COMPARATIVE TRANSPIRATION OF TOBACCO AND MULLEIN.

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Comparative studies of the transpiration rates of Tobacco and Mullein have been carried on during the winters of 1917 and 1918 in the Ohio State University Botanical Greenhouse and Laboratory under the direction of Dr. E. N. Transeau. These experiments were performed with special apparatus designed by him and described in the *Botanical Gazette*, Vol. 52, on pages 54 to 60. By means of this apparatus it is possible to obtain a continuous record of the water loss from sealed potted plants. As many as six different plants can be used at one time.

Continuous records of the common environmental factors influencing transpiration were also obtained by the use of recording instruments; temperature, humidity, duration of sunshine, evaporation and wind velocity. From these records of transpiration from the plants and of variations in the environmental factors, certain conclusions have been drawn concerning the relation of the hairy coverings on the mullein leaves to the resistance of the plant water loss, the relation of the stomata to transpiration, and the daily rhythm of the transpiration curve. Figure 1 shows the results of one of the experiments which was performed in the greenhouse. These curves show the method of expressing the results. The details and records are contained in a paper to be published elsewhere.

When compared with a similar thin-leafed tobacco plant (*Nicotina* sp.) the following conclusions regarding the resistance of the mullein leaves (*Verbascum thapsus*) to transpiration were obtained.

1. Mullein leaves offer greater resistance to water loss in darkness than in light.

2. Mullein leaves offer less resistance to water loss in wind than in still air.

3. Mullein leaves respond as much or more to changes in the environment as to tobacco leaves.

When compared with another individual of the same species, the removal of the hairs from mullein leaves produced the following effects:

4. The removal of the hairs from the mullein leaves does not alter the resistance of the leaves to water loss in still air and light.

5. The removal of the hairs slightly decreases the resistance of the leaves to water loss in wind and light when compared with still air and light because the cuticular surface is more exposed to the air.

6. The removal of the hairs greatly decreases the resistance of the water loss in still air and darkness as compared with still air and light, due to the cuticular surface being more exposed, because the water loss in darkness is entirely from the external surface, the stomata being closed.

7. Hairs as "protective" covering against ordinary intensities of wind and light on mullein may be disregarded. The water loss from the leaves is mostly from the internal (mesophyll) surface of the leaves and not from the external hairy surface. The internal water loss is from twenty to forty times greater than the external or cuticular water loss. The removal of the hairs increases total transpiration only to the extent that the cuticular surface is more exposed, and has apparently no effect on stomatal transpiration.

A record of the size of the pore openings of the stomata was obtained by measuring camera lucida drawings of the pores. The drawings were made from small pieces of epidermis from a plant which was under the same conditions as those used in the measurement of the water loss. Small pieces of the epidermis were stripped from the under side of the leaf and immediately put in absolute alcohol. Samples of the epidermis for different hours of the day were treated in this way, and later mounted in absolute alcohol and a representative number of the pore openings quickly drawn on white paper under the high power of a microscope with the aid of a camera lucida. These drawings were measured and the figures reduced to their actual size in microns. The results were expressed both in terms of the total area, (square microns) and in terms of the length of the peripheries (microns) of the pore openings. Curves of these values were then plotted for the day on cross section paper.

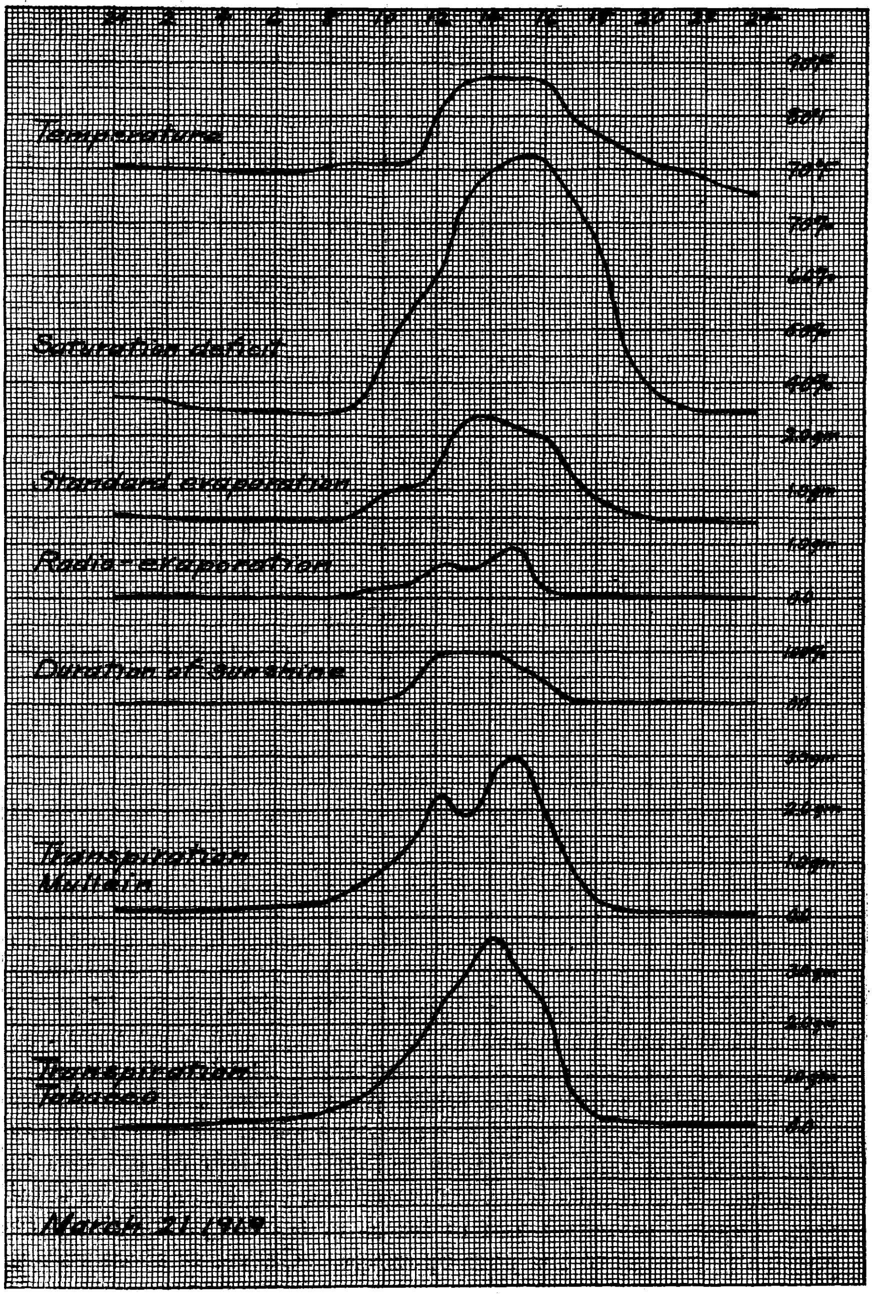

Fig. 1. Curves from one of the experiments showing the daily variation in the transpiration in tobacco and mullein and the variations in the environmental factor for the same period.

The total water content of leaves for each hour of the day from a similar plant was obtained by removing leaves at the different hours and determining their water content by weighing and drying to constant weight.

A curve was then plotted for each of the following factors: temperature, saturation deficit, evaporation, duration of sunshine, leaf water deficit, area of stoma, periphery of stoma, and the transpiration of the plant. The ordinates for each of these curves were reduced to the same scale and the transpiration curve was superimposed over each of the other curves. This makes possible a comparison of the different limiting factors controlling transpiration from muellin and tobacco.

These records show that the differences between the night and day rates of water loss from mullein and tobacco are largely due to the diffusion of water vapor through the stomatal pores. Transpiration from the leaf at night is cuticular and the rate is controlled by the temperature and humidity of the air. But the day rate is controlled by several factors operating to increase or decrease the rate. When the stomata open, the diffusion gradient (the difference between the intercellular saturation and atmospheric saturation deficit) causes a sudden rise in the rate of water loss. This rate continues until the leaf water deficit decreases the diffusion gradient by increasing the resistance of the mesophyll cells to water loss. After the leaf water deficit reaches a certain point (about noon) there are two factors, leaf water deficit and decreasing stomatal pores, operating to reduce water loss and only one factor, diffusion gradient, tending to increase it. This results in a rounded curve. After the saturation deficit reaches a maximum there are three factors, decreasing diffusion gradient, decreasing stomatal pores, and leaf water deficit, operating to reduce water loss with none of the factors opposing them. A rapid decline in the rate of water loss from the plant follows and the night rate is reached before the stomata are fully closed.

While performing the experiments on the relation of hairy coverings to the resistance of the leaf to water loss, a rhythm in the transpiration curve was noticed in certain cases where a plant was placed in the dark room and allowed to remain in total darkness during the following day. This rhythm was shown by a rise in the transpiration curve at the time the stomata usually opens at daybreak. It reaches a maximum about the middle of the forenoon and falls back to the normal night rate at about noon, although the plants were under conditions of constant temperature, saturation deficit, evaporation and total darkness.

A number of experiments were performed which show the conditions under which this rhythm takes place. Tobacco and mullein show a rhythm in the transpiration curve in total darkness when preceded by a day of normal light conditions, while moth mullein under the same conditions does not show this rhythm. This rhythm in tobacco and mullein does not take place on the second day in the dark room. In tobacco this rhythm does not take place on the following day unless the plant is placed in the dark room before noon. It seems, therefore, that this rhythm is due to some definite internal condition and that certain plants show it while others do not. Different plants were used in each experiment and all the plants of a given species agreed in their behavior. The cause of this rhythm is most likely in stomatal activity, but because of the large errors in measuring stomatal movements as compared with the small movement that is necessary to produce this rhythm this fact has not been satisfactorily established.

CORRECTION.

In the November, 1918, JOURNAL OF SCIENCE, Vol. XIX, No. 1, p. 61, in the second paragraph and the second line of the paragraph for the word "family" read "class *Edrioasteroidea*, Billings."

On page 77, in the next to the last paragraph, the citation from Bather is a mistake of the author's. Mr. Bather does not hold the views there ascribed to him. I have Mr. Bather to thank for these important corrections.

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