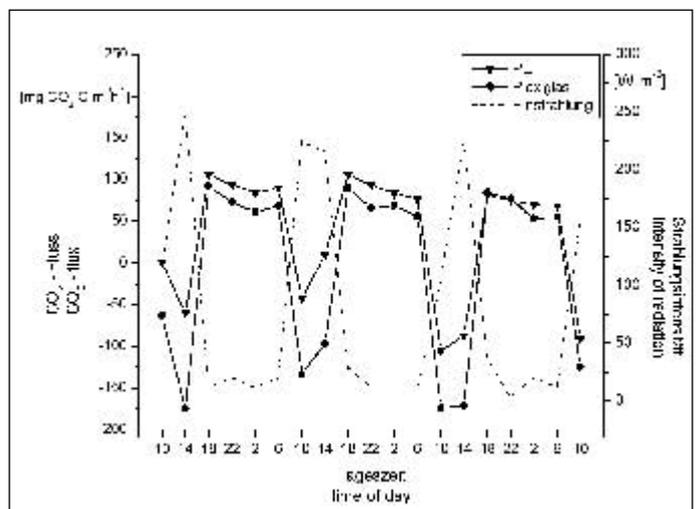
With an exterior temperature of around 30 °C (fig. 4) the temperature under the PE hood rose by 10K to 40 °C after ten minutes, under the perspex hood by almost 20K. But under the cooled perspex hood no difference to the exterior temperature was measurable. With radiation at 650 Wm⁻², this is reduced by almost 40% under the PE hoods. Under the perspex hoods only very limited light losses occurred.

The process of the CO₂ flows as measured in both chamber systems (fig. 5) showed, in association with the time of day, a clear difference. With a high radiation, the measured CO₂ values under the perspex hood were lower. This meant that the plants in this system could absorb more CO₂ and be less influenced in their photosynthetic performance. In that the conditions under the cooled Perspex hood were nearly the same as those of the exterior, these values could be regarded as real ones. Contrary to this, with the measurements in the PE hoods used up until now, the reduction in assimilation meant, in the long term view, that there was a clear over-estimation of soil respiration. As expected, night-time radiation was nearly zero and no difference between the variants was determined as the chamber effect only takes place to a measurable extent during daylight.

Conclusion

The Hohenheim measurement chamber system was developed

Fig. 5: Course of CO₂-flux using different chamber materials, depending on radiation



for the evaluation of trace gases N₂O, CH₄ and CO₂ from soil and growing plants. It was thereby apparent that CO₂ balancing errors could occur through measurements of the trace gas being effected by the microclimate formed under the hoods. With the further development featuring cooled perspex hoods this error could, to a large extent, be minimised because air conditioning and perspex meant that conditions under the hood were almost identical to those outside. Thus the new measurement chambers offer a good possibility of reliably measuring CO₂ flow in standing crops.

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