THE RELATION OF STOMATAL MOVEMENT TO THE DAILY MARCH OF TRANSPIRATION

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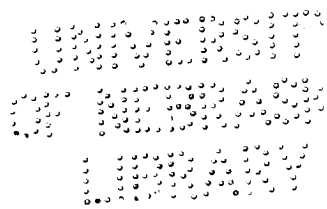

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Introduction

A great deal of literature is at hand dealing with transpiration of plants and transpiration as related to various phases of plant activity. Although much has been done, undoubtedly, much more of especially detailed work will follow. Transpiration is so closely connected with other plant activities that it is difficult to ascertain just how far it affects these activities or is affected by them. It has been studied and investigated extensively from as early as 1727 by Hales (6) to the present time.

The results up to 1904 are to be found in Burgerstein's work (1). In more recent years, more attention has been given to the physical environmental factors (17) in connection with the behavior of transpiration to find how it is affected by them.

Livingston (8) sought to find to what extent stomata are influential in causing the transpiration rate to be relatively greater by day than by night. By measuring stomatal pores and calculating the relative diffusion capacities for night and day he found this capacity to be

2.6 times as great by day as by night. He also worked out that the greatest difference in the evaporating power of the air for day is six times that of night.

He concludes, "In diffuse light the variation in stomatal sizes is great enough to explain that portion of the rise in transpiration rate which is not dependent upon the variation in the evaporating power of the air - but in direct sunlight the variation is too small".

In Muenscher's investigation (13) on the relation of transpiration to the number and size of the stomata, he concludes that there is no constant relation between the amount of transpiration and the number of stomata per unit of leaf surface. This was a rather extensive piece of work on several plant species.

Among the more recent works we have that of Lloyd's Physiology of Stomata (12). Parts of two desert plants were used, namely, Verbena ciliata and Fouquieria splendens. Transpiration and stomatal changes were made note of and special attention was given to the physiology of the guard cells. Briefly his conclusions were, as regards stomata and transpiration, that the former do not regulate or control transpiration.

Darwin (4) in observing stomata made use of the horn hygroscope. He did not think that the microscopic method of observing stomata was reliable. On the other hand the hygroscope he interprets as showing in a measure the

stomatal pore area by the amount of water transpired through them. This, no doubt, is a good quantitative measurement of transpiration but it seems too unreliable as regards the sizes of pores. Livingston (8) has done much, also Livingston and Estabrook (7). The two together worked on the degree of stomatal movement in certain plants.

A rather comprehensive study of transpiration and how it is affected by certain rusts, by Weaver (17) brings out valuable and interesting information on transpiration behavior of certain rust infected plants.

The relation of movement of stomata to infection by Cercospora beticola (14) reveals some points which may be of great economic importance to the beet grower in particular.

Eckerson's work (5) on the size and number of stomata on several plants is a good guide for selection of stomata; also Clapp's (2) results on actual amounts of water lost by some thirty species of plants are valuable for comparison. Many other articles and papers bearing perhaps less directly upon stomatal movement in relation to transpiration will be cited as reference is made to them.

Transpiration is defined as the loss of water vapor through plant parts. No one questions now but that the greatest amount is lost through the stomata. The question thus presented itself as to whether or not there is any

constant relation between the stomatal movement and the daily march of transpiration. With this in view the following investigation was carried out:

Methods

Preliminary work was begun during the winter months of 1916-17. This consisted chiefly of practice work to insure more skillful manipulation in the study to follow. The experimental work was completed July 19, 1917.

The early work consisted of taking stomatal measurements from green house plants as no field plants were then available. Species of the following: Pelargonium, Narcissus, Vinca, Oxalis, Petunia, Begonia and Tradescantia were used. One finds that some plants will permit the removal of epidermis much more easily than others - in some it is almost impossible to separate epidermis from chlorenchyma cells. Again we find stomata that are decidedly clear and distinct in some plants while in others accurate measurements are alsmost impossible. In both of these respects Tradescantia is especially good. Pelargonium and Petunia follow closely, the others are not quite so desirable. No transpiration records of these plants were made, therefore no conclusions can be drawn. Results from plants in the field were preferred, for there we find plants in their normal habitats.

As soon as field plants were available, many were experimented upon as the above mentioned green house plants had been. Here, too, as might be expected, we find plant

tissues varying in the density with which the epidermis clings to the adjoining cells, also variation in clearness and distinction of stomata. Although much excellent material was found, the selection was limited to the following: Plantago major, Taraxacum taraxacum, and Helianthus annuus. These plants in addition to having the above named qualities are abundant and can be found almost everywhere in this locality.

Young plants were brought in from the field and potted. The soil used was a mixture of sand and loam. Plants were well watered and set out in a shady place to recover from the shock of being transplanted. Later they were moved away from continual shade. After they had adjusted themselves to the new situation and growing well they were again repotted. This time into tight tin cans as containers. In the bottom of each can was put coarse gravel to a depth of about one centimeter. A glass tube about one inch longer than the depth of the container, and with a diameter of 3 millimeters was fastened vertically inside of the container with sealing wax. This tube as well as a second one similarly placed opposite it, extended down into the gravel. The purpose of these tubes was to permit the watering of the plants after the container was sealed. Sealing consisted of covering the soil surface to prevent the escape of any moisture from the container by any pathways except through the plants. For sealing materials paraffin with a high degree melting point was used. A

mixture of four parts paraffin and one part petrolatum is quite satisfactory. Any seal that will cover the soil and cling to the edge of the container and to the stem of the plant is good. In using paraffin one must be careful not to apply it too hot to the stems of plants. This can be avoided by letting it cool, then applying it next to the stem. If one finds this is not air tight this can be remedied by heating a scalpel or knife blade and with it carefully melting again the paraffin next to the stem. The sealing material must have a sufficiently high degree melting point to withstand the rather extreme temperature of our summer days.

Plants now were ready for the experimental work. Stomatal measurements as well as transpiration data were taken from plants similarly potted and placed in some environment.

Stomatal measurements were made in accordance with that of Lloyd (12) also Eckerson (5) and Renner (15). This method consists of stripping off bits of epidermis with a pair of sharp-pointed tweezers and plunging them immediately into absolute alcohol. Ninety-five percent alcohol has been used successfully (7) but in this work the absolute alcohol was used throughout.