THE EXTENT OF THE ROOT-SYSTEM OF CUCUMIS SATIVUS.—In Sachs's 'Lectures on the Physiology of Plants' (Eng. ed., p. 13) the following sentence occurs: 'S. Clark has taken the trouble to measure the length of all the roots of a large gourd plant and found that it amounted to 25 kilom.' This statement is repeatedly quoted in other treatises on Physiology, e. g. 'Pfeffer's Physiology,' Eng. ed., vol. i, p. 153, Jost's 'Lectures on Plant Physiology', Eng. ed., p. 28, &c. The reference is not given in any of the more recent works nor by Sachs himself. It may be of interest to quote the original statement, which occurs in a paper by W. S. Clark, President of the State Agricultural College, Amherst, Mass., and published in the 22nd Annual Report to the Massachusetts State Board of Agriculture. The paper in question deals with a wide range of subjects, and is more in the nature of a popular discourse than a scientific research. Some of the statements made by the writer are sufficiently startling. For instance, he states that roots of Clover one year old penetrated the soil perpendicularly to a depth of 8 feet, Lucerne roots to a depth of over 20 feet, and that, on the authority of an unnamed Indian officer, those of *Prosopis spicigera* reached a depth of over 69 feet! The last statement, at least, must be accepted with reservations, more especially when resting on an anonymous statement by one presumably without special botanical knowledge. Pfeffer (Phys., vol. i, p. 258) quotes Clark as his authority for the record that the Birch gives off 6·8 kilos. of sap per day in cases of active bleeding. Clark's statement is, however, that a Paper Birch 15 inches in diameter gave off, in less than two months, over 1,486 lb. of sap, a maximum of 63 lb. 4 oz. being reached on May 5th. This would give on an average 24·4 lb., or approximately 11·1 kilos. per day over 60 days (nearly twice the amount quoted by Pfeffer), while the maximum would represent about 28·5 kilos.

In 'Nature' of June 3, 1875, Clark's paper is reviewed at some length, and the reviewer, although he says he has 'no reason to doubt the accuracy of the statements contained in Mr. Clark's paper', expresses a desire 'to see the observations repeated' —a scepticism justifiable in view of the remarkable observations recorded by Clark. One of these deals with the length of the entire root-system of a 'squash-vine' (*Cucurbita maxima*), and since Clark's measurements have been quoted again and again without comment, and as the original paper is not very accessible, it may be worth while to give the quotation in full:

'But our squash-vine affords the most astonishing demonstration of all that has been said about root-development. Growing under the most favourable circumstances, the roots attained a number and an aggregate length almost incredible. The primary root from the seed, after penetrating the earth about four inches, terminated abruptly and threw out adventitious branches in all directions. In order to obtain an accurate knowledge of their development, the entire bed occupied by them was saturated with water, and, after fifteen hours, numerous holes were bored through the plank-bottom, and the earth thus washed away. After many hours of most patient labour, the entire system of roots was cleaned and spread out upon the floor of a large room, where they were carefully measured. The main branches extended from twelve to fifteen feet, and their total length, including branches, was more than two thousand feet. At every node, or joint, of the vine was also produced a root. One of these nodal roots was washed out and found to be four feet long, and to have four hundred and eighty branches, averaging, with their branchlets, a length of thirty inches, making

a total of more than twelve hundred feet. As there were seventy nodal roots, there must have been more than fifteen miles in length on the entire vine. There were certainly more than eighty thousand feet; and of these, fifty thousand feet must have been produced at the rate of one thousand feet or more per day.'

I cannot find any record that Clark's observations have been repeated or confirmed. Further, Clark does not state how the measurements were made, nor is there any evidence in his paper that he took these measurements himself, or checked them if carried out by others. Thinking that it might be worth while to estimate as carefully as possible the length of the root-system of another member of the same family, I asked the British Botanical Association, Holgate, York, to cultivate for me, under the *most favourable conditions*, a plant of *Cucumis sativus*, and requested the Scientific Director, Dr. Burt, to take special precautions as to the separation of the plant from the soil and preservation of all roots of whatever calibre. This, Dr. Burt assures me, was done with extreme care, under his own supervision.

The plant was grown in a frame 10 feet by 6 feet, and was a full-sized plant bearing fourteen fruits, none of which were removed until quite mature, and until the plant was ready for lifting. The soil was washed away very carefully, beginning at one end of the frame and working through to the other. No roots were lost, even a few fibres, disconnected unavoidably in the process of removal, being preserved for subsequent measurement. The shoot region, including all the smaller branches, measured approximately 32 feet with about 140 leaves, counting in those that had been functional but had withered away at some date previous to lifting the plant. All the roots were then cut off close to the stem, both the primary one as well as the adventitious roots springing from the nodes. After the statements made by Nobbe, that the root-system of cereals may reach a length of 500 to 600 metres, and by Clark, as quoted above, I was much surprised to note the comparatively limited root extent of *Cucumis sativus*. After trying various methods I came to the conclusion that the only satisfactory way of obtaining reliable data was to stretch the root taut, and by aid of compass and centimetre scale to measure the length of the roots individually. The total length obtained was only 85·75 m., or, taking a metre as = 3·28 feet, in English measurements and in round numbers, 281¼ feet. The actual scale measurements were checked by a calculation of (*a*) volume, (*b*) dry weight.

In the former case, the entire root-system was vacuum dried and pressed down in a graduated measure; in the latter the vacuum-dried material was carefully weighed, the volume and weight of a definite length of roots of various thicknesses having been previously estimated. On the basis of the data so obtained, the volumetric estimate gave a length of 285⅓ feet, and the estimate by weight 279½ feet. It may be taken, therefore, that the total length of the root-system of this particular plant of *Cucumis* was about 280 feet.

Wheat cultures were also made, but, owing to the excessive dryness of the summer of 1911, the cultures were to a large extent spoilt, and it was thought better to discard them, and trust to obtaining more normal material in the present year. These measurements, for obvious reasons, have not as yet been made.

R. J. HARVEY GIBSON.

HARTLEY BOTANICAL LABORATORIES,
THE UNIVERSITY, LIVERPOOL.
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