Outdoor plant growth experiments in

Elevated CO_2 Atmospheres

A silent giant, Mount Iwate, guards the peaceful surroundings of the Tohoku Research Center on the northern mainland of Japan.

The Forestry and Forest Products Research Institute studies plant growth in elevated carbon dioxide environments in Japan. At the end of 1999, Dr. Mori started a four-year project to study the effects of carbon dioxide and soil nutrient content on young trees. Vaisala is involved in this project, providing essential carbon dioxide measurement instruments for the outdoor growth chambers.

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A now silent giant, Mount Iwate, guards the peaceful surroundings of the Tohoku Research Center on the northern mainland of Japan. The volcano's fiery prehistoric past, is a strong reminder of how our environment is undergoing constant change. Since the birth of 'Iwate san', mankind has emerged and evolved into an increasingly influential component of our planet's ecosystem. For the first time in Earth's history, it seems that a single species is capable of altering the entire climate system.

From left, Mr. Gaku Hitsuma, Mr. Tatsushiro Ueda and Dr. Shigita Mori on location at the open top chambers.

Vaisala's CO_2 measurement instruments are used in the outdoor growth chambers.

Vaisala CO_2 instruments in forest study

The consequences that global warming has on nature are still largely unknown. Japan is at the forefront of a global effort to study the phenomenon, and to try to minimize its impact. Proof of this is the United Nations' Kyoto Protocol aimed at a worldwide reduction of carbon dioxide and other green house gas emissions.

The Japanese high authority in forestry issues, the Forestry and Forest Products Research Institute (FFPRI), has played an active role in assessing the effects of rising temperature and carbon dioxide (CO_2) concentration. The FFPRI, with its five research centers around Japan, is currently carrying out numerous research projects on the subject. One of these involves studying plant growth in elevated carbon dioxide environments. Vaisala is also involved in this project, providing essential CO_2 measurement instruments for the outdoor growth chambers.

Tohoku Research Center

The FFPRI Tohoku Research Center in Morioka is responsible for forest preservation and research in Tohoku, covering an area of almost 67,000 km^2, over two thirds of which is forest. The majority of the forests are owned either by national or local government. The research center is creating a long-term plan to ensure the well being of the Tohoku forests in the future. It is possible that the effects of global warming can already be seen in various trees in the forests of Tohoku. It seems that the slight climate change and rising concentration of carbon dioxide in the atmosphere are allowing some pests to spread more easily from the south. The complicated migration patterns of forest pests are one example of the new challenges that the research center is facing.

Dr. Shigeta Mori has been conducting research projects for Tohoku Research Center over the last two years. Before Morioka, he spent four years at the FFPRI Hokkaido Research Center. He has a doctorate in agriculture from the Nagoya University Graduate School of Agriculture and Forestry, and has participated in numerous research projects in different parts of Japan. "Japan is a unique country for a forest researcher," explains Dr. Mori. "Although it is a moderately small country in terms of surface area, it stretches right through the forest zone of the Northern Hemisphere. Japan's southernmost islands and the island of Kyushu are in a subtropical forest zone and the island of Hokkaido in the north is in a cool-temperate forest zone. As most areas of Japan also have high mountains, the variety of domestic types of forest is remarkable."

Dr. Mori has led innovative research projects not only in Japan, but also in Siberia and Indonesia. Few researchers have had the opportunity to experience such a wide range of different forests, from equatorial tropical rain forests to huge larch forests in the permafrost of northern Russia.

Open top growth chambers

At the end of last year Dr. Mori started a four-year project to study the effects of carbon dioxide and soil nutrients on young trees. The project is supported by a grant for the 'Development of detailed methods to evaluate CO_2 budgets in forest and ocean ecosystems', funded by the Ministry of Agriculture, Forestry and Fisheries in Japan. If all goes well, Dr. Mori's study will eventually provide new information on the physiological changes that plants undergo in modified atmospheres. These changes, e.g. different allocation of chemicals within the plant, could alter their resistance to the pests mentioned above. It is essential to comprehend these basic mechanisms in order to understand the nature of plant behavior in changing environments.

Since his projects in Siberia, one of Dr. Mori's partners has been Hokkaido Dalton Co. Ltd., a company specializing in designing and manufacturing professional equipment for research and experiments. Once again, the expertise of Mr. Tatsushiro Ueda from Hokkaido Dalton was needed. Under the guidance of Dr. Mori, sixteen open top chambers (OTCs) in total were designed and built on the test grounds of the Tohoku Research Center. The growth of identically cloned cuttings of a hybrid larch, a cross between Japanese larch (Larix kaempferi) and Dahurian larch (Larix gmelinii), is monitored in these chambers. The cuttings are grown in four different environments: two with different atmospheric carbon dioxide levels and two with different levels of soil nutrients.

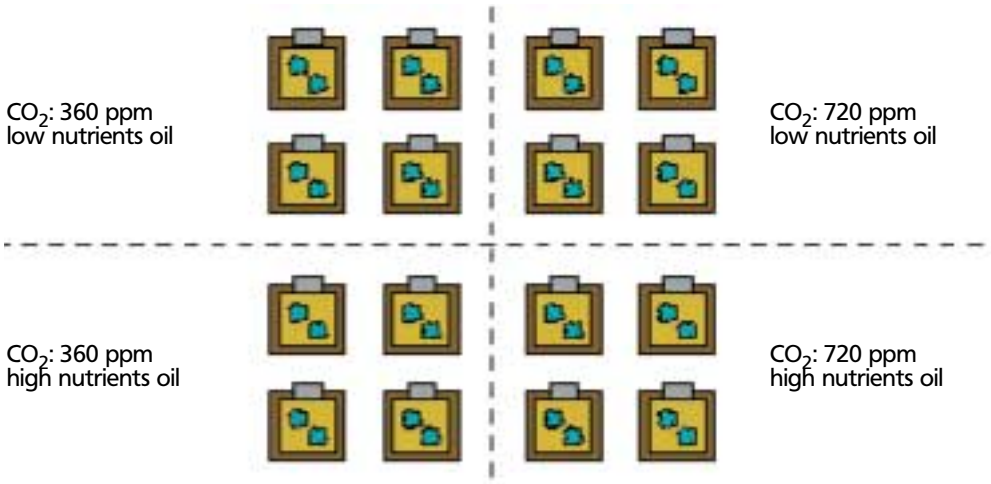

Figure 1: Four different growth environments are monitored.

After four years of growth monitoring, the small trees will be cut down and analyzed thoroughly. In the growth chambers, the plants are subject to outside temperature, humidity and rainfall. As an OTC is closed in at the sides by transparent plastic film, the air that circulates around the plants can be enriched with a particular gas; in this case, carbon dioxide.

CARBOCAP® technology for research use

To provide sufficiently reliable data for a scientific project, sets of four chambers all have the same gas and soil composition. Therefore, a total of sixteen chambers was needed (Figure 1). The carbon dioxide concentration of each chamber is measured by individual Vaisala CO_2 transmitters fitted in the chambers. Half of the chambers are maintained at near atmospheric background concentration of 360 ppmvol and the rest at an enriched environment of double background concentration, 720 ppmvol. The Hokkaido Dalton control system and carbon dioxide bottles needed for the enrichment are in a small hut adjacent to the chambers. The control system not only precisely regulates the CO_2 levels of the OTCs, but is also equipped with data logging for all important parameters.

Dr. Mori and Mr. Ueda were previously familiar with Vaisala instruments, as the FFPRI has used them in several projects. "Everyone involved in producing important environmental measurements knows Vaisala," says Dr. Mori. Up until now, Vaisala products have been used by the institute to measure more traditional weather parameters, including barometric pressure, humidity and temperature. In these new chambers, Vaisala's innovative CARBOCAP® technology has been harnessed for research uses. This was only natural because dependability and good long-term stability were the decisive factors in the choice of the CO_2 transmitters.

Continuing the search for clues

It will be several years before final conclusions will have been made in Dr. Mori's and Mr. Ueda's current project. In the meantime however, the Forestry and Forest Products Research Institute will actively search for answers. One of their ambitious targets is to calculate the carbon dioxide balance of the entire Japanese forest system, by 2002.

Just as there are many factors involved in causing global warming, many answers are also required to solve the puzzle. The joint efforts of the FFPRI research centers are making a difference in this crucial issue, and Vaisala is pleased to offer any assist it can. ■

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