Climate and Tobacco

By W. W. Garner

THE AUTHOR of this article describes the qualities of various kinds of tobacco leaf in such a way that a smoker can almost taste them. He shows how these qualities are affected by climate and weather, tells what is done to offset certain undesirable conditions, discusses the distribution of tobacco throughout the world, and gives examples of the conditions under which some of the finest tobaccos are produced.

1 W. W. Garner is Principal Physiologist, in Charge, Division of Tobacco Investigations, Bureau of Plant Industry.
ALTHOUGH TOBACCO is tropical in origin, tobacco culture is world-wide. The plant is grown as far north as central Sweden at approximately 60° north latitude and as far south as southern Australia and New Zealand at about 40° south latitude. Production in Australia and New Zealand is relatively small, but large quantities are grown in various parts of all other continents. Except in Europe, the bulk of the crop north of the Equator, constituting more than 90 percent of the world total, is grown south of 40° N.

Foreign countries each producing 50,000,000 pounds or more annually...
ally are the Union of Soviet Socialist Republics, Greece, Italy, France, Germany, and Bulgaria, in Europe; India, China, Turkey, Japan, Chosen, Philippine Islands, Java (and Madura), in Asia; Canada in North America; Cuba in the West Indies; and Brazil in South America. Available statistics indicate that China, India, and the United States each produce roughly 1½ billion pounds of leaf and together account for considerably more than half the world output. However, in China and India tobacco is produced to some extent in nearly every province and is grown rather promiscuously under a great variety of climatic and soil conditions. Largely for this reason, the crop, with certain exceptions, lacks uniformity in type and quality, and only a relatively small portion is of commercial importance.

From the standpoint of international trade, only a few small centers of production in other countries are of outstanding importance for the high quality of their products. Striking examples are the east coast of Sumatra, extreme western Cuba, and certain small areas in Turkey and Greece, the products of which are later referred to in more detail. Among other foreign areas producing for export are the State of Bahia in Brazil, the Dominican Republic, southern Bulgaria, and northern Luzon of the Philippine Islands.

In the United States, tobacco culture is highly specialized, and the production of each of several important commercial types is definitely localized (fig. 1), owing primarily to the influences of climate and soil on the properties of the finished leaf.

Thus the tobacco plant can be grown successfully under a very wide range of climatic and soil conditions. On the other hand, the commercial value of the product depends largely on the environment in which it is produced.

In general, the present producing areas in the United States are easily able to meet commercial requirements for all domestic types of leaf from the standpoint of total output, but in each area there is the important problem of avoiding or minimizing harmful effects on the quality of the tobacco resulting from unfavorable climatic or weather conditions. This problem has been met in some instances by direct modification of climate in the field and in the curing barn, in others indirectly by application of appropriate cultural practices and development of control measures for diseases which are active only under certain weather conditions.

WEATHER AND THE GROWTH OF THE CROP

Much the greater portion of the tobacco grown in the world, including the entire production of the United States, is *Nicotiana tabacum*. In cooler climates this species usually requires a frost-free period of 100 to 120 days from the date of transplanting in the field to full maturity, but with a mean temperature of about 80°F. this period may be shortened to 70 or 80 days or slightly less. *N. rustica*, which is extensively cultivated in India and the Union of Soviet Socialist Republics, and to a lesser extent in China and other countries of Asia and Europe, is a more rapidly growing species and in cool climates can be brought to maturity somewhat in advance of *N. tabacum*.

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Before tobacco seedlings can be set in the field they must be reared to the proper size in coldframes or hotbeds, and this requires a period of 6 to 10 weeks. The seeds are frequently sown well in advance of the arrival of the spring temperatures required for germination. At 50° to 60° F. germination and growth are slow; the optimum temperature is about 75° to 80° and the killing temperature 95° or somewhat higher. Glass or cloth covers are used to protect the young plants in the seedbed.

Relatively early transplanting is generally desirable for several reasons. In northern areas, the normal period for transplanting is May 20 to June 20, and only occasionally are the young plants seriously injured in the field by freezing weather. Late planting may involve danger of serious injury from frost in the fall, to which the crop as it approaches maturity is quite susceptible, and also the crop cannot be properly cured in the barn after the arrival of very cool weather. In the South, unless the crop is set early the soil is likely to become so heated by the sun that the young plants are killed or permanently stunted.

Tobacco in the field grows most rapidly with a mean temperature of about 80°, but the crop eventually will reach full size at considerably lower temperature levels, though the leaf may not ripen normally. Temperatures above 95° on bright days may result in considerable burning of the leaf, especially during periods of drought. As indicated by the data in table 1, taken from United States Weather Bureau records, the range in mean temperature of the growing season from southern Wisconsin and the Connecticut Valley to northern Florida is from about 70° to 77°, and for the major, central belt the general average is about 75°. In the southern producing areas, the principal growing period includes a portion or all of April, May, and June, and a portion or all of July. In the central and northern areas the summer months and part of September constitute the principal growing period. In districts north of Maryland and Kentucky, when for any reason the tobacco is abnormally late in maturing, growers frequently harvest their crop before it is ripe to avoid danger of frost. Frost damage of serious proportions does not very often occur, however.

Frequent rains in the late winter or spring months make the preparation of seedbeds difficult, interfering especially with the process of soil sterilization. The soil of the seedbed needs to be well supplied with moisture at all times during the growth of the seedlings, though excess rainfall and humidity are conducive to damping-off and other diseases. Cool, wet weather greatly favors development of the dreaded blue mold (downy mildew) disease, though effective methods for control—spray and gas treatments—have recently been developed and it may ultimately be possible to produce disease-resistant varieties.

Sufficient rain at transplanting time is especially important. After a good rain transplanting is a comparatively simple operation, but during a drought it is necessary to water each hill by hand or machine. If the drought is severe successful transplanting may be impossible. In the meantime the plants in the seedbed may become so oversized and hardened that they flower prematurely when they are set in the field.
TABLE 1.—Average monthly, seasonal, and annual temperatures and amounts of precipitation at various points in the tobacco-growing regions of the United States

<table>
<thead>
<tr>
<th>Month</th>
<th>Mean temperature</th>
<th>Mean precipitation</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>°F.</td>
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</tr>
<tr>
<td>December</td>
<td>31.0</td>
<td>35.8</td>
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<td>January</td>
<td>28.3</td>
<td>32.9</td>
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<tr>
<td>February</td>
<td>27.0</td>
<td>35.4</td>
</tr>
<tr>
<td>Winter</td>
<td>28.8</td>
<td>34.7</td>
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<tr>
<td>March</td>
<td>37.3</td>
<td>43.7</td>
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<tr>
<td>April</td>
<td>47.5</td>
<td>54.3</td>
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<tr>
<td>May</td>
<td>58.8</td>
<td>64.3</td>
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<tr>
<td>Spring</td>
<td>47.9</td>
<td>54.1</td>
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<tr>
<td>June</td>
<td>67.4</td>
<td>72.2</td>
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<td>July</td>
<td>72.0</td>
<td>75.9</td>
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<tr>
<td>August</td>
<td>70.4</td>
<td>74.5</td>
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<td>Summer</td>
<td>70.2</td>
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<tr>
<td>September</td>
<td>63.9</td>
<td>68.5</td>
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<tr>
<td>October</td>
<td>63.4</td>
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<tr>
<td>November</td>
<td>42.6</td>
<td>49.9</td>
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<tr>
<td>Fall</td>
<td>53.1</td>
<td>61.1</td>
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<tr>
<td>Year</td>
<td>50.0</td>
<td>55.0</td>
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</tbody>
</table>

For normal rapid growth in the field, tobacco requires a liberal, well-distributed rainfall or its equivalent in irrigation water, for the water requirements of the plant are high because of its great expanse of foliage. The plant is very sensitive to defective drainage or waterlogging of the soil, however, and a liberal supply of plant food is essential to sustain the desired rapid growth. Thus injury from excessive rainfall takes the form of depletion of the plant-food supply by leaching on the light soils of the Atlantic Coastal Plain and of drowning of the plants and damage from soil erosion on the heavier inland soils. Severe drought, of course, may cause pronounced stunting of the plants, though most varieties of Nicotiana tabacum will successfully withstand drought for a considerable time without prematurely going to seed and, by making very rapid growth when rain comes, may eventually produce a good yield.

The extensive surface and tender nature of the leaves render the crop especially susceptible to serious injury or even destruction by hail and severe wind. With certain types of tobacco, too, a rain and wind storm, if sufficiently prolonged and occurring after the crop has reached an advanced stage, is likely to induce destructive epidemics of the wildfire type of leaf spot disease. A water-soaked condition of the leaf induced by strongly blown rain ordinarily is a controlling factor in susceptibility to the disease. If varieties of tobacco resistant to water soaking can ultimately be obtained, these should be resistant also to wildfire. Susceptibility to water soaking can be partially controlled also by suitable regulation of the nutrition of the plant.

In the tobacco-producing areas of Florida, Georgia, South Carolina, eastern North Carolina, and western Tennessee and Kentucky, the mean annual rainfall is 47 to 51 inches, in southern Wisconsin it is...
only slightly more than 30 inches, and in most other principal areas it is 40 to 45 inches (table 1). The heavier annual precipitation in the extreme Southeast is due primarily to a summer rainfall of about 17 to 19 inches, whereas in other regions, including southern Wisconsin, the average summer precipitation is about 11 to 14 inches. The western Kentucky and Tennessee district has a relatively heavy spring rainfall of about 14 to 15 inches, as compared with 8 to 12 inches for other tobacco-growing regions. Thus during the principal growing season of approximately 90 days the normal rainfall is about 10 to 13 inches in all principal tobacco-producing areas of the country except the extreme Southeast, where it approximates 15 to 16 inches.

In tobacco culture, very high yields, involving a rank type of growth, are incompatible with good quality. For some types moderately high yields are usually correlated with satisfactory quality, as in the case of cigar tobaccos, but for other types, especially those best adapted to the manufacture of cigarettes, relatively low yields are essential to the production of leaf of the highest quality. In this country the normal weather conditions in themselves are conducive to good yields in practically all the important producing centers, and normal differences in yield between these centers are due chiefly to factors other than climate, more or less correlated with differences in the types of tobacco produced. Seasonal variation in weather in a given locality, however, may greatly affect yield. For the United States as a whole, variations in yield due to weather usually do not exceed 10 percent of the normal yield of about 800 pounds per acre.

There are marked differences in average yields of tobacco among foreign countries, but in most instances these apparently are not due primarily to climatic factors but, as in this country, are related in part to the type of leaf grown. In Europe rather high yields are the rule except where culture of the small-leaved so-called Oriental or Turkish types predominates. In Asia high yields are reported from Japan and moderate yields from India and China. In other principal producing countries in Asia, as well as in Africa and South America, low yields are the rule.

WEATHER AND LEAF QUALITY

From the standpoint of quality of product, tobacco is remarkably sensitive to its environment, and as a rule the major problem of the grower is to obtain a crop of high quality rather than a large yield. The commercial requirements with respect to quality may be quite exacting, and they are also specialized and involve numerous elements. The requirements for one type of leaf often differ radically from those for another; the sort of leaf wanted for plug chewing, for example, is quite different from that desired for cigar wrappers. It is well known that foliage leaves of plants in general are sensitive to the environment in which the plants are grown, and these environmental effects, which would be of no special significance for most crop plants, may largely determine both the type and quality, or grade, of tobacco leaf, including the size, shape, color, venation, elasticity, combustibility, and the details of minute structure and chemical composition.

Within the range that favors reasonably rapid growth and development of the plant, temperature in itself is hardly to be regarded as a
factor of major importance in determining quality. At lower tempera-
tures, however, metabolic processes are slowed down and the leaf
may fail to reach the stage of full ripeness necessary for the develop-
ment of some of the properties that determine quality. High tem-
peratures may contribute to development of aroma and to thickening
of the leaf by reducing the water content of the plant.

Rainfall and humidity, by influencing the water relations of the
plant, have a very important effect on various properties of the leaf
contributing to quality. With an optimum water supply insuring full
turgidity at all times and with other conditions favorable, a tobacco
plant may develop 25 square feet or more of leaf area in a period of
60 days. Under these conditions, with optimum moisture content
consistently maintained in the plant, the leaf produced will be rela-
tively very large and broad but extremely thin, with fine veins, and
loose, open structure or texture. Such a leaf when cured ordinarily
will be elastic, light in color, and of bright luster, weighing perhaps
only 2 to 3 grams per square foot of area; it will have a relatively low
nicotine content; and when placed in bulk it will ferment very rapidly
but develop only a weak aroma and contain little gummy or resinous
matter. In addition to favorable rainfall and humidity, other factors
contributing to these optimum moisture conditions include partial
shade produced by sustained cloudiness or by other means, absence
of wind, and soil conditions favoring retention of adequate moisture
without impairing soil aeration, which is highly important.

When not too thin and flimsy, this sort of leaf is the ideal cigar-
wrapper type, but it is not suited to other purposes. With progressive
changes to less favorable moisture conditions there will normally be
a tendency toward a corresponding reduction in size and narrowing
of the leaf, largely compensated by increased density of structure and
weight per unit of area, thickening of veins, decreased elasticity,
deeper coloration with duller luster, increased nicotine content, a
poorer or at least slower burn, and reduced power to ferment readily
but definitely strengthened aroma and more gum and resin. Not all
of these characteristics associated with suboptimum moisture relations
are desirable in any of the various types of tobacco, but certain com-
binations of them, in which each is developed to the proper degree,
are wanted in the cigar filler, cigarette and pipe-smoking, chewing,
and snuff tobaccos. In other words, for best results each commercial
type has its own water requirements.

In recent years research has made important advances in the fer-
tilization and management of tobacco soils which serve to minimize
the harmful effects of deficient or excessive rainfall on growth and
quality of tobacco. It has been found that heavy potash fertilization
and the use of limited quantities of chlorides in the fertilizer are both
effective in increasing drought resistance. Organic matter in the soil
has been shown to be highly important in its bearing on water rela-
tions, but it must be of the right kind. Certain weeds and crop plants
preceding tobacco in the rotation are decidedly beneficial, while others
are definitely injurious.
PRINCIPAL COMMERCIAL TYPES AND WHERE THEY ARE GROWN

To illustrate the correlation of water relations and type of leaf, some of the outstanding commercial types of tobacco and the conditions under which they are grown may be briefly described. It should be kept in mind that, in addition to climate, the variety of seed, the soil, and other factors are of importance in fixing the properties of the product.

On the east coast of Sumatra is grown a cigar wrapper that may be regarded as a world standard of excellence for the various elements of quality already mentioned, as well as for uniformity in grade, wide adaptability, and remarkable wrapping efficiency per unit of weight. The crop is grown on newly cleared soil laden with organic matter so that it has both a high moisture-holding power and ample aeration. The average monthly rainfall during the growing period (spring and early summer) is over 7 inches, and there are about 11 rainy days a month. The mean temperature is about 80° F. and the mean relative humidity 78 percent.

In the Connecticut Valley and in the vicinity of Quincy, Fla., wrapper of the highest grade is also produced, but by means of a unique procedure for modifying the climate—namely, the use of a special type of open-cloth fabric for shading the plants. It has been found that the major function of the cloth tent is to reduce loss of moisture from the soil and the plant by increasing the humidity and reducing air currents. The effect on temperature is negligible, and apparently the reduced light intensity affects the plant only indirectly, that is, by reducing transpiration.

In Pinar del Río Province of western Cuba—especially within an area of about 25 square miles south of the mountains known as Vuelta Abajo—there is produced what is universally conceded to be the world's finest cigar-filler leaf. In fineness and fullness of aroma and the smooth, satisfying property of its smoke, this product has no equal. The crop is grown on sandy loam soils closely resembling in many respects some of the soils of the Southern States. In contrast with the abundant rainfall in Sumatra, the normal monthly rainfall in the growing season (winter) is considerably less than 2 inches. The mean temperature is about 72° F.

In portions of the Macedonia-Thrace region of Greece and in the Smyrna and Baffra-Samsun regions of Turkey the finest grades of the Turkish or oriental types of cigarette leaf are produced. These products possess a very fine, full, quite distinctive aroma, bearing in this respect somewhat the same relation to cigarette tobaccos that the Vuelta Abajo product of Cuba bears to the cigar type. The leaf grown in the Xanthi area of Greece is considered by many to be the very finest of all oriental types. The finest quality of leaf is grown on soil of rather low productivity occupying the slopes of the foothills of the mountains. The outstanding feature of the climate is the

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3 Kuiper, J. Meteorologische gegevens omtrent de oostkust van Sumatra in 1920. Deli Proefsta. te Medan, Meded. (ser. 2), No. 70, 71 pp., illus. 1921.
almost complete lack of rain during the last 2 or 3 months of the 
growing and developmental period of the crop.

The distribution of the various domestic types as shown in figure 1 
cannot be explained on the basis of water relations alone, since other 
important factors, especially the physical and chemical properties of 
the soil and the variety grown, are involved. The interrelationships of 
soil and climate are so intimately concerned in the type of leaf pro-
duced that they can scarcely be considered as separate factors. 
However, yearly variation in rainfall, together with the associated 
conditions in a given locality, is a controlling factor in determining 
the grade or quality of leaf within a type. In wet years the tendency 
is toward production of the sort of leaf described as favored by 
optimum water relations. In dry years the tendency is toward the 
production of a leaf smaller in size, thicker and more dense in structure, 
more gummy, more aromatic, less elastic, darker colored, of poorer 
combustibility, and containing more nicotine. Modifications in 
cultural practices, especially in the height of topping and in the 
method of suckering the plants, can be made in part to overcome the 
adverse effects of unfavorable seasonal weather conditions.

Generally speaking, rapid, uninterrupted growth throughout the 
season favors production of leaf of high quality. Nevertheless, a 
limitation of the rainfall during the early stages of growth is often 
advantageous in promoting root development and conserving the 
plant-food supply, although if dry conditions persist too long, subse-
quent rains, by causing extremely rapid growth, may produce an 
excessively thin, flimsy leaf. Rains following drought which has 
persisted up to the approach of maturity also may injure the quality 
of the crop by inducing a so-called second growth, or renewal of 
vegetative activity in the leaf. In general, only light, infrequent 
rains are desired during the ripening period. When curing is con-
ducted at ordinary temperatures without the use of artificial heat, 
prolonged periods of high humidity may cause losses by decay or 
discoloration of the leaf. Judicious use of artificial heat has been 
shown to correct this tendency. After the curing is completed, a 
period of damp weather is required to soften the tobacco so that it can 
be stripped and graded without breakage.

6 DARRIS, F. R., DIXON, L. F., and GROSS, P. M. FLUE-CURED TOBACCO. FACTORS DETERMINING TYPE 