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CARBON DIOXIDE EVOLUTION FROM ORGANIC MULCHES

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Carbon dioxide is often the limiting factor for plant growth in closed greenhouses (3). One of the major benefits from organic mulches in greenhouses has been the CO_2 evolved during the period immediately following application (4, 5, 6, 7). In the literature available to the author, there was no evidence of a study comparing CO_2 evolution from a series of mulches. This study was designed to compare CO_2 evolutions from mulches of straw, manure-straw, and pine shavings in relation to plant growth.

MATERIALS AND METHODS

Air tight polyvinyl plastic growth chambers were constructed, each with a 27 cu. ft. capacity. Eight mil polyvinyl was used to enclose a 3 foot cubic framework of 1 by 2 inch pine boards. A removable top piece of polyvinyl served as an opening for these chambers. The lid was sealed to the chambers with petroleum jelly and held tight with twine.

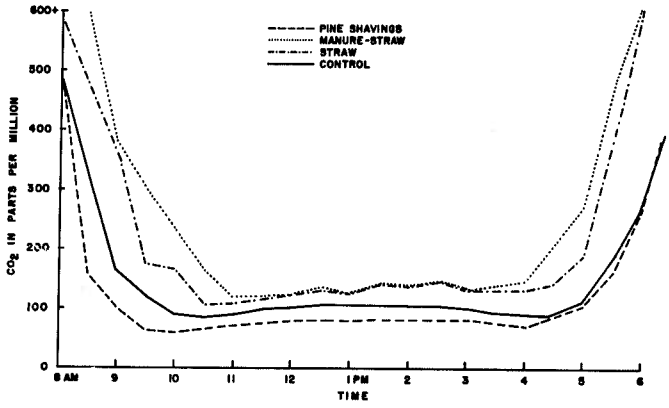
Dry weight equivalent portions of the mulching materials (2323g) were placed in the bottom of three chambers. The control chamber contained no mulch. Small M.O. Greenhouse hybrid tomato plants were planted in 10 inch pots containing volcanic scoria. Nine pots were set on top of the mulch in each chamber. Artificial medium was used in preference to soil because of significant evolution of CO_2 from some soils (1).

The chambers were sealed on March 9, 1963 and the CO_2 concentrations were monitored continuously until March 29 by the method described by Goldsberry (2). Temperatures in the mulches and in the air surrounding the plants were measured by copper-constantan thermocouples shaded by aluminum foil cylinders with lids. A small fan was installed in each chamber to mix the air and thus give more accurate temperature measurements. Water and a complete nutrient solution were supplied to individual plants by means of polyethylene tubing. Daily solar radiation was measured in $g/cal/cm^2$ by an Eppley pyrheliometer. An earlier experiment in January and February served to establish these methods.

1/ Martyn Caldwell completed this experiment while a senior undergraduate student at Colorado State University under the direction of W. D. Holley, Professor of Horticulture.

RESULTS AND DISCUSSION

A study of the CO_2 concentrations in the chambers throughout the day (figure 1) shows that minimum levels were reached by 11 a.m. Figure 2 was plotted to show the CO_2 concentrations in all chambers at 11:30 a.m. throughout the experiment. The relative rates of CO_2 evolution from the mulches is indicated by the number of days the concentration in a chamber remained above 600 ppm. Figure 2 shows manure-straw to be the best source of CO_2, followed by straw and pine shavings. The CO_2 concentration in the control chamber immediately dropped below that of atmosphere and remained at a low level. After March 19 (after the initial high evolution period) manure-straw and straw mulches were still producing appreciable CO_2 thereby better supplying increased demands by larger plants produced in these chambers (figure 2). CO_2 from pine shavings did not supply the demands of these larger plants after March 18. As a result the concentration in this chamber dropped below that in the control chamber.



igure 1. Mean CO_2 concentrations in the four chambers for 8 sunny days near the end of the experiment.

The mean CO_2 concentrations each half hour for 8 sunny days toward the end of the experiment were plotted in figure 1. The days selected for this mean received a minimum of 420 g/cal/cm^2 of solar radiation. The concentrations in the manure-straw and straw mulch chambers remained higher than those in the control chamber even though vegetation was approximately 4 times as great by this time. The concentration in the chamber containing pine shavings was lower than that of the control, again indicating that CO_2 evolution was not keeping up with the initial increased growth and greater demands for CO_2 in this chamber.

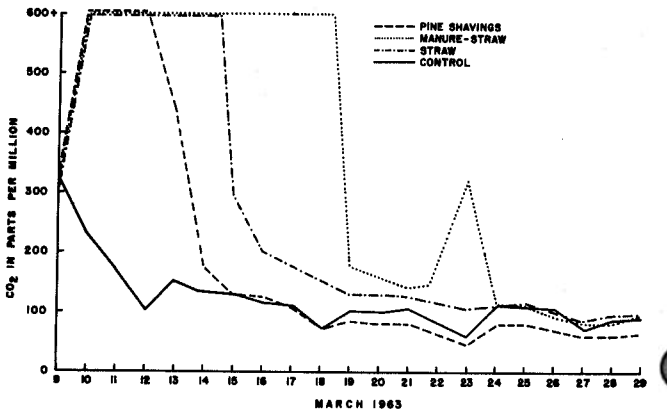


Figure 2. Daily CO_2 concentrations at 11:30 a.m. for all chambers.

The relative size of representative plants grown in the four chambers is shown in figure 3. Mean dry matter per plant at the end of the experiment was 27.0g for the control, 46.7g for pine shavings, 103.1g for straw, and 118.8g for manure-straw. Plant size and dry matter production clearly substantiated the CO_2 measurements. With the exception of temperature, all other factors affecting growth in these chambers was nearly identical. Air temperatures and mulch temperatures were the same on nights and cloudy days. On high light days, air temperatures varied as much as 5°F. between chambers (93° to 98°F). Since no consistent pattern of variation was evident, the possibility of temperature affecting the results is highly improbable and the plant differences in the chambers are attributed to differences in CO_2 evolution from the mulches.

The relative humidity of nearly 100 percent in all chambers at all times and high temperatures during sunny days were conducive to rapid decomposition of mulches permitting a quick comparative study. Further research is needed under conventional greenhouse environments to furnish the grower with information on the relative effectiveness of different mulches as sources of CO_2. The quantity of mulch used in this experiment was approximately 10 times that used in commercial mulching practice.

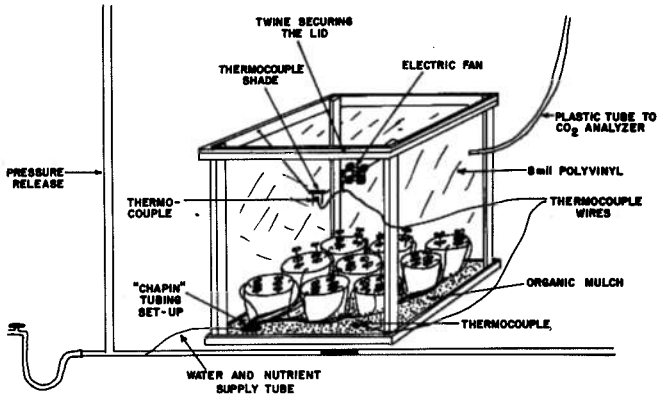


Diagram of one of the growth chambers

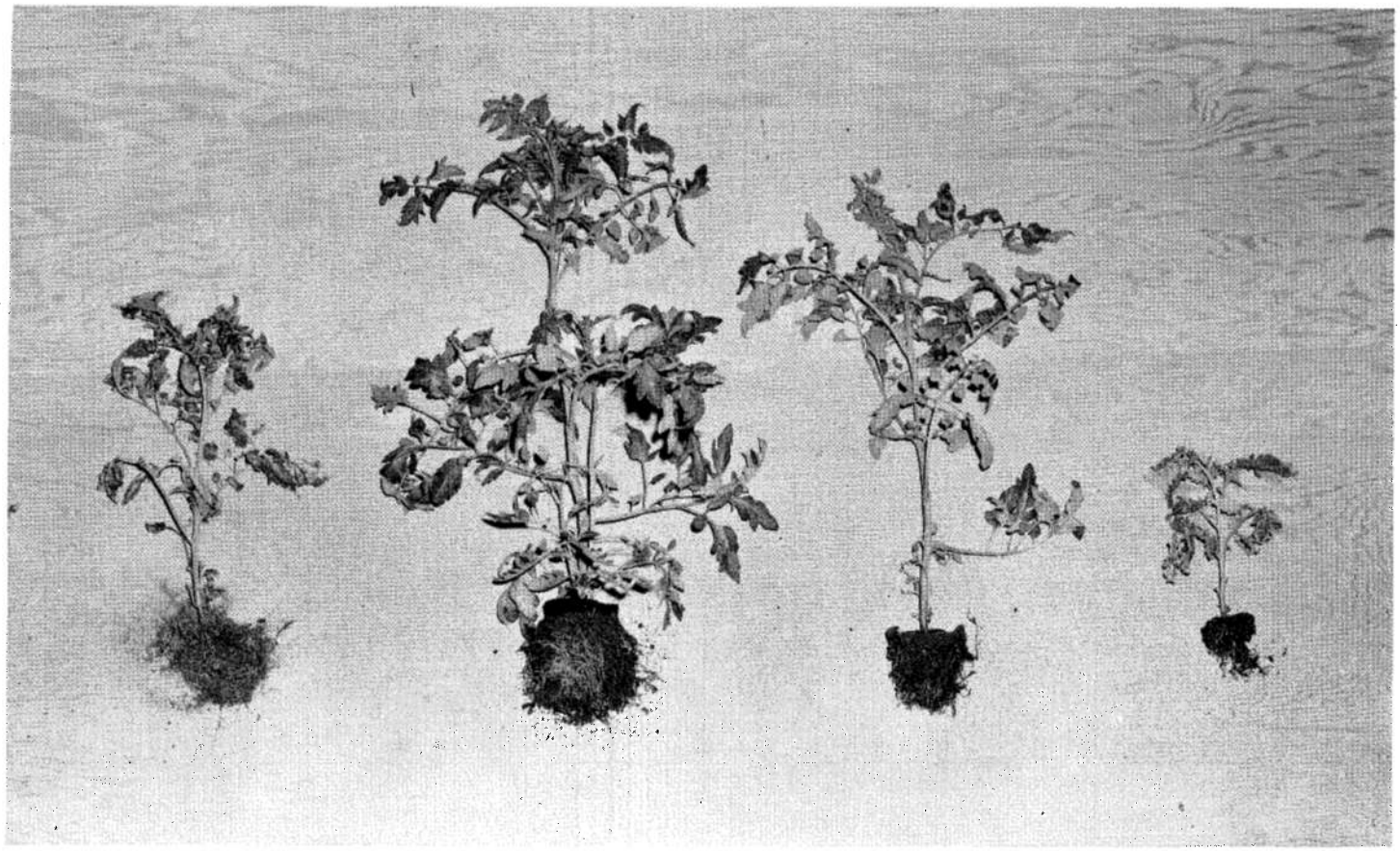


Figure 3. Relative size of plants after 20 days of growth in the chambers mulched with, from left: pine shavings, manure-straw, straw, and control.

SUMMARY

Air tight polyvinyl growth chambers were used to compare CO_2 evolution from straw, manure-straw, and pine shavings mulches. Tomato plants growing in these chambers utilized the CO_2 produced by the decomposition of the mulches. CO_2 concentration measurements from each chamber indicated the relative evolution rates. Manure-straw was found to produce the most CO_2, followed by straw. Pine shavings produced the least CO_2. Plant size and yield of dry matter substantiated these results.

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Your editor,
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