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NOTE ON THE EFFECT OF LIGHT ON THE BIOELECTRIC
POTENTIALS IN THE AVENA COLEOPTILE

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The effect of radiant energy on bioelectric potentials in plants has been little investigated chiefly because of the complexity of interpretation of the results. All previous work of this type has been confined to bioelectric responses of green organs.^{1,2,3,4} Thus the interpretation becomes difficult as photosynthesis itself presumably causes changes in potentials which are superimposed upon the normal bioelectric potentials. The present preliminary note will briefly describe bioelectric responses of the coleoptile of the etiolated seedling of the oat, an organ totally lacking in chlorophyll. In this case it was hoped to obtain the more or less direct effect of light on the potentials of a plant organ.

The experiments were carried out with etiolated seedlings of a pure line of *Avena sativa* (Sieges Hafer) grown at 24°C. and a relative humidity of 90. When the seedlings had reached a length of 30-40 mm., one of them was transferred without injury and totally intact to the experimental chamber. Only weak red light was employed for the observations. The chamber contained two partitions, one for the experimental plant and one for the control plant. Each partition contained a special holder for the seed whose roots were suspended in a vial of water. The coleoptile extended upward through four glass loops placed equi-distant from one another ranging from the coleoptilar node to the tip. Each glass loop held a tap water meniscus which in turn made water contact to side-arms of cups of water in which Zn amalgam-saturated ZnSO₄ half-cells were placed. Thus four fixed electrical contracts were made to each coleoptile so that the potential difference between any two of them could be measured. They are illustrated as *A*, *B*, *C* and *D* in the figure. These contacts are essentially the same as those

used by Glass⁴ in his study of the effect of light on the bioelectric potentials in *Elodea* leaves. No $ZnSO_4$ reached the plant through the side-arms within the time of any one experiment. All contacts were isoelectric to one another. The four contacts made connection by well insulated wires to mercury-in-paraffin switches outside the light-proof chambers. The measurements were made with a single string electrometer of the *Wulf* type.⁵ The instrument was constructed in the physics shops of this insti-

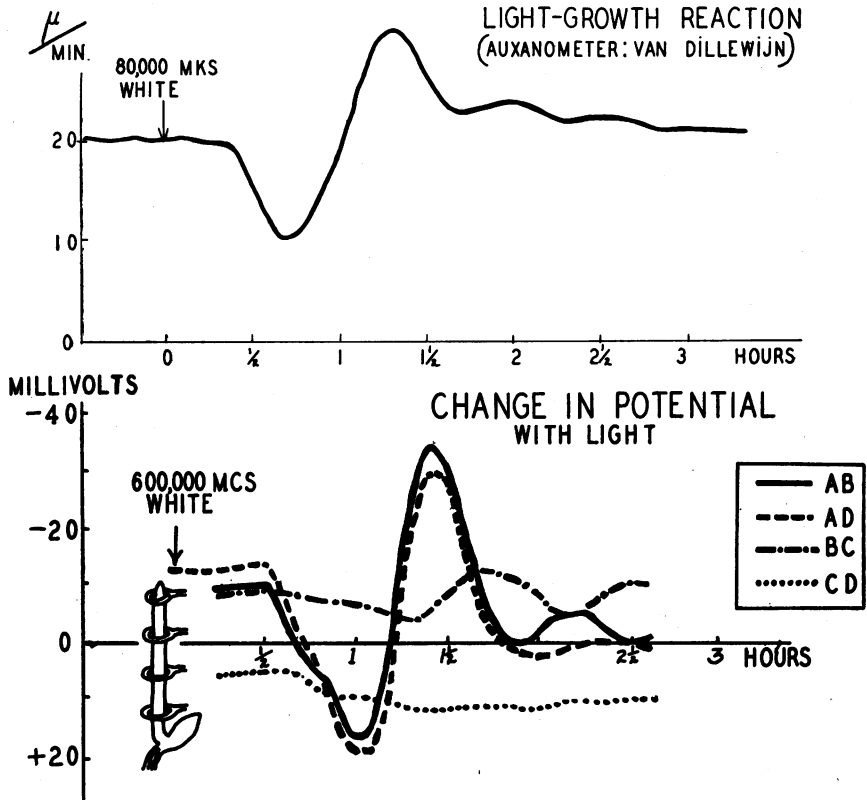


FIGURE 1

tution. Its period was less than a second with a sensitivity of one millimeter scale division per millivolt. The sensitivity remained constant over periods of weeks if the instrument was kept at constant temperature. Because of its simplicity and rapidity of operation, this instrument has proved itself extremely useful for work of this type.

The light source for the stimuli was a 100-watt Mazda incandescent lamp 40 cm. above the tip of the seedling, being horizontally directed to the plant from three sides by means of three mirror strips placed 120°

from one another and 45° to the horizontal. The heat radiation was filtered out by the interposition of a layer of one centimeter of running water between light source and chamber, so that the temperature of both partitions of the experimental chamber remained constant within 0.1°C . while either partition was being illuminated.

Preliminary measurements of plant electrical potentials obtained by contacts moved up and down the plant by means of micro-manipulators and under red or orange light, and at constant temperature, were extremely variable and it was impossible to obtain constancy over any considerable length of time after the most careful manipulation. Only those plants with four *fixed* contacts and in *complete darkness* gave the constancy necessary before the electrical responses to any external stimulus could be determined. With four such contacts, the potential differences (P. D.) between *A* and *B*, *B* and *C*, *C* and *D* and their sum *A* and *D*, were determined by manipulation of the mercury switches. These values were plotted as millivolts. The figure shows the results. Approximately 90 to 120 minutes after setting up the plant elapsed before constancy of the P. D.'s obtained. The changes previous to this usually consisted of a slow fall followed by a slow rise in negativity of the coleoptile tip with respect to the more basal contacts. With respect to time relations and shape of the curve, this reaction corresponds closely with the growth reactions obtained after setting up a similar plant in a Koningsberger auxanometer⁶ as was seen by examination of many auxanometer records.

After constancy was obtained, the light was turned on one plant in one partition while the other plant set up in exactly the same way was kept in complete darkness in the other partition. Measurements were made in a few seconds every five or ten minutes. After the reaction of the illuminated plant was recorded and relative constancy again reached, the other plant was illuminated for its reaction, and so on. Usually two such reactions were recorded in one day's experimentation. The time of illumination was varied, but it was found that with the times most studied, namely 5, 10 and 30 minutes, the curves were similar. Since it was very difficult to obtain a set-up wherein the potentials were constant before illumination, many experiments were necessarily performed before a few good ones were obtained. This condition was somewhat offset by dipping the glass loops in gelatin or agar before mounting the contacts on the plants. Presumably "handling reactions" are caused by the plant rubbing against the solid glass loops (cf. Pfeffer⁷).

Of the experiments performed, seven wherein the period of illumination was thirty minutes gave similar curves. These are typified by the curve given in the figure.

It is noticed that the electrical response comes after the light is turned off. (One hundred watts at 40 cm. for 10 min. = approximately 600,000

meter-candle-seconds, assuming 167 for the mean horizontal candle-power of the 100-watt gas-filled incandescent lamp.) The tip of the coleoptile is normally electronegative to the base, in contradiction to Ramshorn,⁸ who used manipulators to move the contacts up and down the plants, making observations by red light. After illumination, this negativity at first decreases, then increases to a maximum after which it falls again to the original level, usually fluctuating somewhat thereafter. The largest reaction obtains in the sub-apical region, *AB*, with smaller delayed, reactions in the more basal regions. The algebraic sum of the P. D.'s between *A* and *B*, *B* and *C* and *C* and *D* is always equal to that between *A* and *D*. The time relations, the magnitude of the effect (up to 90 millivolts) and the shape of the curve all strongly suggest a relationship to the light-growth reactions of the *Avena* coleoptile.^{9,10} A curve from van Dillewijn (p. 438)⁹ for the light-growth reaction is given in the figure for comparison of shape of the curves and time relations. Whether the electrical reaction is a cause, an effect or a parallel phenomenon possibly associated with growth reactions to light remains to be shown. A closer analysis of the factors involved is now in progress.

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