

with pages of explanatory text; the arrangement is unusual and at first sight not attractive, but as soon as one has become accustomed to it, it is found to have much to commend it. The photographs from which most of the plates were made are exceptionally clear and hence the necessity of using halftones is not so unfortunate as might be. The impossibility of using a lens on such plates is counterbalanced by the numerous drawings of the essential details, so that every important species is amply illustrated. The volume is a credit to the Government Printing Office, as well as to the National Museum, and it amply confirms Fisher's position as chief among students of the Asteroidea.

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#### NOTES ON METEOROLOGY AND CLIMATOLOGY AGRICULTURAL METEOROLOGY

SINCE weather is a prime factor in crop production, the study of agricultural meteorology is not lagging in this great farming country. It is only comparatively recently, however, that the U. S. Department of Agriculture has made available a large amount of reliable information about crops in such a form as to be used readily for comparison with weather and climate. For six years there has been a division of agricultural geography, Mr. O. E. Baker in charge, the principal object of which has been to issue by sections a carefully wrought "Atlas of American Agriculture." An advance rainfall map of the United States,<sup>1</sup> and advance folios on Frost and the Growing Season,<sup>2</sup> and on Cotton<sup>3</sup> have appeared, as well as extensive graphic contributions in the Year Book of the U. S. Department of Agri-

culture, 1915,<sup>4</sup> 1916,<sup>5</sup> 1917<sup>6</sup> and 1918,<sup>7</sup> and a fine small atlas on "The Geography of the World's Agriculture."<sup>8</sup> The Weather Bureau's contribution to the Atlas of American Agriculture has been the material for the climatic section, of which there is much still to be published; and now its division of agricultural meteorology, Professor J. Warren Smith, in charge, is pushing forward several lines of investigation on the influence of weather and climate on dates of planting and harvesting crops and on crop yields,<sup>9</sup> and on the occurrence of damaging frosts and the possibility of forecasting them from weather conditions the day before.<sup>10</sup> Furthermore, with the excellent crop maps now available, Professor R. DeC. Ward, of Harvard, has written an interesting interpretation of the "Larger relations of climate and crops in the United States." Some of the recent Weather Bureau contributions to agricultural meteorology will be reviewed briefly here.

*Relation between Vegetative and Frostless Periods* (by J. B. Kincer, *Mo. Weather Rev.*, Feb., 1919, Vol. 47, pp. 106-110, 5 figs., 8 charts). Since 6° C. (about 43° F.) is gen-

<sup>4</sup> "A Graphic Summary of American Agriculture," by Middleton Smith, O. E. Baker and R. G. Hainsworth, pp. 329-403, 4 graphs, 78 maps.

<sup>5</sup> "A Graphic Summary of World Agriculture," by V. C. Finch, O. E. Baker and R. G. Hainsworth, pp. 531-553, 74 figs.

<sup>6</sup> "A Graphic Summary of Seasonal Work on Farm Crops," by O. E. Baker, C. F. Brooks and R. G. Hainsworth, pp. 537-589, 90 figs. Abstracted and discussed in *Mo. Weather Rev.*, May, 1919, pp. 323-327.

<sup>7</sup> "Arable Land in the United States," by O. E. Baker and H. M. Strong, Separate 771, 10 pp., 10 graphs, 9 maps.

<sup>8</sup> By V. C. Finch and O. E. Baker (Office of Farm Management, U. S. Dept. of Agric.) Washington, 1917. Reviewed in *Jour. of Geog.*, January, 1919, pp. 39-40.

<sup>9</sup> A thorough discussion of the effect of weather on the yields of corn, potatoes and winter wheat, by J. Warren Smith, is published in *Proc. Second Pan-Am. Sci. Cong.*, 1915-16, Vol. 2, pp. 75-92: see review, in *Geog. Rev.*, Vol. 4, 1917, p. 317.

<sup>10</sup> "Predicting Minimum Temperatures," by J. Warren Smith, *Monthly Weather Review*, August, 1917, pp. 402-407.

<sup>1</sup> Reproduced in *Mo. Weather Rev.*, July, 1917, and discussed on pp. 338-345 by R. DeC. Ward. (Reviewed in *SCIENCE*, N. S., Vol. 48, July 19, 1918, pp. 67-71.)

<sup>2</sup> Reviewed in *Mo. Weather Rev.*, November, 1918, pp. 516-517, and in *Geog. Rev.*, May, 1919, pp. 339-344. (Reprinted, *Sci. Am. Suppl.*, August 23, 1919, pp. 117-118.)

<sup>3</sup> The climatology of the cotton plant is being reprinted in the *Mo. Weather Rev.*, July, 1919, and is reviewed in *Geog. Rev.*, May, 1919, pp. 348-349.

erally considered as the temperature at which most plant growth begins in spring and ends in fall, Mr. Kincer made maps showing the advance and retreat of the isotherm of 43° F. in the United States in spring and fall and of the length of the period between the date in spring when the normal mean daily temperature rises above 43° F. in spring and falls below it in autumn. This period he called the "vegetative period." These maps were then compared with the corresponding maps of last killing frost in spring, first killing frost in autumn and average length of the growing season (*i. e.*, between killing frosts); and other maps were made to show the differences, which amount to about ten days in the North and thirty or more in the South, the vegetative period being the longer. Other maps show that the normal mean daily temperature on the average frost dates just mentioned are for most of the country between 50° and 57° F.; on the Great Lakes, the Pacific, and the Atlantic north of Hatteras, however, the corresponding temperatures are below 50° F. Mr. Kincer points out that protective measures against frost damage may be well worth while in the South, where the vegetative period usually continues for weeks after the first killing frost, but not in the North, where, in autumn for example, low temperatures would soon stop the growth of vegetation which might have been protected from the first killing frost.

*Temperature Influence on Planting and Harvest dates* (by J. B. Kincer, *Mo. Weather Review*, May, 1919, Vol. 47, pp. 312-323, 20 figs., inclu. maps).—This is based largely on a study of the maps in "A Graphic Summary of Seasonal Work on Farm Crops,"<sup>8</sup> in comparison with temperature data.

It is suggested that the mean temperature at which planting of a given crop can be accomplished be used as a base, or starting point, for any method that may be employed for temperature summation, instead of a general base for all crops (*e. g.*, 6° C.). . . . Spring wheat seeding usually begins . . . when the normal daily temperature rises to 37° or 40° F. The corresponding temperature for spring oats is 43°, for early potatoes, 45°, for corn 55° and for cotton 62° F. Cotton and

corn are warm-weather crops and the areas in which successful production on a commercial scale can be accomplished are limited principally by both the general temperature conditions and the temperature at which planting may be accomplished. There is a close relation between spring temperatures and the condition of these crops to certain dates in the early stages of growth.

*Alfalfa Hay and Seed Growing in South Dakota and Utah* (separate papers by H. N. Johnson of Rapid City, S. Dak., and J. C. Alter of Salt Lake City, *Mo. Weather Rev.*, May, 1919, Vol. 47, pp. 328-332, 5 figs.).—"Alfalfa seed is usually produced [in S. Dak.] when conditions are such as to retard the maturing of the first hay crop, and then in paying quantities only when there is a comparative shortage in the moisture supply, hence the weather conditions determine whether the second crop shall be cut for hay or left for seed. If there is considerable rainfall, the second crop is usually cut for hay, and a third crop is frequently possible." As rainfall conditions fluctuate widely on the Great Plains, the western South Dakota alfalfa farmer has in such an arrangement a fine insurance against drought or unusual amounts of rainfall. In Utah the seed-crop, which follows a cutting for hay, needs special weather conditions for the best yields: there should be

sufficient moisture during its early growth to produce a vigorous, healthy plant, but the weather should be dry and not too warm while the plants are in bloom. The dry spell must not be too extended, however, as the seed must have sufficient moisture while setting to give it size and weight. It takes nearly twice as long to grow and mature a seed crop as it does a hay crop. As the seed crop is not always ripe on the occasion of the first killing frost in fall, considerable importance is attached to frost and minimum temperature forecasts. On the receipt of frost warnings, the usual practise is to cut as large an area as possible; but as the first cold period is often followed by several weeks of fine ripening weather, and as the value of the seed is said to increase at the rate of nearly \$5 an acre each 24 hours when ripening, efforts should be made to protect the plants from frost damage without cutting.

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