chemistry or physics, in that it is carried on, not in a university laboratory, but in the larger laboratory of out-of-doors and the results therefore are applicable without regard to scale and other uncertainties.

The work done during the year falls under eight sections, namely, (1) the monthly amounts obtained by standard gages, tabulated and analyzed; (2) new type of gage; (3) influence of a Nipher wind shield on the amount collected; (4) the Rochdale deposits; (5) the automatic filter; (6) a jet apparatus for the isolation and examination of atmospheric dust; (7) researches on obscurity and visibility; (8) relations with other organizations.

Thirty-one gages were operated during the year, of which 8 were in London. Data are now available for five years, in many cases, and so comparisons can be made with a view of getting monthly or seasonal departures from mean conditions.

The old unit for amount of deposited matter, namely, the metric ton per square kilometer, has been altered to simplify printing. The amounts heretofore given to two decimal places have been multiplied by 100 and can be read as metric tons per hundred square kilometers and the same figures express the weight in grams over 100 square meters. The gram per square dekameter, $gm/(10m)^2$, seems to be a practical and economical unit.

The year was one of exceptionally fine, clear weather; and also there was a coal strike from April 1 to July 4. The amounts of pollution are below the average and the influence of the coal strike can be clearly traced.

An interesting point brought out by the Rochdale experimental records, is that the impurity of the air is not particularly due to an influx from neighboring polluted areas. By means of twin gages, one collecting material brought by east winds and the other by west winds, it is shown that the high deposit at this place is not due to impurities carried into town by the west wind.

Again during the stoppage of coal and the closing down of factories, duplicate gages made it plain that factory smoke was responsible only for about 66 per cent. of the pollution.

A rough estimate is
Dust 15 per cent.
Factory smoke 66 per cent.
House smoke et al. 19 per cent.

Many interesting graphs are given showing conditions on foggy and non-foggy days.

There is a detailed description of the new jet apparatus dust counter of Dr. J. S. Owens, an instrument which is within reach of the laity.

Near the end of the Report there is a handy bibliography of dust investigations.

ALEXANDER MCADIE

SPECIAL ARTICLES

THE INFLUENCE OF THE TEMPERATURE OF THE SOIL ON THE RELATION OF ROOTS TO OXYGEN

THE rate of root growth of land plants, under normal conditions of aeration, is known to be influenced by the temperature of the substratum in such manner that there are three well defined temperatures of growth, namely, the highest at which growth is possible, the temperature at which growth is most active, and the temperature below which growth ceases. Under conditions of a diminished supply of oxygen, however, these cardinal temperatures of growth appear to be greatly modified. This feature has physiological and ecological bearing of some interest.

In *Potentilla anserina,* which occurs in swampy ground, with the roots in 1.2 per cent. oxygen and the balance nitrogen, the growth of the roots is various. Thus at 27° and 30° C. growth does not take place, but at 18° it is about one fourth normal for that temperature. When given experimental atmosphere containing 2 per cent. oxygen the growth rate is about one fourth normal at 30°, one third normal at 27° and normal at 18° C.

In a garden variety of corn with roots in 3 per cent. oxygen the effect on the rate of growth is quite as striking as in the case of Potentilla. For example, at 30° it is about one sixteenth normal, 20° it is about one fifth normal and at 18° it is about one third normal. When the percentage of oxygen is increased to 3.6 the rate of growth is much increased. For example, at 30° the rate is about one third the expected rate under normal aeration conditions, while at 18° it is about two thirds normal. While in 10 per cent. oxygen the rate at 30° is about nine tenths normal and at 18° it is normal.

In the two species referred to, and the same is true of several species studied, the relative rate of root growth, that is, the rate under given oxygen conditions as compared to the expected rate in normal conditions of aeration, decreases with the increase in the temperature of the soil. It can be seen, therefore, that there comes a point in the diminution of the oxygen content of the soil atmosphere when the growth of the root ceases because it is no longer sufficient to supply the demands for energy correlated with physiological activities of higher temperatures. The diminution of the oxygen supply of a consequence becomes a factor limiting the growth of the root, and which, as the above citations indicate, may have specific value.

Some observations on modifications of the cardinal temperatures for root growth resulting from deficiency of oxygen indicate that the conclusion as stated in the preceding paragraph may in some manner influence such as well. Thus the maximum temperature for root growth of *Opuntia versicolor* is about 42° under normal conditions of aeration, but when the percentage of oxygen is reduced to 1.2 no growth occurs at 30° although it may go on at 20°. This being the case, both the optimum as well as the maximum temperature for growth are greatly reduced.

The optimum temperature for the growth of the shoot in corn is about 33.7° and the maximum temperature is about 46.5°, while the corresponding temperatures for the root are probably somewhat less. In percentages of oxygen less than 10, and except as indicated above, and for soil temperatures below 30°, the growth rate is below normal. However, in 3.6 per cent. oxygen the most rapid growth rate is about 30°, but when the amount of oxygen is reduced to 3 per cent., 20° is apparently about the optimum temperature for growth.

Observations on the relation of the roots of the Rough lemon to the oxygen supply at relatively low soil temperatures indicate that the minimum temperature under certain conditions may also be modified. The Rough lemon has apparently a fairly high minimum temperature for root growth, or at least the rate of growth under normal conditions of soil aeration is relatively slow at 18° C. In 2 per cent. oxygen, however, although growth continues at 26° and at 22°, it does not go on at 20° or at 18° C. In this instance the minimum temperature for growth may have been raised.

The observations above summarized on the relation of root growth to the oxygen supply are apparently in accord with the known variation in the respiratory ratio (of the shoot) which is associated with differences in temperature, being least at those that are medium, that is 15° C., or less.[1]

The ecological bearing of the influence of the temperature of the soil on the oxygen relation of roots can only be suggested. The ecological significance of soil aeration has been referred to in an earlier paper[2] and it need merely be suggested in this place that the oxygen relations of the species with especial regard to the temperature of the soil should also be taken into account. It is quite clear from the summary above given of typical results in relation to several species, and which can probably be extended to other species as well, that in puddled soils with consequent poor aeration, and in summer, the matter of oxygen supply to the roots must be acute. And, in certain species, as, for instance in varieties of corn, in order to attain to a fair rate of root growth at a time of high soil temperatures the aeration of the soil must be good indeed, otherwise, as shown in another paragraph, the rate of growth is very considerably cut down.

The conclusions arrived at and as reported in this notice offer additional reasons for extensive studies on the temperature-aeration relations of the soil, and suggest the desirability of intensive investigations on the oxygen relation of roots as an important physiological factor of ecological moment.

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[1] Palladin's "Plant Physiology," Livingston, p. 190.

[2] "The Ecological Significance of Soil Aeration," W. A. Cannon and E. E. Free, SCIENCE, N. S., Vol. 45, p. 178, 1917.

DISPERSITY OF SILVER HALIDES IN RELATION TO THEIR PHOTOGRAPHIC BEHAVIOR

IN a recent article appearing in the *Journal of Physical Chemistry*, 27, 1–51, Wightman, Trivelli and Sheppard report that in general the larger the silver halide grain and the larger the range in grain size in the emulsion, the more rapid the paper in its action towards light. The authors support their conclusions by means of exhaustive research by means of photomicrographs. There can be no doubt that in the case of their experiments "the relative speed of the emulsions increases rapidly with the increase of average size and range of size of the particles contained therein." However, that this is not always the case is shown by the example quoted in the Eastman Monograph No. 1, p. 104, written by Trivelli and Sheppard, where comparison of two emulsions showed that the one having grains one third the linear dimensions was more than 19 times as fast and that the same was true of individual grains in the same emulsion. Koch and Du Prel (*Physik. Zeit.*, 17, 536 (1916)) conclude that it is not possible to formulate a definite relationship between the grain size and sensitivity with the information at present available, but that it is certain that the largest grains in an emulsion are by no means the most sensitive.

Theoretical consideration: On the basis of the nuclear theory, the speed should depend on the *number of grains affected,* on the basis of the sub-halide theory, the speed should depend on the *amount of halide* affected. From both the continuous wave theory and the quantum theory of light the number of grains affected or the amount of halide affected should increase with the dispersity. Theoretically, then, the smaller grained emulsions should be more sensitive.

Discrepancy between the results of Wightman, Trivelli and Sheppard and the theoretically expected results is perfectly explained by adsorption. Adsorption increases with specific surface, the latter increasing with dispersity. The retarding effect of the adsorbed halide might neutralize or completely reverse the purely dimensional effect. With much adsorption we should expect the sensitivity to be inversely proportional to the adsorption or inversely proportional to the dispersity. Hence the larger-grained