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THE SOILS AND CLIMATE OF COLOMBIA SOUTH AMERICA  
IN RELATION TO  
AGRICULTURAL POSSIBILITIES

by

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to the sacred memory of my parents  
whose last wish I have endeavored to ful-  
fill; to my family that has made me what  
I am.

A thesis submitted for the degree of  
BACHELOR OF SCIENCE  
**in Agriculture**

UNIVERSITY OF WISCONSIN

1921

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The purposes of the writer in preparing the following work have been manifold. He realized that it was necessary for him to get some idea of how the scientific principles of agriculture could be applied to the conditions of Colombia. This need became more pressing as he discovered the absolute absence of reliable data.

During his stay in the United States, the writer has been questioned again and again about the climate of Colombia. He has heard and read unjust statements, caused only by the ignorance of some, and the unfairness of others. In order to help in the true understanding of the conditions of Colombia, the second and third parts of this work have been prepared.

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Of the numerous definitions of a soil the following by Hilgard is perhaps as comprehensive as any: "The soil is the loose and friable material covering the surface of the earth, composed of disintegrated rock particles with some organic matter, in which plants, by means of their roots, may or do find a foothold and nourishment."<sup>1</sup> For agricultural purposes the soil is divided into soil and subsoil. The former includes the first six to eight inches and the latter includes the next three to four feet of the friable and loose material covering the earth's crust.

The solid rock of the earth's crust on exposure to the atmosphere is acted upon by several processes, to which the general name of weathering, has been applied. The action of weathering is partly mechanical and partly chemical. It is the result of the complex work of several agents which can be classified in two groups, physical and chemical, but their action and relations are not independent.

The most important physical agents are changes in temperature, and mechanical action of water, wind and glaciers. The rock minerals expand with a rise in temperature, and contract when the temperature falls. Not all the minerals expand

1. Hilgard, E. W., Soils

and contract uniformly. Fissures are formed which develop into cracks. The rock is finally exfoliated in thin layers which soon break apart. These undergo the same process till the small particles of the rock are set loose. Water penetrates the fissures formed in the rocks and on freezing it expands. On expanding, the fissure is enlarged. The repetition of this process breaks the rock in pieces.

Glaciers exert an enormous pressure on the rocks, breaking, crushing and grinding them. The wind, by removing the small particles, which have separated from the rock, expose new surfaces to the action of the other agents. The mechanical action of wind on rocks depends on its force and velocity. The cleavage of the rock may or may not be favorable for the rapid action of the other agents of weathering. Animals and plants are also mechanical agents of some importance in the process of weathering.

Water, oxygen and carbon dioxide are the chief chemical agents, which attack and change the minerals of the rocks. Water, by hydration, combines with some minerals and forms water of chemical combination. Due to the solvent action of water, some of the compounds are dissolved, and by leaking, are carried away. Oxygen combines with those compounds of a low state of oxidation converting them into a higher state. Carbon dioxide, dissolved in water, attacks and dissolves many compounds.

Some animals, like earthworms, and plants in general, also aid chemically in the weathering of rocks.

Soils are not uniform, either physically or chemically. The variations of soils are very great, depending upon the kind of rock from which they originate, the kind of weathering to which the original rock was exposed, and the transportation to which the loose material was subjected.

A mineral soil is derived largely from rocks. Therefore, the chemical composition of the rock will determine, to some extent, the composition of the soil. Rocks are either igneous, sedimentary or metamorphic. Most igneous rocks contain mainly feldspar with quartz and some secondary iron and potassium bearing minerals, such as mica, pyroxene, etc. Sedimentary rocks vary in composition. They may be either sandstones, limestones or shales.

Weathering varies with the climate. Mechanical agents, chiefly wind, and changes in temperature are more active in the arid regions. Chemical agents are more active in the humid regions. Soils formed in arid regions have nearly the same mineral and chemical composition as the rock from which they are formed. Soils formed in the humid regions vary more in composition from that of the rock, because the soluble compounds formed have been removed by leaching.

The movement to which the loose rock material has been subjected, determines whether the soil is sedentary, colluvial,

or alluvial. A soil is sedentary when the loose material has remained in the same place as the original rock. A continuous gradation is noted in the size of the particles of these soils, from the surface down. Colluvial soils are those which have been removed from the original place by the action of gravity. They have no definite characteristic structure, and are, in general, mixed with material from several rocks. Alluvial soils are those formed by deposition of the particles which have been transported by water from the original place. Rocks high in quartz will produce soils of open texture, while rocks rich in feldspart will produce soils of closed texture. This is due to the hydration and carbonation of the feldspar producing kaolin or clay. Soils formed by wind transportation are, generally, very fine in texture. Soils formed by glacier action are from medium to fine in texture.

The producing power of a soil is taken as the index of its fertility. It is the result of the equilibrium obtained between the different factors, which tend to determine the productivity of the soil. These may be grouped into physical, chemical and biological factors.

The principal physical factors are texture and structure. Texture is determined by the size of the soil particles, while structure depends on the arrangement of the particles. The

texture of a soil cannot be modified, while the structure can be modified by good management of the soil. Texture and structure determine the porosity, or air space, on which depends the drainage, aeration, water-holding capacity and temperature of the soil. All these factors affect the productivity of the soil to a great extent.

The chemical composition of the soil plays an important part in the determination of its fertility. Soils contain most of the known chemical elements, in mutual combination, forming minerals and compounds which are constantly dissolving in the soil water. The rate of solution under soil conditions is very slow. When an abundant supply of the elements which the plant uses is in solution, or in a form readily soluble, the fertility of the soil is greatly increased. The reaction of the soil affects its fertility. Soils which are too acid or too alkaline are low in fertility.

The biological factors are no less important than the others. The soil has a characteristic flora, in which bacteria predominate. The action of bacteria in the soil depends upon the optimum physical and chemical relations. Bacteria multiply most rapidly in soils with an optimum moisture content and a slightly alkaline reaction. The soil flora can be divided into two groups: beneficial and non-beneficial. To the first group belong all the forms which perform a desirable function. The second group embraces all the forms which are either detrimental

or perform no beneficial function in soil fertility.

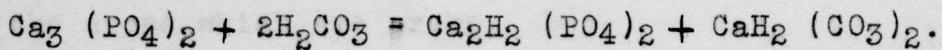
A great deal of work has been done to determine the best methods of maintaining and improving the fertility of the soil. Many good suggestions have been made which in practice give satisfactory results. The soil can be maintained in good physical condition by properly performing the tillage operations and by maintaining a good supply of organic matter.

A soil becomes acid when the amount of basic elements in the soil is insufficient to neutralize the acids formed by humification and weathering. The basic elements should be in an available form. There may be a large amount of them, but not sufficient to neutralize all the acids in the soil, of which the most common are the humic acids, and acid silicates. The remedy for acid soils is the addition of lime. The amount of lime which should be added depends on the degree of acidity, the crops to be grown and the kind of soil.

Of the ten elements which the plant needs to build up its structure, nine are obtained from the soil and one from the atmosphere. Of the elements obtained from the soil, phosphorus, potassium and nitrogen are the three most often present in insufficient amounts. The chemical composition of soils has been studied a great deal and from the agricultural standpoint they are usually well supplied with all the other essential elements. The need of calcium in some soils has already been

mentioned.

Phosphorus is found in the soil in the mineral apatite,  $\text{Ca}_4(\text{CaF})(\text{PO}_4)_3$ , but the form in which it is found most abundantly in the soil is the insoluble tricalcium phosphate  $\text{Ca}_3(\text{PO}_4)_2$ . This slowly reacts with carbon dioxide, according to the laws of chemical reaction and mass action, to form the calcium bicarbonate and the soluble dicalcium phosphate.



Potassium is present in the soil in the minerals known as micas and feldspars. They react slowly with carbon dioxide in the presence of water, forming kaolin or clay and potassium carbonate which is available to plants.  $2\text{KAlSi}_3\text{O}_8 + \text{H}_2\text{O} + \text{CO}_2 = \text{H}_4\text{Al}_2\text{Si}_2\text{O}_9 + 4\text{SiO}_2 + \text{K}_2\text{CO}_3$

Nitrogen is present in the soil in the form of organic matter, which is broken down and the nitrogen converted into ammonia and nitrates by bacteria. In these forms it is used by plants.

The system of cropping of a given field has much to do with the conservation of its fertility. A systematic rotation of crops containing a legume should be practiced, in order to obtain the maximum production, at the least expense.

When the land has been well managed, that is, properly tilled, limed when needed, rotated systematically as to crops, and manured some from time to time, the need of adding commercial fertilizers is greatly lessened. But when the above

named operations and practices are disregarded, the fertility of the soil becomes low and the available supply of the three essential elements becomes largely exhausted. In this case they should be added to the soil in the form of commercial fertilizer. The kind of commercial fertilizer and the proportions in which the three elements should be added are determined according to the condition of the soil, and the needs of the crops which are grown.

Several methods for the determination of soil fertility have been proposed, but only the chemical analysis of the soil gives quick results.

The chemical analysis may be complete or partial. The complete analysis indicates the total composition of the soil and its reaction. The partial analysis usually indicates only the reaction and the amount of the essential elements. Analysis for the determination of the availability of the essential elements has been practiced, but its use is not common at present, and the application of the results obtained has not been very successful.

With the purpose of determining the fertility of the soils of Colombia, so far as chemical composition is concerned, a chemical study of some soils was made and the results obtained are presented here.

For the chemical analysis, thirty samples of soil were

obtained, collected from four farms located at the three different zones of temperature indicated in table I.<sup>1</sup> Information regarding the size of the fields from which the samples were obtained was requested but not secured. The farms are about 200 acres each, but the samples, in all probability, were taken over an area of about 50 acres.

TABLE I

## General Information about the Soil Samples

Field Samples	Place	Altitude. m.	Temp.	Approximate rainfall	Texture	Color
1	1 to 8 Cajica	2660	51.2 F	40"	Very fine	light
2	9 to 16 Viota	2000	71.5	60" )	Fine to	brown
3	17 to 22 Viota	1000	78.8	60" )	coarse	dark
4	23 to 30 Apulo	1000	83.	60"	Fine	very dark

Nothing definite can be said here on the origin of these soils. The only reference available is the work of Dr. Hettner which contains some information of a general character. In the geological map, which he presents, the surface of the region of Cajica is formed by old lake deposits. Considering the fact that solid bed rock is very deep in this region, it is safe to conclude that the soils of this region are not residual. They are not colluvial because they have very fine uniform texture. Therefore, they are probably alluvial soils. Underlying the regions of Viota and Apulo are the Villetas layers of chalky material. The general topography of these two regions is that of an old valley. It presents a great number of mesas and plateaus. The Villeta formations are probably the rocks from

1. See second part of this work, p. 28

which the soils of these two regions have originated.

The soils from field number one are very fine in texture. About two-thirds, by weight, passed through the 100 mesh sieve without any grinding. They are "hard to work and not permeable." They are well supplied with organic matter, but are not very dark in color.

The soils from fields two and three have a great amount of coarse material. They contain large amounts of organic matter and are dark in color. The soils from field four are fine in texture, and also very dark in color. The last three fields are well drained and are "easy to work, loose and permeable."

Total chemical analysis was made of one sample of each of the four fields. Ten samples were analyzed for the three essential elements and for calcium and magnesium. All the samples were tested for reaction according to Professor Truog's method.<sup>1</sup>

The results obtained are fairly uniform for all samples of each field, with one or two exceptions. The results are given in Table II.

TABLE II

Field	Acidity of the Soil Samples		
	Samples	Reaction	Lime needed
1	1 to 8	Very strongly acid	4 tons per acre
2	9 to 16	Very slightly acid	1
3	17 to 22	Slightly acid	1
4	23 to 30	Not acid	none

1. Truog, E., Wisconsin Bulletin, 249em.

In view of the results obtained with the samples of field number 4, determinations of the carbonate content were made of these soils and the results are given in Table III.<sup>1</sup>

TABLE III

Carbonate content of samples of field four

No.	Sample	CO <sub>2</sub>
23		1.6 per cent
24		1.01
25		1.06
26		1.38
27		0.75
28		1.54
29		1.02
30		.95

An attempt was made to correlate the degree of acidity with the amount of the basic elements, calcium and magnesium, present in the soil. The results of the chemical analysis for these two elements are given in Table IV.

TABLE IV

Amounts of Calcium and Magnesium Oxide

Field	Sample #	CaO %	Mgo %	Total %
1	( 1	6.02	1.86	7.88
	( 3	7.78	1.54	9.32
	( 6	4.46	1.99	6.45
2	( 9	5.66	1.84	7.50
	(16	9.78	1.37	11.15
3	(18	7.65	1.61	9.26
	(22	6.72	1.37	8.09
4	(24	17.43	1.24	18.67
	(26	17.85	1.82	19.67
	(30	17.00	1.36	18.36

If these results together with the results of acidity tests are studied, the following conclusions may be made. The

acidity of the soil is affected by other factors than the presence of a given amount of calcium and magnesium. This is shown by the samples of field number one, which have as much of these elements as those of fields three and four, but give a very much stronger acid test. Likewise, samples nine and sixteen give the same kind of reaction although sample sixteen has over three per cent more of these bases. A large excess of base is required in order to produce a condition of free basic reacting carbonates, which neutralize soil acids. This is illustrated by the results from samples of field number four. It is not only the amount of bases that counts in neutralizing the acids, but also the form in which they are present in the soil. Field number one has been sown to grain for several years more than any of the others. Field number two has been in coffee and field number three in sugar cane, both as permanent plantations. These two fields are in the same region and in similar conditions of rainfall. The fact that the field in sugar cane is more acid may indicate the effect or tendency of certain crops to produce an acid reaction by the accumulation of substances derived from the processes of fermentation. Field four is relatively new land. There is no information at hand concerning the system of farming practiced on it.

Four samples were analyzed completely and the results are given in Table V.

TABLE V

Total chemical composition of some Colombian Soils  
in per cent

Sam- ple	Moist- ure	SiO <sub>2</sub>	Fe <sub>2</sub> O <sub>3</sub>	Al <sub>2</sub> O <sub>3</sub>	N <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	CaO	MgO	MnO
6	2.8	66.92	13.17	7.89	.341	.286	.811	4.46	1.99	trace
16	2.1	75.7	11.13	1.57	.332	.528	.695	9.78	1.37	"
22	2.1	76.36	8.3	4.56	.371	.37	.318	6.72	1.37	"
24	2.	60.5	11.4	5.6	.343	.293	1.329	17.43	1.24	"

Table VI presents the results obtained in the chemical analysis for the most important chemical elements, from an agricultural standpoint.

TABLE VI

Amounts of the most important chemical elements present in some Colombian soils.

No.	Sam- ple	Percentage					Pounds				
		P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	N <sub>2</sub>	CaO	MgO	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	N <sub>2</sub>	CaO	MgO
1	( 1	.126	.549	.179	6.01	1.86	2519	10980	3580	120200	37200
	( 3	.203	.812	.337	7.78	1.54	4060	16240	6740	155600	30800
	( 6	.286	.811	.333	4.46	1.99	5720	16220	6660	89200	39800
2	( 9	.328	.950	.315	5.66	1.84	6560	19000	6300	113200	36800
	( 16	.328	.695	.332	9.78	1.37	6560	13900	6640	195600	27400
3	( 18	.423	.579	.382	7.65	1.61	8460	11580	7674	153000	32200
	( 22	.37	.318	.371	6.72	1.37	7400	6360	7420	134400	27400
4	( 24	.293	1.329	.243	17.43	1.24	5860	26580	4860	348600	24800
	( 26	.297	.514	.235	17.85	1.82	5940	10280	4700	357000	36400
	( 30	.298	.897	.203	17.	1.36	5960	17940	4060	340000	27200

The results obtained show the richness of these soils in the essential elements, nitrogen and phosphorus. They are very low in pottasium. It is interesting to note that the amount of the essential elements is somewhat lower in the soil of field one, cultivated with grain and corn, than in the soil of fields

two and three cultivated with coffee and sugar, respectively. The following table gives the number in pounds of the essential and basic elements removed from the soil by some crops.

TABLE VII

Crop	Amount of essential elements, in pounds, removed by crops per acre. <sup>1</sup>					Average yield per acre
	N <sub>2</sub>	P <sub>2</sub>	K <sub>2</sub>	Ca <sub>2</sub>	Mg <sub>2</sub>	
Corn (grain)	50.	8.5	9.5	.7	3.85	50 bushels
Wheat "	42.6	7.2	7.8	.7	2.2	30 "
Oats "	39.6	6.6	9.6	1.3	2.2	60 "
Coffee (clean bean)	23.9 <sup>2</sup> <sub>3</sub>	1.85	16.5	2.15	1.86	1000 pounds
Sugar cane	88. <sup>3</sup>	25.6	150.8	53.2	44.4	40,000 "

The enormous amount of essential elements removed by sugar cane is, in general, returned to the soil, as the residue, after the syrup is extracted, has no market value or use. The table clearly shows that under a scientific system of cropping the coffee and sugar cane crops will deplete the soil of the essential and basic elements, less than the grain crops.

The cultivation of grain in field number one has been continuous, without practical rotation of crops. The coffee tree is a perennial plant. The life of a plantation is at least twenty-five years of good producing power. Only the bean is removed from the tree, and the abundant foliage falls to the ground every year, where it decays. The pulp and parchment which cover the seed are rich in potassium and phosphorus, but

1. Wolff, Emil, Aschen-Analysen von landwirthschaftlichen Producten; Hopkins, Cyril G., Soil Fertility and Permanent Agriculture, p. 154
2. Lecomte, H., Le Cafe, p. 55; Jour. Chem. Soc., Vol. IX, p. 33
3. Deer, Noel, Sugar from Cane Sugar, p. 68

these are returned to the soil every year. This explains the small amounts of the essential elements which are removed from the soil by coffee.

Sugar cane is, in general, grown for several years on the same field. The amounts of essential elements which it removes from the soil are very small, if the residue or bagazo which is left, after the sugar syrup is extracted, is returned to the soil.

The problem of maintaining the fertility of the soil of Colombia is very important. In the cold zone where grains are cultivated, systematic and practical rotations, including a green manure crop, should be adopted. If the soil is maintained in a neutral or slightly alkaline condition by adding lime, good tillage is practiced, and manure is added from time to time, the fertility of the soil will be largely conserved. Most of the land on the savannas of the cold zone is in the hands of city landowners who run the farms in an indirect way for their own benefit. It should be expected that they would take up seriously the problem of maintaining the fertility of their farms. They do not seem to realize that their primitive methods of exploitation of the soil are working to their own detriment. The soil, once impoverished, needs many years of careful management to bring it back to fair fertility.

In the case of coffee, which is grown in the temperate zone, cover crops could be used with advantage. They could be sown right after the bean is harvested and plowed under before

the new leaves appear on the coffee tree. Lime and ashes should be added to the soil, sometime during the life of the plantation. Under the actual conditions of the coffee plantations of Colombia, the use of commercial fertilizers probably would not pay.

With sugar cane which is grown mainly in the hot zone, the use of rotations is more practical and imperative than with coffee. The continuous growing of the cane in the same field should be stopped. Several rotations can be practiced with great profit to the farmer, which will help to maintain fertility. Lime, ashes and the residue of the cane after the sugar juice has been extracted, should be returned to the soil under proper conditions.

Farmers in Colombia have paid no attention to the fact that the soil is impoverished by cropping. The savanna of Bogota was one of the most fertile lands of Colombia. This land has been cultivated since the Spanish settlers arrived there. The wonderful yields of many years ago have decreased to a point where the production of some farms barely pays the cost of cultivation and the maintenance of the farm.

It has been stated that the cold zone is given over to the production of grains. The population of the country in this region has increased considerably. The production of grains per acre has decreased. The acreage has increased, but even so, the market supply of grains and corn scarcely meets the local demand. Why not increase the production when there

is a national need for more of these products? A nation should become largely self-supporting. Colombia is not. With agricultural lands adapted to every plant culture, she has to import many agricultural products. The cultivated area should be increased. But the most important need of the present is the increase in production per unit area. The methods of farming practiced in the cold zone are very inefficient. Intensive farming should be practiced and more farm implements used.

There are several reasons why intensive farming should be practiced and the use of modern economical farm implements made more general. Production per unit area would be increased, the fertility of the soil would be maintained, and the farm labor question solved. If the arable land of the savanna of Bogota were cultivated to its "capacity", there would be a surplus over local demand which could be shipped to other markets. As transportation facilities increase markets far from the center of production can be supplied. Transportation lines are usually established to meet the needs of a region. If there are no pressing needs for the transportation of products there is no hope of a rapid improvement in the means of transportation. The need should be created to stimulate the development of transportation facilities. A second reason is that intensive farming should mean scientific farming and the latter includes the conservation of soil fertility.

There are regions of the country where farm labor is

scarce. With the use of modern economical farm implements, adapted to the needs of the locality, the amount of hand labor used could be reduced. The labor required under a system of intensive farming becomes better and more efficient. This would stimulate education and oblige the farmer to pay higher wages. Higher wages would attract labor from the cities nearby, thus benefiting society and the country as a whole.

It is time for the farm owners, and especially for those who live in the city, to realize that they must work, not merely for their own benefit, but for the benefit of the community at large and the prosperity of the country in general. It is a duty to the country whose prosperity is made mainly by the workers of the soil.

When the soils of Colombia are compared with the famous soils of Brazil, known as Terra roxa, which are considered the best soils for coffee, the greater supply of plant food in the former soils is very marked.

The soils of Colombia which have been studied, compare very well with many good soils of the United States and many many countries of South America. They are not inferior to the best soils of these countries as is shown in Table VIII.

If the soils of Colombia are not very productive at the present time, it is because of the farming methods and careless application of the scientific principles of agriculture. The future of agriculture in Colombia will be very bright, if the

farmers of today take care to improve and maintain the fertility of the soil. If they do this, the producing power of the soil will not be decreased, and the prosperity of the individual and the country will go hand in hand during the years to come.

Colombia is bounded on the east by Brazil and Venezuela, on the west by the Pacific Ocean and on the northwest by Costa Rica. To the north, Colombia reaches as far as  $12^{\circ}15'$  N. latitude, its eastern extension being  $75^{\circ}40'$  and its western limit  $82^{\circ}40'$  longitude, while its southern limit is  $5^{\circ}$  south of the equator, thus giving to the country an irregular outline.

**AREA.** The area of the country is about 513,845 square miles, of which only a little over one-fourth are inhabited. Its greatest length is 1,742 miles and the greatest breadth 1,118 miles. It is nine times as large as Wisconsin.

**TOPOGRAPHY.** The principal features of the surface of Colombia are the two main mountain branches into which the great mountain chain of the Andes divides, as it enters the territory of the Republic: (1) The Cordillera Occidental (western cordillera) follows a northerly direction ending in the state of Bolivar; (2) The Cordillera Oriental (eastern cordillera) follows a northeasterly direction subdividing into ranges, a) the Cordillera Central (central Cordillera) the one at the left, following a northerly direction ending in the same state of Bolivar, and, b) that named Cordillera Oriental which again subdivides into two branches, one ending in Colombia and the other in the neighboring country of

LOCATION. Colombia is located in the northern part of the South American continent and is the only country in South America with a coast line on both the Atlantic and Pacific Oceans. It is bounded on the north by the Caribbean sea, on the south by Ecuador, Peru and Brazil, on the east by Brazil and Venezuela, on the west by the Pacific Ocean and on the northwest by Costa Rica. To the north, Colombia reaches as far as  $12^{\circ}15'$  N. latitude, its eastern extension being  $70^{\circ}40'$  and its western limit  $82^{\circ}40'$  longitude, while its southern limit is  $5^{\circ}$  south of the equator, thus giving to the country an irregular outline.

AREA. The area of the country is about 513,845 square miles, of which only a little over one-fourth are inhabited. Its greatest length is 1242 miles and the greatest breadth 1118 miles. It is nine times as large as Wisconsin.

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Venezuela.

The number of mountain ranges is large, forming big mesas and plateaux of large area which are very conspicuous and are the most densely populated regions, due to their mild climate, salubrious air and the productivity of the soils.

The topography of the country on account of the several chains of mountains, also divides the rivers into several systems of drainage named according to the mountains where the main rivers originate. The main rivers of the country form large valleys of which the most fertile and prosperous are the Magdalena valley, 50 miles in width, formed by the river of the same name, which is the most important fluvial artery of the country, the Cauca valley formed by the Cauca River, also navigable, and the valley of the river Bogota.

CLIMATE. There are few data on the climate of Colombia, and what are available are observations of only a very general character.

The country is situated in the torrid zone, and a large part borders on the two oceans. Crossed by great valleys and mountains, the country possesses an unusual variety of climates. The maximum temperature which on the coast and in the hot lowlands reaches 98° F., drops to zero in the high altitudes, the regions of perpetual snow, 14,760 feet above the sea.<sup>1</sup>

1. Bulletin of the Pan American Union, Vol. 40 (1915) p. 194

The climate of Colombia is varied notwithstanding its complete tropical situation. This is due to its position in the belt of the tropical calms and to the complex system of mountains, by which the country is traversed.

Mr. F. M. Chapman in his book on Colombia gives interesting observations on the climate of Colombia: "The temperature of any given locality in Colombia shows so little fluctuation throughout the year that the seasons are marked, not by the increase of cold or heat, but by rainfall. To demonstrate the narrow and regular path traveled yearly by the thermometer in Colombia, and as a contribution to the unfortunately limited amount of published meteorological data from that country, I append a summarized record of the temperature for the year 1907 at the sugar estate of La Manuelita, in the Cauca valley, near Palmira. These records were made by Mr. Charles J. Eder and are selected as an average from a series covering a period of 10 years."<sup>1</sup>

It will be observed that there is only a difference of six degrees in the average weekly temperature for the entire year.

1. Bulletin of Pan American Union, Vol. 46 (1918) p. 319-332; "The Distribution of Bird Life in Colombia," in Bulletin of American Museum of Natural History, Vol. 36 (1917) p. 79.

## Temperature for the Year 1907 at 'La Manuelita'

Week ending	High-est	Low-est	Aver- age	Week ending	High-est	Low-est	Aver- age
Jan. 4	85	66	74 $\frac{1}{2}$	July 5	86	63	74-3/7
" 11	86	63	74 $\frac{3}{4}$	" 12	86	64	74 $\frac{1}{2}$
" 18	86	63	75	" 19	85	65	74
" 25	84	65	73	" 26	89	59	74 $\frac{1}{2}$
Feb. 1	86	64	74	Aug. 2	87	65	76
" 8	86	67	73	" 9	91	61	76
" 15	86	64	74	" 16	90	61	76
" 22	85	64	74	" 23	90	66	78
Mar. 1	86	62	72	" 30	80	64	77 $\frac{1}{2}$
" 8	86	64	75 $\frac{1}{2}$	Sep. 6	89	65	75
" 15	86	64	75	" 13	91	64	76 $\frac{1}{2}$
" 22	88	65	76	" 20	89	64	76 $\frac{3}{4}$
" 29	85	64	74 $\frac{1}{2}$	" 27	90	65	76 $\frac{1}{2}$
Apr. 5	86	64	75 $\frac{1}{2}$	Oct. 4	88	67	76
" 12	87	66	75	" 11	86	64	76 $\frac{1}{2}$
" 19	86	66	76	" 18	89	65	77
" 26	86	67	76 $\frac{1}{2}$	" 25	88	64	75 $\frac{1}{2}$
May 3	86	65	75	Nov. 1	87	66	75
" 10	86	67	75	" 8	87	66	76
" 17	85	64	73 $\frac{1}{2}$	" 15	87	68	77 $\frac{1}{2}$
" 24	86	66	73	" 22	80	66	75
" 31	83	63	74	" 29	86	66	76
June 7	85	62	74	Dec. 6	86	65	76
" 14	86	64	75 $\frac{1}{2}$	" 13	85	65	75
" 21	86	66	75	" 20	87	64	76
" 28	84	65	73-1/3	" 27	90	66	77 $\frac{1}{2}$

The preceding observations were made in the tropical zone, but an equal stability in the yearly range of temperature is shown at localities in the temperate and cold zones.

Climatic conditions are determined by the latitude, altitude, topography, winds, and nearness to bodies of water. Certainly Colombia offers a wonderful field for observation of the factors affecting climate.

The latitude of the country has been given above as 5° S. and 12°15' N. and it would be expected from this to have a very

hot climate due to its nearness to the equator. This is true in <sup>24</sup> the lowlands and in the llanos (sandy bottoms of old seas), but these areas are not very great in proportion to that of the entire country, and are not of very great economic importance.

The presence of many mountains and the considerable altitude of them causes a variation in the temperature and pressure. It is well known that the temperature decreases on an average of  $1.6^{\circ}$  F for each 300 feet of elevation and the pressure, which also varies with the latitude and temperature, decreases .1 of an inch for each 90 feet in elevation, not taking account of the temperature and moisture.<sup>1</sup> In Colombia, according to Hann, the decrease in temperature with the altitude is  $.54^{\circ}$  C per 100 meters going up from sea level to the plateaux.<sup>2</sup>

Mr. Robert Blake White in his Notes on the Central Provinces of Colombia, says "From numerous series of information of the mean temperatures at different altitudes in the cordilleras, collected from a great many observers, I have formed a table of mean temperatures corresponding to a series of altitudes from sea level up to 16,400 feet in height, which will be found very generally applicable over the whole of the Colombian territory. These temperatures are derived from observations made on distinct

1. Davis, W. M., Elementary Meteorology, p. 13

2. Hann, Julius, Hanbuch der Klimatologie, pp. 360-366

systems but as a rule the temperature of the earth, in a part sheltered from the sun and rain, at a depth of 30" from the surface of the ground, will represent in these latitudes the mean temperature of the locality."<sup>1</sup> And he adds what confirms the writer's criterion and purpose of this discussion of the climate: "In tropical regions, where vegetation is not exposed to great variations of temperature, the most important point to which an agriculturist should look is the mean temperature if he would judge correctly of the climate of any locality."

The following is the table of mean temperatures of the United States of Colombia, between 2° and 6° N. latitude, compiled from observations by Humboldt, Caldas, Mosquera, White and others:

Height in feet above the sea	Mean Temper- ature F.
0	82.4
820	80.4
1640	78.4
2460	76.3
3280	74.3
4100	71.2
4920	68.
5740	65.3
6560	62.6
7380	59.9
8200	57.2
9020	55.4
9840	53.6
10660	50.9
11480	48.2
12300	45.5
13120	42.8
13940	40.1
14760	37.4
15580	32.
16400	30.2

1. Proceedings Royal Geographical Society, Vol. (1883) p. 263, 264.

According to these figures the decrease in temperature is  $1^{\circ}$  F for each 314 feet of elevation, which is in very close agreement with the figures given by Hann of  $1^{\circ}$  F for each 327 feet.

The isothermal lines for the world mean temperature corresponding to  $75^{\circ}$  F at the north and  $85^{\circ}$  F at the south include in January all the territory of the country, and in July the isothermal line  $75^{\circ}$  F passes through the southwestern part of the country and the line  $80^{\circ}$  is just north of it.<sup>1</sup> This is the annual migration of the isotherms. The statement that the highest annual average temperature experienced at any part of the country is  $86^{\circ}$  F, and the lowest in the inhabited portions of the cordilleras in  $20^{\circ}$  F is, in all probability, very true.<sup>2</sup> The migration of the isothermal lines explains also the fact that the season of higher temperature in this region is when the temperature is lowest in the north. In general the time of the seasons in the belt of the tropical calms is reversed, but, as it has already been said, the change in temperature from season to season is very slight in that region.

Julius Hann in comparing temperatures of places situated at the same latitude, but on different sides of the equator,

1. Bartholomew, J. G., Physical Atlas, Vol. III

2. Bureau of American Republics, Vol. 7, No. 33, p. 13

gives the mean temperature of Bogota as  $57.9^{\circ}$  F, the maximum ever registered as  $74.3^{\circ}$  and the minimum as  $42.9^{\circ}$ ; that of Medellin as  $84.9^{\circ}$  F and  $56.5^{\circ}$  F maximum and minimum respectively. He goes into considerable detail of the changes taking place on the western coast, Buenaventura, and also at Sierra Nevada, near Santa Marta, in the northwestern part of the country, and gives the month of January or February as the hottest month at the former region, and the month of September or October as the coldest, but with an annual range of only  $2.5^{\circ}$  F. In Bogota the temperature reaches the maximum in March and April and again in November; the minimum temperature in July or August and again in January.

He gives the following table of mean monthly temperature for three cities of Colombia located at different altitudes and latitudes:

Place	Puerto Berrío	Medellin	Bogota
Latitude	$6^{\circ}22'$ N	$6^{\circ}10'$ N	$4^{\circ}35'$ N
Longitude	$74^{\circ}28'$	$75^{\circ}45'$	$74^{\circ}14'$
Altitude	542 feet	4950 feet	8728 feet
January	79.3	70.1	57.5
February	79.1	70.8	57.9
March	78.6	70.1	58.6
April	78.1	69.8	58.6
May	78.6	70.1	58.2
June	78.8	69.8	57.8
July	78.4	69.6	57.2
August	78.4	69.8	56.9
September	78.4	69.6	56.9
October	78.6	68.7	57.9
November	78.8	68.3	58.2
December	79.1	69.1	58.1

Annual average	78.6	69.6	57.9
Variation per cent	.6	1.4	.9
Maximum		84.9	74.3
Minimum		56.4	42.9

When the changes in temperature caused by topography and location are considered, Colombia may be divided into three zones: hot, temperate and cold,<sup>1</sup> without taking into consideration the amount of rainfall.

The hot zone, extending over an area of a little less than 300,000 square miles, and containing territory varying in altitude from sea level to 3280 feet above sea level, has an average temperature of from 76° to 86° F. This zone comprises the coastal regions, the hot valleys of the great rivers and the plains of the eastern section. Of this zone only about one-half of the area is of any economical agricultural importance.

The temperate zone covers an area of more than 100,000 square miles comprising the high plains and water sheds of the mountain chains, from 3,280 to 6,560 feet high, with an average temperature a year of 60° to 75° F. Economically this zone is of more importance for Colombia than the other, as in this zone the coffee crop is raised.

The cold zone extends over an area of about 100,000 square miles, of which more than two-thirds are in plains and

1. Bulletin Pan American Union, Vol. 40 (1915) p. 194

savannas. It embraces the elevated parts of the mountain ranges, commencing at a height of about 6600 feet and with an average temperature of 59° F. In this zone is the fertile savanna of Bogota. This zone embraces the regions of densest population. As a part of the cold zone, mention should be made of the "Paramos", which are over 10,000 feet in elevation with a temperature of 20° to 30° F.

Chapman, in his work already mentioned, divides the country into four zones as follows: Tropical zone (tierra caliente) from sea level up to 4500-6000 feet; subtropical zone (tierra templada) from 4500-6000 up to 9000-9500 feet; temperate zone (tierra fria) from 9000-9500 up to 11000-13000 feet; "Paramo" zone, from 11000-13000 up to snow line.

Hettner, basing the limits of his division upon an apparently purely arbitrary assignment of isotherms to zonal boundaries, places the upper limits of the tierra caliente at an altitude of 3282 feet; the tierra templada from 3300 to 6500 feet; the tierra fria from 6600 to about 10000 feet, and Paramo from 10000 feet up to the snow line.<sup>1</sup>

The classification of Chapman, which was made for his work on the fauna of Colombia, cannot be used for agricultural purposes. His limits of altitude are too high, with the result

1. Hettner , Die Kordillere von Bogota, p. 70.

that many cold places like Bogota are within the temperate zone, while every writer agrees that Bogota is within the cold zone. Heetner's, which is identical with the one made by Vergara,<sup>1</sup> from whom he probably took it, is very good but the writer prefers to use the first classification here given, based on temperature as it is affected by the topography, (the discussion of the crops to be given elsewhere).

WINDS. Mr. H. M. Wright in an article "A Traveler in Northern Colombia," writes: "Colombia thus possesses every climate range from the subtropical through the successive stages of the temperate zone to that of the lofty regions of glaciers and eternal snow. For the artist, the lover of color, of majestic mountain masses, appalling gorges, roaring torrents, primeval forests of luxuriant tropical growths, flowering vines and delicate orchids, Colombia is a paradise. Moreover, the climate of northern Colombia, which is warmer than that of the southern highlands, has a peculiar charm, both upon the sea coast, which is cooled by the sea breezes, and in the foothills, which are cooled by the proximity to the mountains and also by the monsoon."<sup>2</sup> The monsoon as I have known it, is a wind that comes up about three o'clock each afternoon, subsiding, for a time, at sundown, and is felt in greatest intensity between

1. Vergara Velasco, F. J., Nueva Geografia de Colombia.

2. Underlined by the writer

nine o'clock and midnight."<sup>1</sup> The above quotation has been made for the purpose of showing how the winds modify the temperature of the northern part of the country.

Colombia receives on the western coast the southeast trade winds which are diverted from their natural course, and drawn to the coast as westerly winds: These winds are cool, and in their deviation inland meet the western cordillera and, with the change in temperature, cause the heavy precipitation on the western coast of the country. The same coast during the second part of the year receives the benefit of the monsoon coming from the north in a southeasterly direction. In the north the Caribbean coast receives the winds from the Atlantic from a northeasterly direction, but more from the north from December to May and June, and more from the south during the rest of the year, with more or less uniform intensity. This is due to the fact that the country is situated in the belt of the tropical calms with its storms and cyclones. Due to this system of winds the climate of the coast is very much stabilized.

RAINFALL. Mention has been made of the seasons of Colombia. They are characterized by dry and wet periods rather than by changes in temperature, but the data available on observations of rainfall in the country are less satisfactory than those made on the temperature, and no doubt due to its location,

1. Bul. Pan Amer. Union, Vol. 46 (1918) p. 173

Colombia will prove to be a field of very interesting study, for variations in the rainfall in the same locality and at neighboring stations are very great and it is difficult to make any general estimates.

"Two types of the seasonal distribution of rain are commonly recognized in Colombia: one a wet season of six months duration is followed by a dry season of equal length, the other wet seasons, each of three months duration, are separated by dry seasons of the same duration.

"Under the first named conditions rain usually falls from May or June to November or December and the season is termed invierno (winter), while the months from November and December to May or June are dry and the season is known as verano or summer.

"North of latitude  $8^{\circ}$  the seasons are characterized by one dry and one rainy period; south of this latitude two rainy and two dry seasons are the rule . . . There is, however, much irregularity both north and south of latitude  $8^{\circ}$ , while the amount of variation in annual precipitation at stations separated only by a few miles may exceed 300".<sup>1</sup>

The rainfall on the western coast has reached 400" a year and a heavy precipitation should be expected here as the western cordillera is only a hundred miles from the ocean and

1. Chapman, op. cit., p. 81

receives the equatorial rains. The rainfall farther east is influenced markedly by the presence of mountains which give rise to semi-arid regions on the eastern side of the mountain ranges. The rainfall of the southeast is very high since it extends into the area of the Amazon river where the heaviest precipitation occurs, due to the easterly trade winds and to the cyclonic disturbances which occur on the east coast of South America and which reach a long way inland.<sup>1</sup>

Dr. Hettener in his work already cited makes the following notes on the rainfall and climate of Colombia:

"The Cordilleras of Bogota which occupy the central and north central part of the country belong in part to the equatorial territory with its two rainy seasons varying according to the zenith position of the sun, and in part, in the north, to the territory of the tropics with one rainy season. However, there is a difference between the west and the east sides of the Cordilleras.

"In the west the lowlands of the upper and middle courses of the Magdalena up to about 8° north latitude possess the equatorial rainy season, while north of this point to the coast the months of April or May up to October or November may be designated as the rainy season. During the remainder of the year there prevails the monsoon with dry weather.

"On the east side of the mountains, however, the region

1. Davis, op. cit., p. 302

of the two rainy seasons lies much farther to the south. It runs along a line at the foot of the mountains which incidentally begins below  $3^{\circ}$  north latitude, and then proceeds in a southeasterly direction.

"The western part of the mountains joins the rain district of the western plain, the eastern part that of the eastern plains. The dividing line of the weather runs approximately along the watershed. Nevertheless, in the months of June, July and up to August mists and light rains came over from the east side to the west side of the mountain ridge, where they are called 'Paramitos'. Fine weather prevails in the entire mountain region from December up to February. In March the rains set in on the western side, which, however, on the eastern side do not begin until April. In the second half of April and in May it rains everywhere. In June and July, fine weather prevails on the western side, with the exception of the Paramitos of the border zone, whereas at this time on the eastern side the very heaviest rains are falling. In August and September the rain in the east begins to diminish somewhat, but does not cease entirely until November. In the west the rains begin anew in September, and last until December. Naturally the dividing lines between the rain periods vary somewhat with the different years.

"In the mountains, especially in the higher parts of them,

there are in addition to these general rains the local ones caused by rising currents of air. In the higher parts of the outer slopes, especially at the upper end of the steep valleys, only the mornings have fine weather. Then one sees suddenly mists come pressing up from below, which soon envelop everything, and which last all day long. Not until towards or after sunset does the weather clear up. If, however, the mist is heavy, the nightly cooling of the atmosphere may cause condensation and rainfall. Sunshine at noon in the highlands belongs to one of the rarest phenomena of nature.

"The rain caused by the rising currents of air is a fine drizzling rain, since it falls from a low elevation. It may, however, like our steady rains, last for days."

The northern part of the country has a rainfall of 60" to 80" according to the mean annual precipitation map of the United States Geography of the world,<sup>1</sup> and the rainfall at Bogota, which is situated almost in the middle of the country is given by Petre as 42" during the six months wet season.<sup>2</sup> Perhaps it is safe to calculate the mean annual rainfall of the country at 100" but the distribution of this rainfall should be considered as there are regions where the rains come in such a constant way at certain periods as to make cultivation imprac-

1. U. S. Department of Agric., Geography of the World.

2. Petre, F. L., The Republic of Colombia, p. 53

ticable during that time, inundating the land, which during the dry season needs irrigation if any cultivating is to be done. Such is the case in the eastern central plains. Other regions such as the big savannas of Tolima and Bolivar, have a fair rainfall, but poorly distributed, and since evaporation is great the problem of irrigation exists in these places, and it is of great importance for the agriculture of these exceptionally fertile lands.

Chapman in his cited work gives the following tables which are of only local importance. They are inserted here for the purpose of collecting all the data available which may be useful in drawing general conclusions on the climate of Colombia.

Record of rainfall at Pato Mines on the Rio Neche, Antioquia, from August 1913 to July 1914:

1913	Inches	1914	Inches
August	17.4	January	8.7
September	20.3	February	1.8
October	15.7	March	.6
November	18.6	April	8.8
December	7.8	May	18.8
		June	14.4
		July	10.7

Record of rainfall in inches at Central Stations on the Pacific Railroad (by R. Alvarez Salas):

Stations		1910	1911	1912	1913	1914
Buenaventura		82.3	62.	67.5	59.8	66.8
San Jose	Km. 37	68.7	70.7	102.	78.	
Caldas	" 82	13.9	11.8	13.1	12.7	7.9
Palmar	" 98	8.7	6.4			
Lomitas	" 109		8.7			
Jumbo	" 158				9.6	

Rainfall at La Manuelita, Cauca  
Valley, 1900-1910. Averages.

Year	Amount in inches	Days in which rain fell	Monthly Average	
			Month	Amount in inches
1900	37.97	123	January	3.19
1901	45.21	136	February	3.10
1902	33.80	148	March	4.16
1903	56.38	131	April	6.09
1904	37.74	141	May	5.37
1905	33.79	113	June	2.92
1906	39.96	126	July	1.50
1907	47.80	144	August	1.49
1908	54.94	177	September	2.98
1909	55.13	172	October	5.81
1910	48.50	160	November	4.78
			December	<u>3.20</u>
			Annual amount	44.59

Hunn gives the following table of average monthly and annual rainfall:

Place:	Medellin	Bogota
Latitude	6°10'	4°35'
Longitude	75°45'	74°14'
Altitude	4950 feet	8728 feet
Years of observation	5	4
	<u>Inches</u>	<u>Inches</u>
January	1.4	2.35
February	1.6	2.25
March	3.4	2.9
April	4.4	6.1
May	4.9	4.1
June	4.2	2.
July	2.6	1.7
August	3.2	2.1
September	4.07	1.85
October	4.7	5.35
November	3.7	6.1
December	1.7	3.6
Annual average	39.9	40.3

Ludwig Vofb in his work on South America gives the same table which he improves in the following way:<sup>1</sup>

Seasons in		Inches of Precipitation in		
Colombia	United States.	Bogota	Medellin	Antioquia
Summer	Winter	8.17	2.17	1.43
Fall	Spring	13.2	12.8	7.8
Winter	Summer	6.	10.7	7.7
Spring	Fall	13.3	12.5	8.4

No region of Colombia is arid in the same sense as the arid west of the United States. The total rainfall of all regions is quite high but the distribution is not always favorable and evaporation in general is very great; hence the problem of irrigation and moisture conservation exists in regions with sixty or more inches of annual rainfall.

The data here presented shows clearly the climatic conditions of Colombia. There are regions of constant summer temperature, but the whole country is not the "hot region" which people wrongly think. There are all variations of climes and according to the observed occurrence of denser population in the cold regions, the cold zone of Colombia is the most populated and developed. Another idea is that the "hot region" is only a breeding place for tropical diseases, yellow fever and so forth. There is no yellow fever in the tropical region of South America and by paying attention to sanitary conditions and proper living habits any man can live comfortably there.

1. Vofb, Ernst Ludwig, Die Niederschlagsverhältnisse von Sudamerika, Vol. 33, p. 34

With the broad division of the country into zones depending on temperature and altitude and from the rough estimates of the rainfall which have been given, it is easy to see the truth of the statement that the country has climatic conditions suitable for any plant culture.

The favorable climatic conditions of Colombia have caused the growing on a small scale of many varieties of plants and it is only in the past few years that concentration on a given plant culture has been undertaken.

The economical influence of transportation facilities in the opening of a new country and its agricultural development is well known. Prior to the year 1900 transportation facilities were very poor and agriculture was almost stationary. In the last twenty years transportation facilities have improved with the natural result of an increase in production and trade which has been further stimulated by the great demand. This has resulted in the opening of new land with specialization and large scale production which has furnished a great deal of employment, improved the standards of living, and added greatly to the prosperity of the country as a whole.

In the following brief discussion of the principal crops of Colombia, not only those of commercial importance at present but also those of probable importance in the near future, are considered. Only mention will be made of those crops belong-

ing to the temperate and cold zones.

### Hot Zone

The most important crops of the hot zone of Colombia are: the banana, cocoa, sugar cane, cotton, rubber and tagua.

BANANA. Musa sapientum, R. B. The history of the origin of the banana plant is lost in the shadows of antiquity. There are writers who affirm it is of Asiatic origin, while others are inclined to think the banana originated in Central America. Most of the evidence is in favor of the East Indies as the native place of the plant.<sup>1</sup>

The varieties of banana cultivated most are M. sapientum and the M. paradisiaca or Jamaica banana. The old standard kind of banana known in United States as "dwarf Chinese banana" M. cavendishii, is gaining in popularity and intensity of culture in Central America.

This plant is a monocotyledonous, and of the order Musaceae. It has underground stems or rhizomes, from which rise leaves, their aerial petioles forming sheaths which are rolled concentrically around one another forming what is called the stem, which grows to a height of 18 feet. From the crown of the leaf-sheaths the blades spread out like palm leaves; each blade is from 6 to 10 feet long, about one foot wide, and ovalated in shape, with a strong midrib which runs down the middle of the blade with veins at right angles towards the margins.

1. De Candolle, A., L'Origine des Plantes Cultivees, pp. 242-48

The axis of inflorescence which grows up the center of the petiole sheath rises from the rhizome and emerges among the blades where it bends over and produces its flowers on a long spike, which ripen into fruit. When the whole aerial growth decays to the ground, the rhizome continues growing and sending up new aerial shoots. So the plant is a perennial perpetuated by sprouts.

The banana begins to bloom in from 18 to 24 months, but generally 18. It should have plenty of light, water and space. It grows in almost any kind of soil, but the plantations which are most productive are those on new residual sandy loams where the plants are placed at a distance of 15 feet apart each way.<sup>1</sup>

The cultivation of the banana is very popular in the hot and temperate zones, but the production on a large commercial scale is confined to the Santa Marta region, not because of very favorable climatic conditions, but on account of the nearness to the sea ports.

The climatic conditions required for the culture of bananas are a high humidity, heavy precipitation, or means of supplying abundant water, and a minimum temperature of at least 70° F during the whole year. These requirements satisfied, the plant is able to withstand fairly well any other unfavorable condition, and if the drought period is not excessive, the lack of moisture does not hurt the plant a great deal except that it makes the

1. Bur. Am. Rep., Vol. 18 (1904) p. 909.

fruit smaller.

The banana plant is attacked by various fungi of which Leptospora musae, an organism causing the disease known as Surinam panama, is the most destructive in the plantations of the northern coast of Colombia.

SUGAR CANE. Sacharum officinarum. It belongs to the family of the grasses. The history of this plant is well known. It was found in the East Indies by Nearchus in the expeditions of Alexander, 325 B. C. It was prescribed as a medicine by Galen and introduced into Europe in 625 A. D. Sugar cane was transplanted from Tripoli to Syria about the year 1138, thence to Madeira and to the West Indies and to tropical America in 1510.<sup>1</sup> As Colombia is one of the countries where the exploitation of the colonies by the Spanish government was most active and Spain needed the increase in sugar, it is almost certain that the sugar cane was introduced into Colombia at the very beginning of the sixteenth century.<sup>2</sup>

The plant is a native of the tropics and has as wide a distribution or range of adaptation as the banana plant; it is grown as far north as latitude 32° and as far south as latitude 37°.<sup>3</sup>

1. Bur of Am. Rep. Handbook No. 1, p. 56

2. Introduced in Brazil in 1502. Boletin de Agricultura, 20 Serie No. 7, p. 214

3. Publication of the Sugar School of Habana, Cuba, Tecnologia de la Cana de Azucar. 1916

The plant is a tall, stout perennial plant with flat, distichous alternated leaves, many jointed culms and an ample panicle at the top. It is not reproduced by seeds but by cuts of the stem after the panicle has been removed. The leaf clasps the stalk at the node or joint and under the base of each leaf in the node is a bud incased in a protecting sheath, the external part of which is covered with a plant enamel for protection. These buds are capable of propagating an individual plant when the joints are planted. Above each joint there is a row of dots extending around the stalk which produce temporary roots. The roots, as in all grasses are fibrous and not deep.<sup>1</sup>

The best conditions for the cultivation of sugar cane are a temperature of 80° F with a long period of growth of not less than seven months with warm days and nights. It is estimated that during the growing season the soil should contain at least 25% moisture which in the hot and temperate zones is supplied by an annual rainfall of 60 to 70 inches. The distribution of the rainfall is very important, for an excess of moisture during the most active part of the plant growth is not favorable for the utilization of the plant food.<sup>2</sup>

Neither heavy clay soils nor loose sandy soils are the best for sugar cane. The clay soil does not permit sufficient aeration, and the sandy soil is not only insufficiently reten-

1. Surface, G. T., The Story of Sugar, p. 4

2. Freeman, W. G., and Chandler, S. E., The World's Commercial Products, p. 84

tive of moisture but the cane growing in it has very weak roots for support. The best soils for this plant are the deep fertile loams, with high amount of humus; those derived from alluvial depositions, and from decomposition of volcanic coral or crystalline rocks are well adapted. Clays which are not so heavy as to greatly obstruct the free percolation of water are also quite well adapted.

Cultivation of the plantations should be very intensive. The soil should be plowed deeply and then harrowed and rolled. The plantation should be kept as free from weeds as possible and in order to most economically do this, a system of planting should be found and adopted that would permit the use of modern farm implements.

In about ten months after planting some flowers may appear, but in general flowering cane is the exception.

The harvesting is done in November or December, the planting having been done in May or June of the preceding year. The stalks are cut two inches from the ground and then the panicle is separated from the rest of the stalk. The upper part of the stalk which is still covered with leaves is cut off and saved for propagation of the plant, which in planting produces by germination four or more stalks. This is not a good practice.

The cutting of the cane does not have to be done in a short time. In large plantations it may stand in the field for two months after ripening without any harm, although the total

amount of sugar may be reduced thereby.

Sugar cane is attacked by the sugar cane borer, Diatrea sacharalis and by the sugar cane beetle, Ligyris rugiceps, both causing great losses, especially in plantations set on heavy soils. It is also attacked by Ligyris tumulosus, Sphenophorus sericeus, the root borer Diaprepes abbreviata, Delphas saccharivora and some others less serious.

COCOA. To this perennial plant Linnaeus gave the name of Theobroma cacao, placing it in the tribe Buettnerieae of the order Sterculiaceae. There are about twelve species of which only two have commercial importance and all are distinguished by the shape, appearance or color of the buds and beans or seeds. It is indigenous to tropical America and it is found wild in the basins of the Amazon and Orinoco rivers. De Candolle says: "The common cacao T. Cacao is a small tree found wild in the forests of the Amazon and Orinoco basins and of their tributaries, up to four hundred feet of altitude."<sup>1</sup>

The tree, which reaches a height of from ten to fifteen feet, with many branches, offers the peculiar characteristic of some tropical trees, that of bearing fruit on the side of the stem and branches, away from the leaves. A dozen or more of small, bright red flowers appear on the trunk and are succeeded by pods and finally by fruit.<sup>2</sup>

1. De Candolle, A. de, op. cit., p. 250

2. Freeman, W. G., op. cit., p. 114

The fruit of this tree, inside of which the seeds or kernels are, is a melon or cucumber shaped pod, 7 to 10 inches long and e to  $4\frac{1}{2}$  inches thick. The rind is hard, tasteless and varying in color from yellow to red and purple, marked with longitudinal ridges. In the interior the fruit is divided into five cells, each one containing a row of seeds embedded in a soft pinkish, acid pulp. The beans are the size of a thick sweet almond and are, after the preparation, the raw cocoa of commerce.

Cocoa is a crop of very limited area and very exact needs when compared with other tropical crops. It grows from  $20^{\circ}$  north latitude to  $20^{\circ}$  south latitude if the altitude and the rest of the conditions are suitable. There is no cocoa grown at an altitude over 2500 feet and planters rather select an altitude not over 2000 feet, other things being equal.<sup>1</sup> The humidity of the region must be very high and the soil should have an abundant supply of water and a perfect drainage. If drainage is poor the roots of cocoa decay very easily. The cocoa tree needs at least a mean annual rainfall of 80".

The temperature of the best regions for cocoa cultivation is between  $80^{\circ}$  and  $90^{\circ}$  F,  $85^{\circ}$  having been considered the optimum temperature.

The best soil is an alluvial one, well supplied with or-

1. Bur. Am. Rep., March 1894, p. 39

ganic matter.<sup>1</sup> The cocoa tree is found wild in the same regions where rubber is found and it is found that the cocoa tree grows best in soils in which rubber trees have been grown. In general, a good sandy loam, deep, rich in humus and containing some lime, is the best type of soil.

Mr. J. H. Hart, superintendent of the Botanical Gardens of Trinidad, in his book on Cacao says: "The ideal spot in which to found a cacao plantation is a well-sheltered vale, covered with large trees, protected by mountain spurs from the prevailing winds, well watered, and yet well drained, with a good depth of alluvial soil on which rests a thick deposit of decayed vegetable matter."<sup>2</sup>

Shading is indispensable for the plant. Two kinds of shadings are used. Before the small plants are transplanted from the nurseries to the field a shade crop, such as banana, is established, thus insuring some produce from the soil during the years that cocoa does not bear fruit. The permanent shading is supplied by taller trees and the madre de cacao (mother of cocoa), a leguminous tree of the group Bois immortal, (Erythrina spp.) is the most commonly used.<sup>3</sup>

1. Whympers, R., Cocoa and Chocolate

2. Hart, J. H., Cacao, p. 27

3. Freeman, op. cit., p. 122

The planting is made from the seeds, either right on the field or in nurseries from which the young trees are transplanted when two or three feet high. When the seed is planted, three or more are planted in one hill and only one is selected and left. The common distance for planting is from 12 to 24 feet apart in each direction, but 18 is the best distance.

Clean cultivation of the plantation is necessary. Pruning is practiced especially when the plant is young, before bearing fruit. Grafting is practiced in some regions and is becoming more popular as the different varieties of cocoa are known better, giving good results.

There is no definite time for picking the fruit for the tree gives flowers and fruit every month after it is five years old. In general the main crop is harvested in December; the pods need at least four months to ripen. Another less important picking is made in May or June.

The pods are left on the ground for one or two days; they are then collected and broken to remove the beans. After this the process of fermentation is allowed to go on--(such fermentations as lactous, butyric mucous, etc.). The fermentation process is of very great importance as it determines the quality of cocoa. During the fermentation, the pulp around the kernels is removed; some chemical changes also occur in the kernel, as the change from a bitter to a sweet taste. This process is made in "sweating-houses", specially constructed for

this purpose, and after several steps which take from four to eight days, the beans are ready for drying, an operation performed either in steam-dryers or by exposure of the kernels to the hot sun.<sup>1</sup>

The kernels of a bright color, friable, cleaned and dried, are ready for the channels of trade, going to the manufacturer who prepares the cocoa commonly known.

The most common diseases of the cocoa tree are the black pod, Phytophthora omnivora (De Bary); pod canker, Nectria Bainii (Masseé); stem canker, Nectria theobromae. The organism causing the "root disease" has not been definitely identified. Botryodiplodia theobromae attacks the shoots causing great losses.<sup>2</sup>

RUBBER. Rubber is one of the great essentials of modern life. With iron or steel, with copper and with glass it may be compared in the diversity of its use; it has the advantage over these, and may be compared in this latter respect to corn, wheat and the necessary foods, in that it is capable of eternal reproduction if mankind will but apply to its culture his experience and scientific knowledge.

1. Freeman, op. cit., p. 125

2. Hart, J. H., op. cit., Chap. IX

The classification of rubber bearing trees carries the number well toward one hundred and if many latex-producing shrubs and vines are included the tale might be made three fold. For practical purposes, only four great species are recognized: (1) The Euphorbiaceae containing the Hevea and Manihot; (2) the Urticaceae, containing the Castilloa and the Ficus; (3) the Apocynaceae, containing the Harcomia and the Landolphia; (4) the Asclepiadeae, containing the Cynanchum. The six most important trees are under the first two varieties.<sup>1</sup>

Hevea is the best tree. It is indigenous to the regions of the Amazon river. It is a large tree of rapid growth and long life. The variety originated in Brazil and is known as Hevea brasiliensis, also called "Para rubber".<sup>2</sup>

The Para rubber tree attains a height of over sixty feet and a girth of 4 to 8 feet. The leaves are three-lobed, elliptical and smooth; the flowers are uni-sexual and almost inconspicuous individually, but the female flowers are larger.<sup>3</sup> They are green in color, highly scented and borne in little sprays or panicles, succeeded by dry fruits, each containing

1. "Rubber and its Relatives" in Bur. Am. Rep., Vol. 27, pl 990

2. Freeman, op. cit., p. 280

3. "Rubber Cultivation in Brazil" in Bulletin Pan. American Union, Vol. 47, p. 69

three seeds of small size, with the brown and black mottling characteristic of this family. The seeds are thrown away and soon lose their vitality if not in favorable conditions. The leaves fall from the trees about June, at the dry season, being replaced a few weeks later. The flowers, which are dioecious, appear shortly after the new leaves, and ripen into fruit in about six months.

The Manihot glaziovii tree produces the Ceara rubber of commerce. Its native locality is a high, stony, arid, and in places semi-desert country. Its latex yields a rubber remarkable for its strength and tenacity. The plant is somewhat shrubby, not over 30 feet in height, and has the same characteristics of leaves and flowers as Hevea.

The Castilloa markhamiana, next to the Hevea is the best known rubber producer. It is native of Central America, and is found wild in Colombia, on the western side of the Andes where the principal rubber plantations are located.

The Castilloa tree is as large as the Hevea and sometimes reaches a height of 150 feet. It has very large, oval leaves arranged along both sides of special branches which fall off with the leaves. The flowers are massed in dense heads and each flower produces a single seed which is white and comparatively small. The bark of Castilloa is harder than that of Hevea.<sup>1</sup>

A botanical description of each variety of the named rubber trees would be so extensive that there is not space for it here. Each variety has a peculiar characteristic in the shape and behavior of its leaves, flowers, fruits and seeds. But all give a latex which contain from 20 to 70% of rubber identical in chemical composition, though it may vary in physical properties.

The Hevea requires a low-lying, rich, deep soil and an abundance of moisture such as that found in the region of the Amazon where the rainfall is estimated at 150". It is limited in altitude to about 1500 feet. It requires a constant period of growth with a temperature not less than 85° F for the annual mean.<sup>1</sup>

The Castilloa appears to thrive best in deep loamy soil near the banks of streams and in valleys, but it does not like swampy or boggy land.

In general the rubber tree of any variety grows best in alluvial soils of regions within the 10° S. latitude and the 15° N. latitude, where the mean annual temperature is not less than 85° F, with 80 to 150 inches of rainfall, and where the short dry and wet seasons alternate.

The propagation is made from seed or by cuttings. In planting the square or the hexagonal system of planting is used,

1. Johnson, W. H., The Cultivation and Preparation of Para Rubber, p. 21

with a distance not less than 20 feet each way. Cultivation is practiced, for the tree should be free of weeds and vines.

The rubber tree begins to give latex when it is five years old or older and the common practice of tapping the trees is carried out between June and February, or during the dry seasons. One collector is assigned for each 100 to 150 trees; he inspects the trees and selects those at least 2 feet in girth; V-shape incisions are made around the tree, in line and from the bottom up. A small pan is first placed to receive the latex. The rubber begins to run immediately from the incision and it is allowed to run into the cup for several hours. When the flow has ceased all the little pans are emptied into a large vessel. The trees may be tapped as many as thirty times if care and proper methods are used. On the basis of 100 trees to an acre, from 110 to 280 pounds of latex are obtained yearly, depending on the age of the trees.<sup>1</sup>

The next step is to convert the liquid latex into solid rubber.<sup>2</sup> A fire is lighted and nuts of various species of plams are placed on it. A dense smoke containing acetic acid and creosote is produced, which rapidly coagulates any latex exposed to it. A kind of paddle is dipped into the latex and then

1. Bul. Pan. Am. Union, Vol. 47 pp. 66-75

2. Freeman, op. cit., p. 284

held in the smoke to coagulate the rubber, forming a thin layer on the paddel; this is then again dipped into the latex and smoked; the process is repeated until a sufficiently large mass of solid rubber has been collected on the paddle. The rubber is then removed and is ready for sale and export. Vinegar is also used a great deal to coagulate the latex and there are some mechanical process also practiced to day.

The rubber tree is attacked by several organisms. There are three which attack the roots: Fomes semitostus, Hymenochaete noxia, and Sphaerostilbe repens. Phytothora faberi causes the canker malady. Two attack the shoots,--Gloeosporium alborubrum and Botryodiplodia theobromae.<sup>1</sup>

COTTON. Cotton was known and used in India 800 years before the Christian era, and was described by Nearchus in 327 B. C., who found it on the shores of Arabia and the Gulf of Persia. India was the center of cultivation.<sup>2</sup> In America, Columba found it growing abundantly in the West Indies and neighboring coasts of America.<sup>3</sup>

The cotton plant belongs to the mallow order, or Malvaceae, closely related to the wild mallows and to the hollyhocks. The

1. Lock, R. H., op. cit., Chap. VIII

2. De Candolle, op. cit., p. 325

3. Todd, J. A., The World's Cotton Crops, p. 18; Freeman, op. cit., p. 328

principal varieties of cotton are the following: Gossypium hirsutum, native of Mexico, which has both short and long hair and is the most widely cultivated in United States; Gossypium herbaceum, a native of India, which is the most important cotton of the world; Gossypium barbadense or "sea-island" cotton, a native of Barbados and Central America, and found wild in Colombia according to Triana<sup>1</sup> who also mentions a variety of hirsutum but fails to say if it is found in a wild state; and G. arboreum which is found native in Africa and South America. Mr. M. T. Dawe in his report to the government of Colombia,<sup>2</sup> recommended the cultivation of cotton in the northeastern part of the country, and said that the kind generally grown is the perennial type G. arboreum common to South America; and G. religiosum found wild in Asia and on the western coast of the Andes in America.

Cotton is cultivated in a very wide area, from 40° north to 30° south latitude, but the requirements of the plant are not found everywhere within these latitudes. The cotton plant requires a long period of growth of not less than seven months, in a warm climate. It is very sensitive to frosts. Approximately the best temperature for the growing of cotton is an average

1. Triana and Planchon, Prodr. florae Novo-Granatensis, p. 170

2. Dawe, M. T., Account of a Journey down the Magdalena River, p. 17

of 65° to 70° F for the year. Besides a long growing period and a high temperature the cotton plant requires a very high humidity and an annual rainfall of not less than 60 inches, well distributed.

The cotton plant grows in almost any kind of soil, but it is well known that it grows better, other things being equal, in fine sandy soils. A. Laliere says: "Le cotonnier est une malvacée et, a ce titre, il préfère les sols siliceux ou silico-argilleux dont le sable est intimement mélangé aux autres parties . . ."<sup>1</sup> In the United States most of the cotton is grown in the fine sandy soils of the Norfolk series. In general the soil should be well supplied with organic matter and the essential chemical elements.<sup>2</sup>

As cotton growing is so well known in the United States it only needs to be added that in Colombia it had received no attention until a few years ago. The writer, judging by private information, thinks cotton will be one of the leading crops in sections of Colombia where the conditions are favorable.

IVORY NUT. Regarding the cultivation of the ivory nut, the following words of Mr. Dawe are of interest as he had the opportunity to see the plant in a wild state: "The tagua or ivory nut palm Phytelephas macrocarpa is of social habit and

1. Laliere, A., Le Coton, p. 30

2. U. S. Dept. of Agriculture, The Cotton Plant, p. 180

is found growing together over considerable areas, generally in wet and heavy clay land. The palm is stemless, having only a rootstock from which the leaves and fruits are produced but little above the ground level. It is dioecious, consequently only female palms bear fruit. The nuts as they are known in commerce are borne in heads, one head containing about fifty nuts. These heads are usually collected and carried to a tree where on the spreading roots they are beaten out with a wooden mallet. In good seasons, when there is a good yield, from 100 to 125 pounds are collected by one person in a day."<sup>1</sup>

The cultivation of the palm has been undertaken in some regions very recently in order to supply the increasing demand for the nuts, and some information should be published soon. The importance of this commercial product which is the principal product now exported from the forests of the Carare made the writer mention it.

The most important and valuable crops of the hot zone of Colombia having been discussed at length, mention should be made of the following:

**TOBACCO.** It is indigenous to Central America and north of South America, and belongs to the family Solanaceae. There are two species known, the Nicotiana tabacum and N. rustica. It is grown in very limited extent in Colombia, but its cultivation is extending very rapidly. The quality of the leaves pro-

1. Dawe, op. cit1, p. 5

duced is very high and it should be one of the most important crops of the future.<sup>1</sup>

RICE. It is indigenous to China and was cultivated for the first time in America in Brazil at the beginning of the sixteenth century. It belongs to the family of the grasses; its botanical name is Oryza sativa. The Zizania aquatica, wild rice of America comprises two species which are well characterized by the structure of their flowers and panicles.<sup>2</sup>

Rice cultivation in Colombia is not well developed and the production is far below the consumption. Some way to encourage its growing should be found, as there are large areas of land suitable for the purpose.

YUCCA. Yucca glauca. It is a root, indigenous to subtropical America, rich in starch, and of about twice the length of the sugar beet. The plant belongs to the order Lilaceae.

"Arracacha" Arracacha esculenta is a yellow root, native of America, rich in sugar starch. The cultivation of these roots is of national importance as they constitute a substitute for potatoes and because of the wide application that they have and will have in industries. Ananas sativa, or pineapple, should be mentioned for its importance as a fruit in foreign countries. Its cultivation has been well described by H. J.

1. "Tobacco" in Bul. Pan Amer. Union, Vol. 44, p. 52

2. "Rice in the Americas" in Bul. Pan Amer. Union, Vol. 44, p. 137.

Webber in his report on the pineapple industry of the United States.<sup>1</sup> In Colombia its cultivation is developing rapidly. The Metnion should be made of the quinoa, or quinine, Cinchona ledgeriana,<sup>2</sup> which is cultivated extensively now and whose importance and need is world wide. Sarsaparrilla, another drug which is produced by Smilax ornata (Hook), and In chicle, Achnas sapola, the basis of chewing gum, which is found wild in the north of Colombia, are forest products of Colombia and their culture should be developed soon on better commercial basis. Fique, Furcraeas macrophylla (Baker) found wild in Colombia may become a very important cultural plant for the fibre industry of the country. Mr. Lyster Dewey, the fibre expert of the United States Department of Agriculture, writes to Mr. Dawe as follows: "Some specimens of fibre of Furcraea macrophylla which we have cleaned by hand from leaves received here at this department indicate that the fibre is finer, whiter and softer than that of either the true sisal of the Bahamas or the henequen of Mexico."<sup>3</sup> "Peta", another fibre producing plant of the family Bromeliaceae is also a crop of future culture

1. Bul. Pan Amer. Union, Vol. 47, p. 350

2. Bul. Pan Amer. Union, Vol. 42, p. 61

3. Dawe, op. cit., p. 8

1. De Candolle, op. cit.

and of great importance.

In the temperate zone the most important crop is coffee, the cultivation of which will be described shortly. Sugar cane, banana and some of the crops placed in the hot zone are also cultivated in the temperate zone, but the writer thinks the most economical culture is carried on in the hot zone. In the temperate zone the culture of fruits is very common and if there were space the writer would mention some of the many distinct and delicious fruits of this zone, unknown outside of the country.

In the upper limits of altitude and lower limits of temperature of this area, maize or corn, wheat, barley and oats are cultivated very extensively. The bulk of vegetables, of which there is a great variety, is also produced mostly in the same limited area.

COFFEE. Coffee derives its name from the city of Kaffa, south of Abyssinia where it is believed the coffee tree originated, but the history of coffee before the fifteenth century is unknown.

At the beginning of the fifteenth century coffee was cultivated in Abyssinia and the beverage prepared was called, cobo or cahove, coava or cave. By this time it was known also in Arabia and from this country passed to Turkey, Persia and Egypt during the sixteenth century.<sup>1</sup>

1. De Candolle, op. cit.

From a tree sent from Amsterdam to Louis XIV, it is said that the first seeds sown in America originated. At any rate the coffee tree was in America during the first twenty years of the eighteenth century and it was, in all probability, introduced by the Dutch. In Colombia coffee has been cultivated since some years after 1802.<sup>1</sup>

The plant belongs to the order Rubiaceae, to the genus Coffea. There are two main species, C. arabica and C. liberica, and other varieties of less importance.<sup>2</sup>

The tree cultivated in America is the C. arabica. It is a perennial, evergreen plant that may grow to a shrub 14 feet high or more, having no branches in the lower part of the stem. In cultivation it is pruned<sup>3</sup> to only four feet high when it branches in the lower part, forming a cone. It has numerous thin roots with a tap root going straight down. The leaves are ovalated and leathery. In the axilla of each leaf in the spring there are formed from 12 to 16 buds, which soon bloom. The flowers are white and very fragrant, and always in clusters. They stay on the tree for a short time only. They become dark

1. Bur. Am. Rep., Vol. 18, p. 2, Handbook No. 1, p. 56

2. Boutilly, v., Le Cafeir de Liberia, p. 1

3. Pruning is not procticed in Brazil.

and wither in two or three days. Two or three efflorescences occur before the buds become completely ripe.

Groups of seeds issue when the leaves fall, long after the flowers have fallen from the small stems. They are at first green and coarse, turning red and smooth as they ripen. The fruit in its ripened condition is called a cherry and is of variable size, dark red, and containing two seeds. The seed is convex on one side and flat on the other, covered by a delicate silver colored skin and wrapped in a cartilaginous membrane of rough consistency. Between the epidermis of the fruit or cherry and the named membrane of the seed there is a sweetish, fleshy, mucilaginous, saccharinate and somewhat agglutinated pulp. The fruit ripens in about seven months from the time of blossoming.

Coffee plants are propagated from seeds. The seeds may be planted directly in the field, but the best practice is to plant the seed in beds and nurseries, transplanting when the plants are four or six months old or about two feet high. Care should be taken to harden the young plants before transplanting them in the field, which is best done during the rainy season.

The tree needs shade, especially when young. Banana plants are used for what is called temporary shading when the coffee plants are young, and rubber trees or any other are used for permanent shading. The intensity of the shading required for

the plant depends upon the site, elevation and temperature of the region. Too much shade is not good. The coffee does better with just slight shading.

The tree bears lightly when it is three years old and the normal fruiting takes place when it is five or more years old. In some places the fruiting comes at two or three different times during the year but in general the bulk of the fruit is picked right along during April or May, November or December, depending upon the locality.

The geographical distribution of coffee lies within a sub-tropical and tropical zone comprised between  $20^{\circ}$  N and  $22^{\circ}$  S latitude, and between longitude 160 west and 150 east of Greenwich. It does not grow well in altitudes above 5000 feet sea level, and in Colombia it is not cultivated in the hot lowlands or in lands of an altitude lower than 2000 feet. The best altitude is about 3000 feet above sea level with a temperature during the year of from  $70^{\circ}$  to  $75^{\circ}$  F and a very heavy well distributed rainfall, not lower than 50 inches a year. The essential thing regarding altitude and temperature is that the region be entirely free from frosts because frosts at any time of the year kill the coffee tree.

A gently sloping surface and an eastern exposure is preferable for the plantations. The need of good aeration or free circulation of air is more important as altitude increases and

temperature decreases, in order to avoid frosts.

Coffee thrives best in a moist, rich and well drained soil<sup>1</sup> but it is also grown in some semi-arid regions where the water is supplied by irrigation in which case the seeds are smaller and the yield lower. Texturally, almost any kind of soil will do for coffee if it does not have too much clay. Fir-able, sandy or even gravelly soils are the best. With good drainage considerable clay is not objectionable. Soils that retain standing water do not give good coffee though the trees reach a large size. The most essential thing about the soil is that there should be good under drainage. The following words emphasize the importance of a well drained soil: "Coffee thrives best on a light, porous loam of considerable depth which has not before been brought under cultivation. Clay land should generally be avoided as unsuitable."<sup>2</sup> Mr. A. Lazo Arriaga, writing on the plantations of Guatemala says that the sandy soils with a good proportion of humus and characterized by a dark red color are the best for coffee.<sup>3</sup>

In Brazil the best coffee plantations are planted in the famous "Terra roxa" which though relatively poor in essential

1. Bur. Am. Rep., Vol. 1, no. 12

2. Bur. Am. Rep., Vol. 3, p. 702

3. Bur. Am. Rep., Vol. 14, p. 1520

elements, gives the best results. These soils have very good physical properties: They are very deep, with an impervious sub-soil; they are 6 to 9 feet deep and can hold water without harming the roots of the tree. The texture of these soils is a medium sand with a great amount of humus and a darkish red color.<sup>1</sup>

After the plantation is under way, care is taken to maintain a clean field by cultivation. Pruning is done the first year after the small trees are transplanted and is done every year in order to maintain a convenient shape of the tree and the vigor of the plant. In order to establish a good plantation, care should be taken that the trees are not set too close together, and in general not more than 300 and not less than 250 trees per acre give the best results.

Gathering of the beans is done by trained hand labor as soon as the bean has the dark red color mentioned. A man for each 1000 trees is the minimum labor required for this operation. The picking is made by separating the fruit from the pedicle that holds it, which should be left on the branch. The fruit is collected by using wagons or is transported by water in special channels. Its preparation on a large scale is then undertaken.

The ripe cherries are treated by either of two methods.

1. Queiroz, Fonseca, Informações uteis sobre a Cafeicultura, p. 38; Walsh, Joseph M., Coffee its History, Classification and Description, Chap. IV.

In the dry method the beans or cherries are spread on boards or shallow boxes, or on canvas; during the first days the beans are frequently stirred up so that all are exposed to the sun, and when the pulp has fermented and is dry the beans may be stored or may pass to the hulling machine. In the wet method the beans are separated as to quality in water. The large, plump beans sink and the others float. From here they are carried, after they are dried, to the "pulpers" which are of various types, either cylindrical or disc shape, where by a rasping action the cherries are reduced to a pulp.<sup>1</sup>

After the beans or cherries have passed through the "pulper" they are not yet clean, but the "parchment" wrapping of the seed is still covered with a slimy layer which can not be gotten rid of in the pulping machine. Fermentation is allowed to set in and continue for from twelve to forty-eight hours or more and then the beans are washed. The beans which are not developed sufficiently and are light and float, are separated. All the beans are dried again in the open air or by mechanical processes, as described for cocoa. The beans when thus prepared constitute what is known as "parchment coffee". The removal of this parchment covering is called the peeling operation, which is done in special machines of various types and designs. A further rubbing and winnowing gets rid of the silver skin, leaving the seeds clean. Now the seeds are graded according to size and pass to the different processes of curing,

1. Freeman, op. cit., p. 182; Keable, B. B., Coffee, p. 29

that is, coloring, polishing, etc.

The important diseases of the coffee plant are the leaf-blight, caused by Homilica vasatux, the canker or bark disease and the Stilbum flavidum causing the common "iron spot".<sup>1</sup>

In Brazil the most terrible parasites of the coffee plant are the Hemilleia vastatrix, which attacks the leaf; the Demathophora necatrix which attacks the roots, and Loranthus bras, which attacks all the plant.<sup>2</sup> Mr. Dawe mentions the Hemilleia vastatrix as being very common in Colombia.

In the cold zone corn, wheat, barley, oats, vegetables, etc., are grown to supply the national needs, though perhaps not completely.

The cultivation of the potato is very extensive in the paramos where the mean annual temperature is 10° C and there is a good amount of moisture. In these regions fine crops of potatoes are obtained.

The writer does not think there is any need of discussing the crops of the cold zone, which are so well known. The reader who wants information about the forests and cattle raising in Colombia is referred to the two excellent articles in English, viz., "A Traveler in Northern Colombia"<sup>3</sup> and "The Cattle Industry in Colombia and its Possibilities."<sup>4</sup>

1. Walsh, op. cit., pp. 84, 88

2. Fonseca, Queiroz, pp. cit., 77

3. Bul. Pan Amer. Union, Vol. 46, p. 468

4. Bul. Pan Amer. Union, Vol. 40, p. 194

TABLE VIII

Content of essential elements of some of  
the different countries of South America and their  
crops.

<u>Place</u>	CaO	K <sub>2</sub> O	P <sub>2</sub> O <sub>5</sub>	N	MgO
1					
Brazil--Sao Paulo--Ribeirao					
Preto--Coffee, cotton	.287	.0497	.1076	.215	.0972
Sao Paulo--Jhu					
Coffee	.078	.0119	.0526	.152	.049
Sao Paulo--Campinas					
Coffee	.053	.0215	.0191	.083	.054
Prairie soil, uncultivated	1.55	.048	.027	.155	- - -
Prairie soil, "	trace	.009	.01	.08	- - -
Prairie soil, cultivated	.083	.007	.058	- -	- - -
Same soil improved	.019	.014	.034	.102	- - -
2					
Uruguay					
Soil	.3516	1.095	.0025	.114	.178
Subsoil	1.1325	1.171	.0151	.0711	.079
3					
Argentina					
State of Buenos Aires	.833	.441	.089	.13	
" " Santa Fee	.294	.504	.043	.045	
" " Cordoba	.826	.508	.145	.151	
" " Misiones	.106	.070	.078	.158	
4					
Peru					
Location not given	1.6	.083	.18	.105	
" " "	1.6	.235	.19	.104	
" " "	1.99	.311	.2	.0924	
5					
United States					
Illinois unglaciated		31.450	.950	.1890	
" upper Illinoisan	3.0	34.860	.840	.2010	
Late Wisconsin	9.80	37.370	1.870	.8900	
Pre-Iowan		37.180	.850	.2390	

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Soil series	CaO %	K <sub>2</sub> O %	P <sub>2</sub> O <sub>5</sub> %	N %
"Roxas"	.24	.10	.10	.15
"Massape"	.16	.13	.07	.12
Sandy	.14	.10	.05	.11
Loams	.20	.12	.12	.2

Summary of the average composition of the four most important soils of the State of Sao Paulo.<sup>1</sup>

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Approved:

E. Truog  
Solo



