THE EFFECT OF BORON ON PLANT GROWTH.

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PROBLEMS of plant growth and nutrition are frequently attacked by the method of water cultures, in which plants are grown in liquid nutrient media composed of the necessary inorganic salts dissolved in distilled water. In the course of long experience with this method certain species, especially among the Leguminosae, always failed to grow satisfactorily until, by accident, it was discovered that in the presence of a trace of boric acid broad beans completed their development. Repeated experiments,¹ made with nutrient salts examined spectroscopically for purity, have shown that in the absence of boron the broad bean (*Vicia faba*) grows for a short time and then dies off in a characteristic manner. The growing point withers, the flower buds blacken and fail to open, the leaves become brittle at the point of junction with the stem and later fall off at a touch (Fig. 1). Associated with these external phenomena is a blackening of the interior of the stem from the tip downwards, which is correlated with disorganization of the vascular tissues and ultimately with

FIG. 1.—Left: *Vicia faba* grown without boron. Right: *Vicia faba*, same age, grown with 1:2,000,000 boric acid.

breaking down and discoloration of the cells. *Pari passu* root growth is adversely affected, and the laterals become thickened and fail to branch or to increase in length in the

normal way. All this is prevented by the addition of 1 part of boric acid (or even less) to 2,500,000 parts of nutrient solution. The smallness of the quantity required accounts for the fact that the phenomena are not observed in field culture, as all normal soils contain sufficient boron to supply the needs of the plant. On the other hand, too much boron is toxic, as 1 part boric acid in 5,000 parts solution causes the lower leaves to turn black and wither, while heavier doses seriously check growth.

Analyses show that a considerable amount of boron is present in the seed; and it is probably due to this that the plant is able to make the initial healthy growth before dying off in boron-free solutions. It has been suggested by Agulhon² that boron, when present in plants, may act as a catalytic agent. In the ordinary sense a catalyst would enable the organism to utilize larger quantities of

FIG. 2.—Right: *Vicia faba*. Main shoot dead, owing to initial absence of boron from the nutrient solution. Left: *Vicia faba*. Healthy lateral shoot, developed when 1:2,000,000 boric acid was added to nutrient solution after death of main shoot.

other nutrients, the initial supply of boron remaining unfixed and available for continued use. This is apparently not the case here, a constant supply of boron being necessary to ensure complete development. If boron-starved plants, with dead main shoots, are transferred to solutions containing boron, the lateral buds grow out into strong healthy shoots which flower freely and show no sign of adverse conditions (Fig. 2). If, on the contrary, boron is withheld from healthy plants at any stage of life, the characteristic signs of boron starvation begin to appear about three weeks later and become intensified the longer growth continues, thus proving the necessity of a constantly available supply of the element.

Other species of Leguminosae, including scarlet runner, dwarf bean, crimson clover, and white clover, show a similar need for boron and die off at the growing points before flowering if it be not supplied. Curiously enough, peas do not seem to conform to this, but grow vigorously, flower, and ripen seeds in solutions to which no boron has been added. The same applies to barley, oats, and rye, all of which are frequently used as experimental plants in water cultures. Barley grain grown under normal conditions in soil contains little or no boron, whereas it is present in appreciable quantity in the seeds of all plants found to need boron for growth. This suggests a selective absorption of the element by different species, and that certain plants, as barley and peas, are independent of boron for nutritive

purposes. The bare possibility remains, however, that in reality all plants do require boron, but that some need such very minute quantities that they are able to obtain sufficient from extraneous sources such as the glass containers used for experiment, or from the air, the latter being most improbable. Up to the present no other element has been found capable of replacing boron in the economy of the plant, though many still have to be tested.

The physiological function of boron remains obscure. The quantity requisite is exceedingly small, a total of 0.002 gram boric acid, supplied in fractions in successive changes of nutrient solution, being ample to ensure the complete development of a bean plant weighing 20 grams when dried. The harmful consequences resulting from the absence of this small amount suggest that the action of boron on plants is in some way comparable with that of vitamins on animals, though at present our knowledge is too incomplete for a definite analogy to be drawn. From the death of the growing points and flower buds it would seem that boron is in some way associated with the development of permanent from meristematic tissue. This conclusion is supported by anatomical investigation and by the fact that root tubercles, which are developed after inoculation with *Bacillus radiclecola* and are essentially centres of meristematic activity, tend to be abortive or abnormally developed in the absence of boron.

Experiments are being conducted along various lines in this connexion and it is hoped that further results will soon be ready for publication. Hitherto the bulk of the work has centred round *Vicia faba*, as it offers a favourable subject for experiment, but it is fully realized that a very wide field of investigation lies open and that the results to date must be regarded as preliminary and subject to possible modification as the physiological conditions connected with the action of boron on plants become better known.

REFERENCES.

¹ Warrington, K. (1923): The effect of boric acid and borax on the broad bean and certain other plants. *Ann. Bot.*, xxxvii, pp. 629-572.

² Aguilhon, H. (1910): Recherches sur la présence et le rôle du bore chez les végétaux. *Thèse de Paris*.

A BLINDED SOLDIER RELEARNING TO SEE.

BY

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TWENTY-SEVEN years ago I removed two Morgagnian cataracts from a Hindu fakir who had been totally blind for thirteen years, and I then noted vaguely the phenomena of gradually returning sight, but in those days I had not learned to speak Tamil fluently, and found it difficult to communicate freely with the patient, so that it was not possible to follow the visual development in his case. In the following case this difficulty did not arise, and the facts are sufficiently striking to be worthy of placing on record.

Captain F. B., attached to the military mission at Washington, lost the sight of both eyes by the bursting of a machine gun in February, 1918. From that time forward, until the end of 1923, he was absolutely blind.

On examination it was found that the left eye had been enucleated. The right eye was flattened and scarred, but there were two small and very peripheral areas of clear cornea—one to the outer and one to the inner side. The outer was a little the larger, and extended further toward the centre; moreover, the chamber, which was very shallow indeed, was a shade less so here than on the inner side. The iris, with the remains of the lens matted in a dense exudative mass, was adherent to the cornea over a large part of its centre, and effectively blocked all vision. The patient's past history, kindly furnished by the authorities, proved conclusively that the lens had been involved in the trouble, and had largely disappeared. He was barely conscious of light and darkness, but when a powerful beam of light was thrown on his eye he could at once identify its direction, thus suggesting that his retina was healthy and in

position. He had been advised by various surgeons that operation was useless, but on being told there was a "sporting chance" of the return of some small measure of vision he at once accepted operation.

On December 3rd, 1923, a Ziegler's knife was introduced into the chamber opposite the clear portion of cornea on the outer side, and a very tiny opening was made through the dense membrane present. It was an extremely difficult operation, and at one time it did not seem likely that it would succeed, but a sharp push backward of the point of the knife penetrated the obstruction, and left, as has been said, a tiny opening.

From this time the interest of the case begins. Immediately the operation was over he said, "I see a bright light"; but that was all he was capable of. That evening, as he lay facing the window, he said, "I am sure there is a window in front of me." The next morning he said, "There are three panes to that window." The same evening he counted fingers at a few feet distance. Gradually he was able to see more and more, and he next discovered that there were houses on the other side of the road; that the ward sister had a patch of white on her dress; and so on. A day or two later, his vision steadily improving, he saw a trap passing, and correctly made out that there were two figures in it, silhouetted above the line of the trap. He went home at the end of six days, and his vision improved steadily. On December 21st, 1923, he returned, and with a +28 D. sphere could read two letters of 2.5/24.

One of the most extraordinary features of the case has been what one may call the "patchiness" of his sight. He would see things for a moment, and sometimes in the most astounding detail, and then lose them altogether. On the other hand, the impression given has been that, as a whole, his retina had forgotten to see, and was being re-educated in a manner highly suggestive of the blind man of Bethsaida whose sight was restored.

On his return on February 13th, 1924, he stated that there had been a great improvement in his vision, and with his own lens he read the full 18 m. line at 5.5 m. (5.5/18 vision). He is apparently steadily improving. He can read advertisement signs, the names of stations, etc.; he can find his own way about his house, can recognize his relatives, and do a number of other useful things for which sight is necessary. No view of his fundus can be obtained even with a powerful light on an electric ophthalmoscope.

The patient has not recently been able to come up for examination, but he reported, on June 25th, 1924, that his vision is steadily improving in acuity, and that he is getting a wider field. He can now read a newspaper, and is slowly "relearning to write"; he hopes shortly to write me a letter "entirely on his own," but wishes to perfect himself first. A proof of this report of his case, kindly submitted to me by the Editor, was sent to the patient, and he has read and re-read it several times over from start to finish with the greatest interest.

The importance of the case lies in the manner in which sight has gradually returned. Allowance must be made for the clearing of the media following the operation, but the jerkiness of the improvement, and the extraordinarily erratic manner in which some of the advances in vision have taken place, suggest that the patient is really "relearning to see."

This case and that of the fakir recall the evidence of the blind man of Bethsaida whose sight was restored (was this founded on a couching for cataract?), that he first saw "men as trees walking," and later that "he saw every man clearly."

One is reminded of the way in which a foreign language learnt in childhood comes back gradually to a man when he revisits the country in which he learnt it. The stored impressions of earlier years gradually reawake under the influence of the renewal of the old stimulations which originally evoked their storage in the cerebral cortex. It is not often that our cataract patients in this country are long shut off from visual impressions derived from one or the other eye, but in those in whom two cataracts have progressed side by side, and the patients have been bidden to wait for full maturity before operation is attempted on either—to the writer's mind an unsound plan, though much in favour—we not infrequently find that it takes the patients long periods before they get used to seeing comfortably with appropriate correcting glasses. It is admitted that there may be other causes for this besides the amblyopia ex anopsia, but that latter factor is one which cannot be wholly forgotten.