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Aerobic Methane Production by Banana Plant

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ABSTRACT

Previous conclusions about the global methane budget have been proven incomplete with the discovery of large methane emissions coming from tropical rainforests during the dry season and by the findings of Frank Keppler and his colleagues, that certain plants are a source of aerobic methane production. Since methane is a greenhouse gas, these studies could have important implications for global warming. I studied methane emission from the leaf of a banana tree (*Musa acuminata*), a plant prevalent in the tropics, using gas chromatography with a flame-ionizing detector. Banana leaf samples were incubated in 22 mL glass vials, in the dark at 30°C. Banana leaf samples were also incubated in 22 mL glass vials in the presence of 300 μmol/s•m^2 of light at 30°C. Methane concentrations in the vials were measured at T=0 and 24 hours. Using the paired t-test, the data from the experiments were analyzed. The results indicated that there was a statistically significant increase in aerobic methane production by the banana leaf samples kept in the 300 μmol/s•m^2 of light (P=0.00727) and not a statistically significant increase by the samples incubated in the dark (P=0.0959). The statistical significance of the samples incubated in the light improved when the mass of the leaf samples were accounted for (ng CH_4/g of leaf), further justifying the results (P=0.00473). Mean (low/high) values of emission rates for the samples incubated in the light were 2.08 (-3.35/7.77) ng per g (dry weight) h^{-1}. These values readily correlate with the emission rates found by Frank Keppler and his colleagues, which were stated as "typically ranging from 0.2 to 3 ng per g (dry weight) h^{-1}". My results suggest that the aerobic production of methane by plants may be more active with light. These results, along with the findings of other scientists may put more emphasis on the importance of the Kyoto Protocol and the global need to reduce greenhouse gases.

Keywords: *methane, greenhouse gas, aerobic methanogenesis*

INTRODUCTION

Anthropogenic activities have accelerated the amount of methane released into the air over the last 50 years. Methane is an important greenhouse gas because of its longer atmospheric half-life than carbon dioxide and its strong absorption of infrared radiation. Methane also is the most abundant trace gas in the atmosphere (a mixing ratio of ~1.8 p.p.m.) (Keppler, 2006). It was thought that the significant sources of methane emissions were known, including natural wetlands, rice agriculture lands, ruminant animals, and energy production. Recently, however, there have been studies indicating that there is an unrecognized source of methane that has been unaccounted for. This concept was initiated by Frankenberg and his colleagues when they determined higher than expected methane concentrations above tropical regions during the dry season. In their findings, they used a space-borne global methane detector, SCIAMACHY (scanning imaging absoption spectrometer for atmospheric chartography) for their CH_4 readings. They noted a strong relationship between areas of unusually higher methane concentrations and the presence of evergreen forests (Frankenberg, 2005). It was previously thought that methanogenesis was a strictly anaerobic, bacterial process. In January 2006, Frank Keppler and his colleagues at the Max-Planck Institute for Nuclear Physics in Heidelberg, Germany published evidence of aerobic methanogenesis by certain plants, including leaves of ash (*Fraxinus excelsior*), leaves of beech (*Fagus sylvatica*), sweet vernal grass (*Anthoxanthum odoratum*), maize (*Zea mays*), and wheat (*Triticum aestivum*) (Keppler, 2006). It is not yet known if all plants are capable of aerobic methanogenesis. Keppler's results called for a reexamination of the current methane budget, estimating that short-lived biomass and plant litter could potentially contribute 63-243 millions of tons (Tg) of CH_4 per year. The importance of this estimate is easily revealed when the ranges of other major sources are considered: total wet lands (92-237 Tg yr^{-1}), rice agriculture (40-100 Tg yr^{-1}), ruminant animals (80-115 Tg yr^{-1}), and energy generation (75-110 Tg yr^{-1}) (Lowe, 2006). Factors such as sunlight and increased temperature were shown to affect the amount of methane released from the plants in Keppler's experiments. I studied methane emission from the leaf of a banana tree (*Musa acuminata*), a plant prevalent in the tropics, using gas chromatography with a flame-ionizing detector (FID).

MATERIALS AND METHODS

For my standard I used a known concentration of 15 ppm CH_4 in air (Scott Specialty Gas, Plumsteadville, PA). My r^2 value was 0.9982. I collected banana leaf (*Musa acuminate*) matter and prepared it using an aseptic technique similar to Keppler (Keppler, 2006).

Then I cut the banana leaf into 20 sample pieces of approximately 0.2 g per piece. I placed the samples into 22 mL glass vials and capped with gastight tops containing rubber septa. I incubated the banana leaf samples in the dark at 30°C. I took readings of methane concentrations at T=0 and 24 hours using a gastight syringe. Then I measured CH_4 concentrations using gas chromatography with flame-ionizing detector (FID). Finally I dried the plant matter in a 105°C oven to a constant mass. For my second experiment I repeated the experimental steps described above but incubated the banana leaf samples in 300 µmol/s•m^2 of light at 30°C.

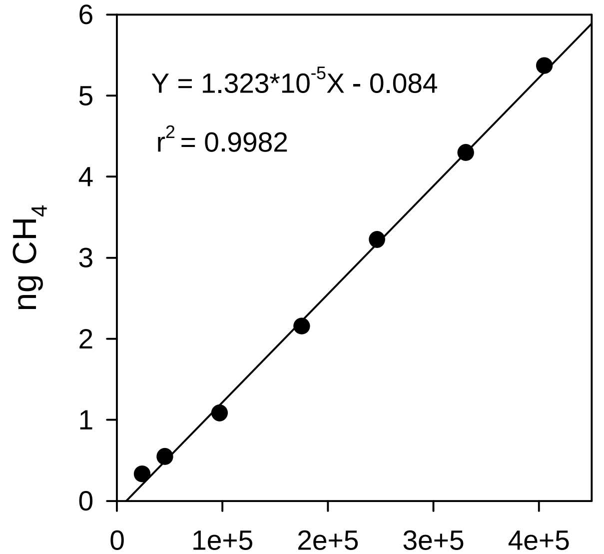

Figure 1. Methane standard curve. Sample CH_4 concentrations fell between 30 and 50 µL.

RESULTS

Using the paired t-test, the data from the experiments were analyzed. It showed that the banana leaf samples incubated in the dark did not show significant aerobic methane production (P=0.0959). The banana leaf samples incubated in 300µmol/s•m^2 of light did show a significant increase in methane concentration (P=0.00727). The statistical significance of the samples incubated in the light improved when the mass of the leaf samples were accounted for (ng CH_4/g of leaf), further justifying the results (P=0.00473). Mean (low/high) values of emission rates for the samples incubated in the light were 2.08 (-3.35/7.77) ng per g (dry weight) h^{-1}. These values readily correlate with the emission rates found by Frank Keppler and his colleagues, which were stated as "typically ranging from 0.2 to 3 ng per g (dry weight) h^{-1}" (Keppler, 2006).

DISCUSSION

Banana (Musa acuminate) plant is a significant source of aerobic methane production in the presence of 300 µmol/s•m^2 of light. Due to the greater variability in the data collected from the dark experiment, my technique may have improved as I went along in the experiment. Therefore I cannot be sure if the statistical significance of the dark run is due to experimental error on my part or due to the biology of the situation. However, due to the lesser variability in the light run, I can be sure that the results of statistical significance are correct.

It is still not known if all plants possess the ability of aerobic methanogenesis. Plants producing the greenhouse gas methane is not a new event, however the discovery of another

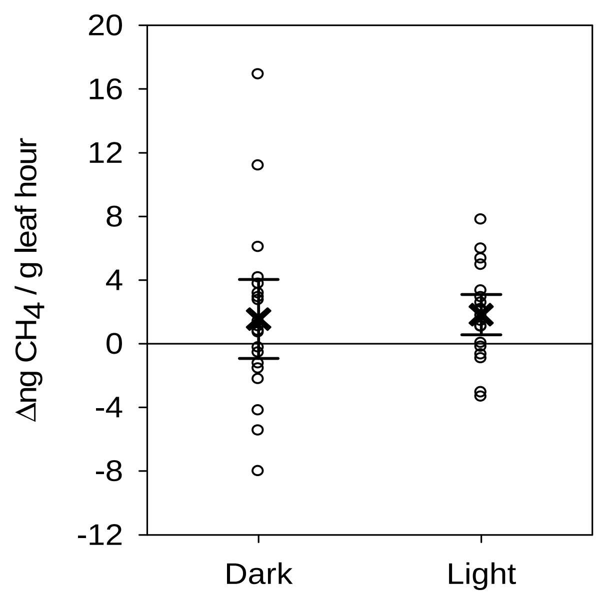

Figure 2. Change of CH_4 concentrations per gram of leaf per hour for the plant samples incubated in the dark and in 300 µmol/s•m^2 of light at 30°C. The mean of both sets of data are indicated by the **X**'s and the 95% confidence levels are indicated by the bars.

significant source of methane emissions is very important. Estimated emissions for terrestrial plants may constitute 10-30% of the annual total of methane released in the atmosphere (Lowe, 2006). While the mechanism of aerobic methane production in certain plants is currently unknown, it is thought to involve pectin (Keppler, 2006). Another interesting idea is the terms of the Kyoto Protocol which stated that reforestation may be used as a CO_2 sink to counteract the emissions of greenhouse gases (Lowe, 2006). While I am in favor of rebuilding our forests, it may now be evident that reforestation would only enhance the greenhouse effect. Therefore, the only practical solution seems to be to reduce anthropogenic greenhouse gas emissions.

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