PRESIDENTIAL ADDRESS

BY

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In addressing you this afternoon, I had the intention of placing before you the advance made in Botanical Study in India within the last few years before I gave you an account of the results obtained on work carried on in the Madras University Laboratory. But you had been given a fairly exhaustive account by the President of the Botanical Section of the Science Congress this morning. Still there is one point which cannot be passed over. In the citation of work in the different parts of India, it is surprising that Madras had not attracted Dr. Chaudhuri's attention and I feel I must supplement this omission. If you will permit me I wish to point out that long before most of the Universities in Upper India started, Botanical work was being carried on in Madras by Dr. Bourne and Prof. Fyson and his co-workers. In the early life of the Botanical Section of Indian Science Congress, most of the papers contributed came from Madras. But apart from this, the point that is of greater interest to this Society is that the Journal of the Society had its birth in Madras and it was mainly due to the enthusiasm of Prof. Fyson. I need not mention the great influence the Journal has on the advance of Botanical work in India.

While addressing the Botanical section of the Science Congress last year, I pointed out that our knowledge of the relation between the working of the root system and its environment was limited. I drew particular attention to two points. One was as to the effects of changes in the composition of the soil atmosphere and the other was the possibility of oxygen supply from the shoot system to the root system. Work carried out in the Research laboratories of the Madras University throws light on some points.

The gas-water system of the soil is a fluctuating and not a static system. The fluctuation in the water system is gradual and extends over a long period. But in the gas system, the fluctuations are of greater magnitude and also of diurnal periodicity. The metabolic activity of the roots of plants and of the soil organisms tend to decrease the O_2 concentration and increase the CO_2 concentration. The physical factors such as diffusion and mass movement tend constantly to counteract the former. It is the relative intensity of these two processes that determines the composition of the soil gasses at any moment.

A method was deviced by which the dynamic system under which the roots of a plant normally work in the soil can be imitated under experimental conditions. By this method, it was possible to control the composition of root atmosphere by controlling the extent of its communication with the external atmosphere.

I do not wish to place before you at present the details of the data obtained. Let me draw your attention to certain main features of the results. These can be brought under three headings.

Firstly I will deal with the change in the composition of the root atmosphere when all connection with the external atmosphere is cut off. There is a fairly regular increase in CO_2 concentration and a fall in O_2 concentration due to respiration of the roots. The rate of increase or fall in CO_2 or O_2 decreases with time, that is to say the intensity of respiration shows a gradual fall from the outset. But the rate of decrease is increased after a critical concentration of the two gasses is reached. This turning point is of importance as its effect is seen on other functions of the roots as well.

If the root atmosphere is now placed in communication with the external atmosphere, the rate of respiration gradually increases till it settles down at a more or less uniform rate. This reversibility is possible only within certain limits of concentration of the two gasses. Beyond this limit, the roots are injured, they turn brown and eventually die.

The second aspect is the evidence that is made available as regards the supply of oxygen to the roots by the shoot system. The data for the actual composition of the gasses round the roots at any time show that the sum total of the CO_2 and O_2 percentages varies within small limits round about 21, that is the same as in the atmosphere. But that this similarity is only apparent will be brought out by the following considerations. As the CO_2 concentration increases, part of the gas produced will go into solution in the water round the roots and part will diffuse through the tissues. So the figure for CO_2 concentration as obtained by actual analysis will be resultant between addition by respiration and loss by solution and diffusion. In the case of oxygen, the position is that O_2 in solution in the water will escape into the gaseous phase to a certain extent and there is the possibility of diffusion inwards through the tissues. Let us consider one such analysis. According to the actual figures obtained by analysis, the amount of CO_2 given off is equivalent to the amount of O_2 used up. But the real equation will be something approximating to this:

$$CO_2 + O_2 = (A+X-Y-Z)+(B-C+D+E) = 21$$

where A is the initial amount of CO_2, X is the amount produced by respiration, Y the amount lost by solution and Z the amount lost by diffusion. B will be the initial amount of oxygen. C, quantity lost during respiration, D, quantity added by escape from solution and E, quantity added by diffusion. Since $A+X+B-C=21$, $Y+Z$ must be equal to $D+E$. Because of the difference in the solubility of the two gasses, Y will be greater than D. So it appears that a larger volume of O_2 enters the roots from the shoot system than the CO_2 that may diffuse out through the same path. Apart from the quantitive relations for which there are not enough data available, it is evident that more CO_2 is produced than can be accounted for by the loss of O_2 from the root atmosphere. The excess O_2 that is thus used for respiration can come in only from the shoot system. Proof of such a supply of O_2 was obtained in one instance. When the root atmosphere had reached certain concentrations of the two gasses, a small quantity of water was introduced into the bottle. The immediate effect of this was that some quantity of CO_2 went into solution. Now the combined percentage of CO_2 and O_2 was much less than 21. After 24 hours, it was found that both the CO_2 and O_2 percentages had increased. That is to say, a quantity of O_2 bigger than what was used up for respiration during the 24 hours had diffused into the bottle. This has been recorded in the case of each of the three plants used in this study. The total percentage of CO_2 and O_2 came back to 21 in the course of 48 hours after the introduction of water, with a definite excess of oxygen. I need not say that very careful precautions were taken to prevent leakage through stoppers and connections.

The third aspect of the results obtained is the effect of the changes in the composition of the root atmosphere on transpiration. It was mentioned earlier that more or less uniform concentrations of the two gasses obtain when the root atmosphere is kept in communication with the outside, and that when the connection was cut off CO_2 concentration increases and that of O_2 falls. During the first three days after the cutting off of communication with outside, transpiration shows a tendency to increase gradually till a maximum rate is reached. This maximum rate coincides with the critical concentrations of the two gasses noted before in connection with respiration. When the change in the concentration of the two gasses passes this limit, transpiration rate falls as was the case with respiration also. The next effect observed is the wilting of the experimental plant during the day while the control is quite normal. The plant at this stage is capable of recovery and the next morning the leaves get turgid. At this stage, then, the rate of absorption by the roots is lowered and is not able to replace water lost during day time but the deficit is made good in the latter part of the day. The stomata also show partial closure as compared with the control. If the root atmosphere is now placed in communication with the outside, a complete recovery takes place. The next stage is one when the plant does not recover from the wilting condition. The roots show browning indicating death.

These results bring out one important point and that is that there is a critical concentration of CO_2 and of O_2 at which a maximum rate of transpiration is reached. It is remarkable that below this critical concentration, that is when there is more oxygen and less of carpon di-oxide in the bottle the rate is lower. Putting in other words, one of these two gasses acts as a stimulant and furthers transpiration while a certain concentration is being reached. This critical concentration varies in the case of each of the three plants referred to. This stimulatory effect or that there is an optimum concentration of the gases at which transpiration is at a maximum is, I believe, brought out prominently by these studies.

The composition of the root atmosphere was manipulated so that this critical concentration was reached either when going up from that of the atmospheric air or coming down towards it. On each occasion the rise in the rate of transpiration was noted.

Though further confirmation is necessary as the number of plants worked with so far is few, there is an indication that this critical concentration is nearer that of the atmospheric air in the case of herbaceous or shallow rooted plants. Whereas it is further away in shrubby or deep rooted plants.

Whether this maximum transpiration is brought about by an increased absorption or by a change in the leaf cells to accelerate transpiration is a point of interest for further investigation.