This rust was collected on an isolated clump of Panicum virgatum, in the same region as that in which P. vexans was found. The date of the formation of teleutospores was not obtained owing to the destruction of the grass by fire.

8. Aecidium Pammelii Trelease. On Euphorbia corollata L. Tippecanoe County.

This aecidium was collected June 9, 1901, on plants of E. corollata, which were growing in close proximity to the clump of P. virgatum that was affected with the rust P. panici. The absence of any other aecidium suggested to the writer that possibly this was the aecidial stage of P. panici. Accordingly some of the affected Euphorbia leaves were collected and inoculations made upon potted plants of P. virgatum in the station greenhouse. Leaves of these plants were inoculated June 11 and 14, the latter being made with freshly collected material. In each instance well-developed uredosori were obtained in eight days from the time of infection. As both inoculations were entirely successful, it would appear reasonably certain that A. Pammelii on E. corollata is the aecidial stage of P. panici on P. virgatum.

9. Aecidium physalides Pk. On Physalis heterophylla Nees. Tippecanoe County. Collected May 22, 1901.

The writer wishes to acknowledge his indebtedness to Dr. Arthur for the determination of the rusts.

Effect of the Composition of the Soil Upon the Minute Structure of Plants.*

Herman B. Dorner.

The growth and distribution of plants are dependent upon four factors, namely, light, temperature, moisture and soil. Under moisture are included both that of the soil and that of the atmosphere. Soil and moisture may well be treated together, since the one is greatly dependent upon the other. In the work carried out, the only factor which was varied was that of the soil.

The changes occurring in plant structures, due to the variation of any of these factors, may be divided into two groups. These may be con-

*An abstract from a thesis presented to the Faculty of Purdue University for the degree of Master of Science.

veniently called *permanent* and *temporary* changes. By permanent changes are meant those which have become fixed in the plant and are due to generation after generation being subject to the same conditions. By temporary changes are meant those which have taken place for only a generation or two and which have not become impressed upon the plant to such an extent but that it will again revert to the normal on being placed under the former conditions. To this latter group belong the temporary reduction of leaf surfaces, stunted growths, and other similar changes. It is only this latter group which can possibly figure in the work carried on.

The study of the gross changes, due to the variation of soil conditions, has always been one of great interest to the botanist. These changes may be seen in nature all about us and often the vegetation of a region will give, to the trained eye, the conditions of the soil. The soil is now studied, not by chemical analysis, but by what will grow upon it.

The object of the experiment has been to determine whether these variations in the soil have given other than gross changes. Although the minute differences were the main object in view, all gross changes, which occurred, were noted in order to trace their connection with the minute ones.

The soils used in the experiment were a good, dark loam, a good yellow clay, and a clean pit sand.

The loam used contained only a very small quantity of sand and was taken from a field which had been under cultivation for a number of years, but to which little or no manure had been added for some time. It contained a large amount of silt and humus.

The clay also contained a very small quantity of sand and was secured only a short distance from a brickyard. The soil, however, was a little too light for brick-making.

The sand was a clear pit sand, not over sharp or very coarse. On washing it showed very little silt or foreign substances.

The other three conditions, temperature, light and moisture, were kept, as nearly as possible, uniform for all.

In watering, great care was taken to keep them in the best growing condition. The plants were only given water when they required it, so that in no case were they overwatered or allowed to dry out more than possible.

The plants were grown in a greenhouse with a day temperature of about 21 degrees C., and a night temperature of about 16 degrees C. However, on bright, sunny days, the temperature went as high as 27-30 degrees C.

The plants were arranged upon the bench with enough distance between them to allow them to receive light from all sides. This was necessary in order to avoid distortions due to overcrowding.

In selecting the plants, an attempt was made, as far as possible, to select only those which were representatives of large families. Those used were the carnation, chrysanthemum, geranium, bean, corn, and the onion. At the same time they also represent three modes of reproduction; namely, by seeds, by bulbs, and by the ordinary cutting or slip.

In making a study of the gross difference the following points were noted: The size of the plant, the length of the petiole, size and color of the leaves, diameter of the stems, length of the internodes, and size and abundance of the roots. For the minute differences, the structures of the leaf, stem, and roots were studied.

In counting the number of stomata sections were taken from various parts of the leaves. The sections were then placed under the microscope and a spot chosen at random. Twenty counts were made for each side of the leaf and the average taken.

The bulbs of the onion and the seeds of the corn and bean were planted directly into the five-inch pots in which they were to remain. On the other hand, the rooted cuttings of the carnation, chrysanthemum, and geranium were first planted in two and one-half-inch pots and later transferred to four-inch pots, in which they were allowed to remain.

A close study of the changes in the gross structure, due to the variations in the soil, show that the effect of a heavy clay upon a plant is almost the same as that of a sand. This may be partly explained by the fact that although a clay soil is very rich in plant foods, the roots find such difficulty in penetrating it that the greater part of it is unavailable. Hence, the plant suffers in the same manner as when grown in sand, which is poor in plant foods.

A change in soil was found to result in:

First.—A decrease in size from the loam to the sand. In all cases the sand produced a dwarfed growth.

Second.—A decrease in leaf surface from loam to sand. In no case was the leaf surface in the sand over one-half that of the loam.

Third.—A variation in color. The clay soil gave a very dark green leaf, while that in the sand was always of a sickly, yellowish green.

Fourth.—A decrease in length of petioles from loam to sand.

Fifth.—A decrease in the diameter of the stem from loam to sand.

Sixth.—A decrease in the length of the internodes from loam to sand.

Seventh.—A decrease in the mass of roots from the loam to the sand with the exception in the case of the onion. However, when the size of the plant is taken into consideration, the mass of roots of the plants in sand was always relatively the greatest.

As a result of these numerous variations, the plants in the sand have a stunted growth above soil and an increased growth in the soil. This is also true of the clay, but not to such a great extent as in the sand.

The changes in the histological structure are not so general. Those which do take place are more for specific rather than general cases. The changes which are general may be summed up as follows:

First.—A decrease in the transpiring surface from the loam to the sand.

Second.—A decrease in the relative size of the woody tissues of the root from the loam to the sand. This decrease was due to a variation in the number of cells rather than to their size.

Third.—A larger number of crystals for the clay soil than either of the other two. This was true in the two plants in which the crystals were found, the carnation and the geranium. These crystals were found both in the stems and the leaves.

Fourth.—A greater wood development in the loam than in either of the others. This increase was not due so much to an increase in the size of the cells as to their number.

There was quite a variation in the number of stomata, but these variations were specific and not general. In some cases the loam had the highest average, in others the clay, but in most cases the greatest number were in the sand. In one case, the corn, the loam showed the greatest average for both sides of the leaf. In the bean, the clay gave the greatest average, while in the onion, carnation and geranium the sand gave the most. (See table.)

In five cases out of the six, the loam gave the thickest leaves. In the sixth case, that of the carnation, the clay gave the greatest average. This increase in thickness was caused by a general increase in thickness of all the tissues of the leaf.

In those plants bearing trichomes it was found that those growing in the loam had the smallest number.

An interesting fact was noted in connection with the development of wood in the carnation. The loam here gave the greatest wood development and the clay the least, while on the other hand the clay showed a heavy band of hard-bast. A decrease in the amount of woody tissue seems to have been followed by an increase in the amount of hard-bast. In the clay specimens where there is such a large amount of hard-bast, the wood is merely represented by a few large vessels and a few wood cells.

In conclusion, it may be said that as a result of the variation of soils, there are more marked changes in the gross than in the minute structure. The changes in gross structure are general for all the plants studied, while the changes in the minute structures are more for specific than for general cases.

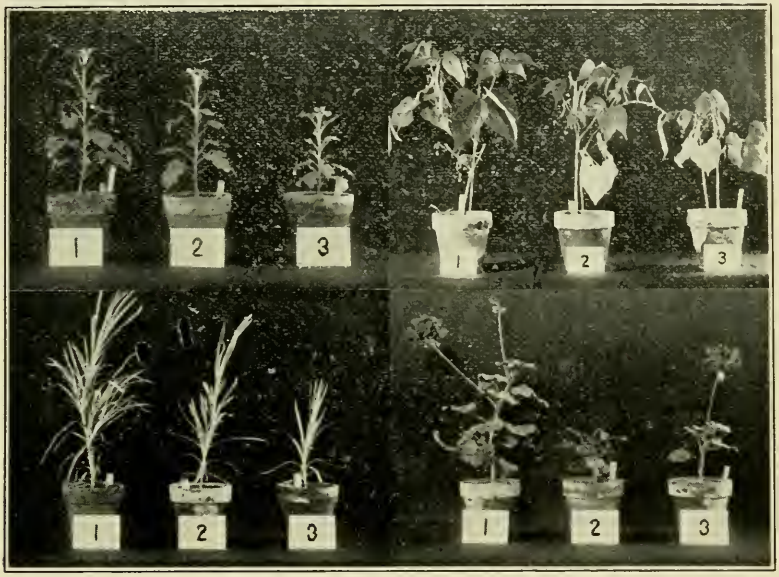
TABLE SHOWING NUMBER OF STOMATA PER SQUARE MM.

	Upper Side.			Lower Side.			Average for Both Sides.		
	Sand.	Clay.	Loam.	Sand.	Clay.	Loam.	Sand.	Clay.	Loam.
Bean	7.2	1.6	3.6	342.8	382.8	162.4	175.0	192.2	133.0
Corn	34.0	32.0	43.6	72.8	63.2	72.0	53.4	47.6	57.8
Onion	....	....	....	85.6	53.2	53.6	.....	.....	.....
Carnation	87.2	88.2	74.6	73.8	69.4	67.6	80.5	78.8	71.1
Geranium	62.4	42.4	35.2	209.8	177.0	195.6	136.1	109.7	115.4
Chrysanthemum*	....	....	....	81.6	97.4	88.2	....	.....	.....

*No count was made for the upper side, as it was impossible to remove the epidermis.

EXPLANATION OF PLATES.

In the illustrations, 1 always represents those plants grown in loam; 2, those in clay; and 3, those in sand.

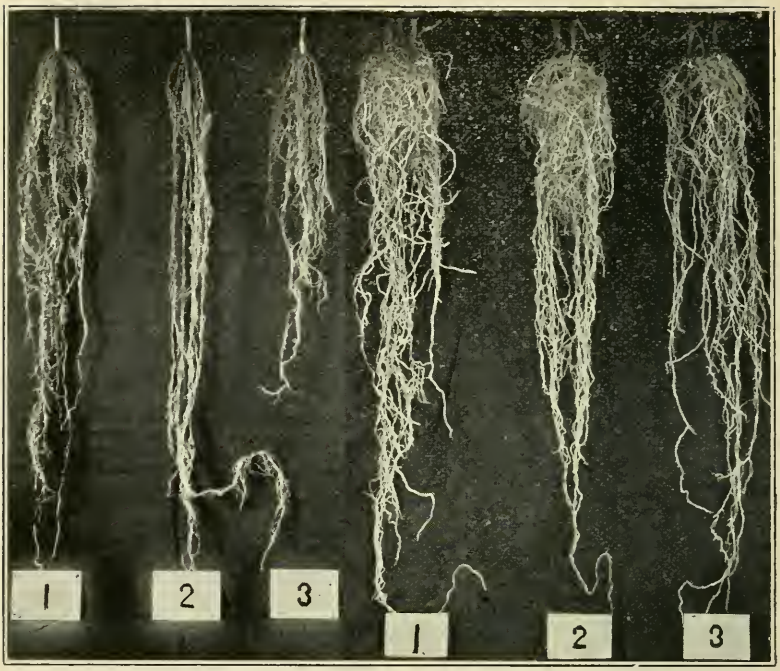


Chrysanthemum.
Carnation.

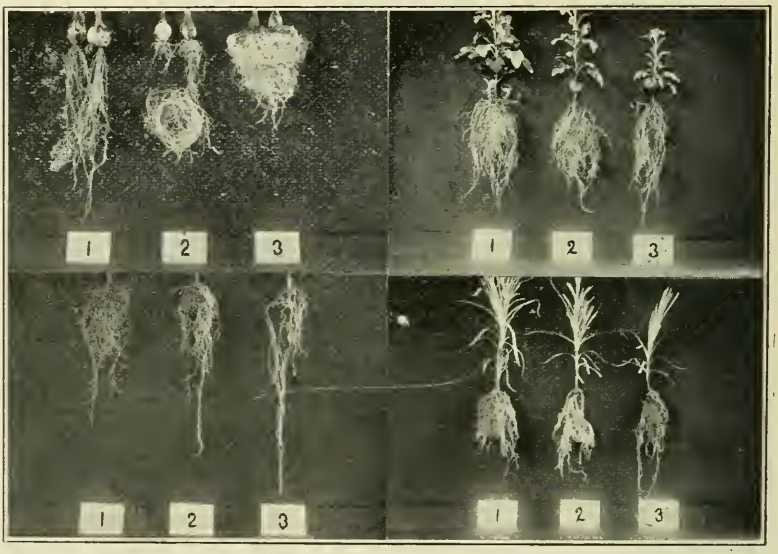
Bean.
Geranium.

Onion.

Corn.



Bean. Corn.



Onion.
Geranium.

Chrysanthemum.
Carnation.