no doubt had an important part in shaping the topography of the region, which may be described as the level to rolling bottom of an ancient lake or arm of the sea dotted with sandy knolls or modified sand dunes. The shifting also presents to the farmers of the section some problems of soil management.

Probably the most striking instance in recent years of wind erosion of soils in this vicinity occurred on the days of April 27 to 30, 1922. Observations by the writer showed a drift as deep as three inches, the deepest observed being on the south sides of tobacco barns. Onion seeds were blown out of the soil necessitating in some cases reseeding, and no doubt many tons of fertilizer were carried from recently fertilized onion fields on which a first application of one ton of high grade fertilizer is the common practice. It was observed that any sort of a ground covering, even loose tobacco stalks, was rather effective in checking erosion, but a growing cover crop as commonly used in tobacco, but not onion, fields was most effective.

The winds most disastrous from the standpoint of soil erosion are those of two or more days' duration, the first day usually being required to dry the soil. Although sandstorms may occur frequently during the year, the most damage is done in the spring when the land is being or has been recently prepared for crops.

A. B. BEAUMONT

AMHERST, MASS.

SCIENTIFIC BOOKS

Development and Activities of the Roots of Crop Plants: A Study in Crop Ecology. By JOHN E. WEAVER, FRANK C. JEAN and JOHN W. CRIST. 17 x 25 cm., VI + 117 pages, 42 figures, 14 plates. Carnegie Inst. Washington, Publ. no. 316. May 11, 1922.

STUDENTS of plants, especially in physiology, ecology and agriculture, will be interested in Weaver, Jean and Crist's book on the roots of crop plants, in which is brought forth a mass of detailed information in a field that has been largely neglected until recently. The studies now reported are a continuation of those presented in Weaver's "Root Development in the Grassland Formation" (1920). Much of the present work follows the methods of his earlier investigations on the form and distribution of the root systems of uncultivated plants. The descriptive data are obtained by what must seem to most botanists very tedious and laborious excavations; each root is traced to its end and the size, form, etc., of the whole root system of each plant is shown diagrammatically on a chart. The published charts frequently show the size of the top, as well as the depth and spread of the root system and the number of roots. Root systems of plants growing under field conditions are described, in several stages of their development, for Lincoln and Peru, Nebraska, for Phillipsburg, Kansas, and for Burlington, Colorado, these stations having mean annual precipitations of about 33, 28, 23 and 17 inches, respectively. The plants dealt with are: oats, wheat, barley, maize, potato, alfalfa and sweet clover, for the seasons of 1919, 1920 and 1921. Some excellent experimental studies bearing on the soil-depths from which water and nitrate were removed during several developmental stages of the plants are considered in the final chapter of the book.

It is pointed out that the root systems of crop plants show modes of growth similar to those of native plants growing in the same region, both being apparently influenced by the environmental moisture conditions. With higher evaporation intensities and drier surface soils the root systems tend to be developed less extensively in the superficial soil layers and they extend farther into the deeper layers. There are some differences between the different forms of plants, but all the forms studied usually have, at the approach of maturity, a set of roots that ramify laterally in the upper 30 or 40 cm. of soil, and a set that reach downward, with more or less profuse branching, to depths of from 1 to nearly 3 m. The two portions of the root system may be relatively distinct or they may be nearly continuous. The deepest soil layers reached are of course not generally well occupied by branches.

The authors emphasize the fact that the roots of crop plants usually penetrate and ramify far beyond the depth of tillage (12 to 20 cm.) and their studies lead to the conviction that much of the soil water and solutes entering the plant during its later growth stages must come from the greater depths. This appears to be at variance with statements in the prevailing text-books, as the authors remark, but of course the discussion of root activities is still necessarily very superficial in such treatises. It seems probable that, with increasing age of the plant, the region of greatest absorption is gradually transferred to the deeper soil layers. In almost every case of actual excavation, the total root development below the region of tillage was found to be as great as, and usually much greater than, that within the tilled region. To gain some quantitative information regarding absorption from the different soil layers, some ingenious experiments were carried out. The methods devised for this experimental study of absorption, together with the results secured, constitute the most valuable part of this book, and they should furnish an added impetus toward a physiological phase of root ecology, which is much needed and which seems about to be developed from several points of view.

Vertical sheet metal cylinders were employed as soil containers, large enough to allow complete development of the plants. The moist soil was placed in these, consecutive horizontal layers 15 or 30 cm. thick, separated by horizontal wax partitions that prevented movement of soil solution between adjacent layers but did not hinder root penetration. Sodium nitrate was added to some of the layers. Several kinds of controls were also employed. Rain was practically excluded. Oats, barley, potato, maize and two native grasses were studied, at various stages of their development, determinations being made of the loss of water and of nitrate from the several soil layers.

The amounts of water removed from the different soil layers were closely related to the frequency of roots, and absorption occurred from all layers occupied by the root systems. Maize absorbed large quantities from the third and fourth 30-cm. soil layer (counting from the top of the cylinder), and smaller quantities from the fifth. Potato absorbed to a depth of 75 cm., approximately the lower limit of the root system. Similarly, nitrate was markedly absorbed from the deeper occupied layers; maize removed 203, 140 and 118 parts per million from the third, fourth and fifth 30-cm. layer, respectively.

While the quantitative data are not expressed in terms such as would render them most valuable from all points of view (the authors use parts per million for nitrate measurements and percentage data for water measurements, both apparently based on the dry weight of the soil), yet they furnish convincing evidence that roots absorb water and nitrate at whatever depths the roots occur in the soil. This is quite in accord with what should be expected from our knowledge of the molecular physics of root absorption.

When a root system advanced into a soil layer to which nitrate had been added it developed more profusely than would have been the case without the extra nitrate, and this stimulation of branch development in the fertilized soil was accompanied by a corresponding retardation in the farther advance into the next layer below. From this observation it is suggested that, in field practice, the presence of added fertilizer salts in the superficial soil layers may hinder the development of roots into the deeper-lying soil, with possible resulting crop failure in case of a subsequent serious lack of water in the surface layers.

As a minor detail, it is regrettable that the metric system of measurements of distance seems not yet to have been appreciated by the authors, though weights are expressed in grams instead of ounces.

From my own point of view, the authors' presentation might have been improved considerably by a more thorough digestion of the results, with less space devoted to unessential details and more given to the fundamental considerations. There is evident a noticeable tendency toward "publishing the note-book." The general headings of the tables, and the column headings, might have been made much clearer. A well-made summary of the descriptive portion of the book would have rendered it much more valuable and far-reaching. And the experimental results apparently contained considerable evidence that was not deduced from them, concerning some of the most fundamental questions of physiology. For example, it is not very useful to know rates of water or nitrate absorption from a soil as the authors express these, but it would be very enlightening to have these data expressed on the basis of the soil volume, or simply as absolute weights. What I have in mind, in this instance, is the question whether the solvent water of the soil solution carries the solute nitrate into the roots at its own rate of capillary or imbibitional flow, or whether the nitrate enters more or less rapidly than its solvent. A little more logical analysis and more attention to the deeper and somewhat hidden meanings implied in the experimental results might have strengthened the presentation very much. These suggestions are not made here, however, as serious adverse criticisms of the book I am reviewing. They are introduced, rather, with the idea that they may be a bit helpful in preparing the way for studies that will carry our knowledge of root ecology far beyond the present conceptions of any of us. The experimental methods employed by the authors involve essentials that are very promising indeed, and the results here published form an excellent beginning toward the illumination of one of the darkest corners of physiological ecology.

BURTON E. LIVINGSTON

SPECIAL ARTICLES

SOME ALGAL STATISTICS GLEANED FROM THE GIZZARD SHAD

IN a recent paper[1] the writer called attention to the desirability of using the gizzard shad, *Dorosoma cepedianum* Le Sueur, as collectors of the plankton algæ. These "living tow nets" do not get caught on snags and roots, the string does not break, and the algal collection is very representative of the body of water from which the fish were taken. It is necessary only to catch the young fish and examine their stomachic and intestinal content to secure a proportionate concentrated sample of the plankton. In aquatic areas where the gizzard shad are common these fish are well worth considering as aids in the collection of the plankton algæ.

Through the courtesy of its director, Dr. Stephen A. Forbes, the laboratory of the Illinois State Natural History Survey sent me some months ago several specimens of gizzard shad, collected in certain streams and ponds of Illinois during the late spring and summer of 1899 and 1900. Rather extensive collections of gizzard shad from Ohio, made during the summers of 1920 and 1921, gave some interesting statistics regarding the distribution and abundance of the non-filamentous algæ in various localities of the state. A comparison of the results of an examination of the stomachic and intestinal content of the fishes from Ohio and Illinois reveals similarities and differences in the algal flora of ponds and streams of the two states and in addition warrants some conclusions concerning the algal food of the gizzard shad in general.

1. The total number of species and varieties in an identifiable condition in the gizzard shad from the two states is a hundred and fifty. Very nearly identical forms indicate the phytoplankton similarity of the habitats from which the fish were taken.

2. The amount of mud present in the digestive tract is in some cases considerably more abundant in the Illinois fishes. It is not, however, in either case a matter of selection on the part of the fish but rather a direct function of the number of suspended mud particles present in the water, *i. e.*, it depends upon what enters with the water as the fish swims along with its mouth open.

3. Diatoms are relatively much more abundant in the Illinois fishes than in those taken in Ohio. When a microscopic mount is made of the intestinal content of some of the Illinois specimens, little else except diatoms can be seen. In this connection one might almost improve upon the epitome of Dr. Mann:[2] "No diatoms, no hake," for in that case it was necessary to have herring and copepods as

[1] *The Ohio Journal of Science*, 21, No. 4, p. 113, 1921.

[2] *Ecology*, 2, No. 2, p. 79, 1921.