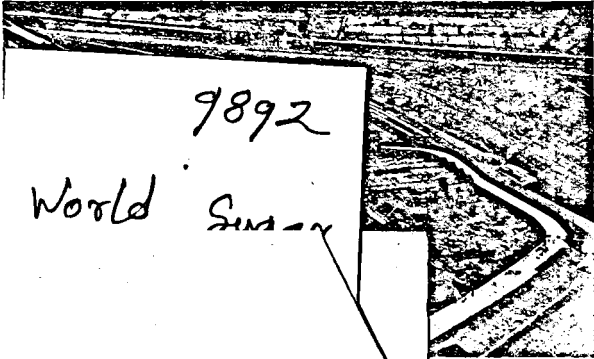


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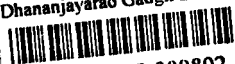
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WORLD SUGAR PRODUCTION & CONSUMPTION

AN ECONOMIC-GEOGRAPHICAL STUDY

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BY

C. J. ROBERTSON,
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WITH A FOREWORD BY
NOEL DEERR

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FOREWORD.

WHILE there are numerous books available dealing with the technicalities of the manufacture of sugar, there are few which are concerned with the economics of its production. This is so much so that it has become a matter of routine to design a factory to operate on so many hundreds or thousands of tons of raw material per day. This alone will not ensure success to any projected scheme; a study of the economics, including therein such matters as labour supply, access to markets and utilization of natural facilities, are of equal or even of more importance.

These matters are discussed in this book and the method of their presentation leaves little to be desired. The effect of climate, density of population, tariffs, the relationship of research to industry and many other controlling factors are all considered in detail. Though addressed, in the first instance, to the economist, there is much of interest to the producer also.

NOEL DEERE.

PREFACE.

EXHAUSTIVE treatises on the technical aspects of sugar production have been written, dealing with cane or beet agriculture, with the factory processes in the production of raw sugar from cane or beet and with sugar refining. A book giving a comprehensive survey of the world's production of sugar from both cane and beet and with emphasis on the economic-geographical aspects has, however, been lacking. The author's realization of this need arose from his experience when lecturer on the Sugar Trade at the City of London College. With the growing interest in specialized training for commerce the desirability of concise but thorough treatment of the various commodities from the economic-geographical point of view has become more apparent. The present volume aims at meeting this need in the case of sugar. It is hoped, however, that it will prove useful to a wider public than that directly interested in commercial education.

Whether open competition or regulatory planning is predominant, the relative advantages of the various sources of supply and the factors determining present and future consumption of the commodity remain of fundamental interest to all directly concerned with sugar, as growers of cane or beet, as producers of the raw or refined article, as brokers or as large consumers. Sugar, too, has long been to an exceptional degree a commodity of political interest and, though its rivals in this respect have in recent years increased rapidly in numbers, retains amongst them all a prominent position in the news of the day. While no attempt has been made in the following pages to discuss the national and international schemes for the regulation of the market, it is hoped that an adequate factual basis has been provided for an understanding of the main issues and that the book may thus be of interest to a circle of readers much wider than that of those directly concerned with the trade.

The attempt to treat the commodity by a method very largely geographical may be of interest to students

of economic geography and will at any rate provide them incidentally with material not elsewhere easily accessible. The author regrets that cost has excluded any cartographical treatment.

The principles on which the matter is arranged will be readily apparent. After chapters devoted to the general conditions of production of cane-sugar and beet-sugar respectively, the principal producing countries or groups are dealt with separately. It will be noted that a political rather than a regional grouping has been considered more useful. Owing to the need for condensation and for avoiding repetition many of the facts relevant to an understanding of the position in individual countries must be sought in the general chapters. Only existing conditions are dealt with, there being no attempt at historical treatment. The chapters on the principal producing areas are followed by a study of the refining industry. The concluding chapters discuss the main factors affecting the demand for sugar and the prospects of world production and consumption. To avoid encumbering the text with statistical material most of this has been relegated to the notes at the end of the chapters and to the appendix.

The material on which the work is based has been drawn from such a vast number of sources, mainly in periodicals and official reports, that it is impossible in a book of this size to indicate these adequately.

The author desires to express his acknowledgments to the Editor of *The Geographical Review*, published by the American Geographical Society at 156th Street, Broadway, New York, for permission to incorporate in this book portions of an article contributed to that journal. Similar acknowledgments are made to the Editor of *Geography* for permission to reprint material that here forms the bulk of Chapter II. Chapter XII and part of Chapter XIII originally appeared in *Facts about Sugar*.

C. J. ROBERTSON.

The International Institute of Agriculture,
Rome.

CONTENTS.

CHAPTER	PAGE
I. AN OUTLINE OF THE WORLD TRADE IN SUGAR	1
II. GENERAL CONDITIONS OF CANE-SUGAR PRODUCTION	5
III. GENERAL CONDITIONS OF BEET-SUGAR PRODUCTION	17
IV. CUBA	25
V. JAVA	31
VI. INDIA	38
VII. BRITISH EMPIRE PRODUCERS EXCLUDING INDIA	44
VIII. UNITED STATES PRODUCERS INCLUDING THE PHILIPPINES	62
IX. OTHER CANE-SUGAR PRODUCING COUNTRIES	77
X. EUROPE AND THE SOVIET UNION ..	85
XI. THE REFINING INDUSTRY	92
XII. THE COMPONENT FACTORS OF CONSUMPTION	106
XIII. PROSPECTS OF CONSUMPTION AND PRODUCTION	118
BIBLIOGRAPHICAL NOTE	133
INDEX	134

CHAPTER I

AN OUTLINE OF THE WORLD TRADE IN SUGAR

THE world trade in sugar presents the particularly interesting feature of bringing into direct competition the agricultural production of tropical and temperate zones, an identical commodity being produced from two very dissimilar plants growing respectively under very different sets of geographical conditions. Until the beginning of the nineteenth century the sugar-cane was the only important source of the commodity. The development of a large-scale international trade in sugar dates from the opening up of the Caribbean and Brazil by the colonizing powers. Introduced into the West Indies very shortly after their discovery by Europeans, the crop spread rapidly in the course of the sixteenth century, the chief centre of production being at first Santo Domingo; in the seventeenth century Brazil took the lead, but in the eighteenth century the West Indies regained their position, with Haiti as the chief producer, and in the nineteenth century Jamaica and Cuba. Meanwhile production in Java, which had undergone great expansion in the eighteenth century, though with very large fluctuations, had also reached a high level. The great expansion of Cuban production since the beginning of the present century has retained the leadership in the Caribbean lands, which in the five years ending 1929-30 produced over one-third of the world's cane-sugar (including that of India, but not the statistically unknown production of China) and well over one-fifth of the total world sugar supply. The only other area with a comparable concentration of production is Java, which in the same period accounted for 15 per cent. of the world's cane-sugar and 10 per cent. of the total. The very large production of India,

2 WORLD SUGAR PRODUCTION AND CONSUMPTION

mainly in the north, rivals, *tel quel*, that of Cuba, but consists, except for a relatively small proportion, of a crude product not comparable with the sugar of international trade.

In the first half of the nineteenth century the beet-sugar industry in Europe gradually increased in importance, and in the latter half much more rapidly, until at the end of the century beet-sugar accounted for 64 per cent. of the world's total sugar supply. From this maximum its relative importance subsequently declined and in the period 1909-10 to 1913-14 the proportions of cane-sugar and beet-sugar respectively were 52 per cent. and 48 per cent. In 1919-20, when the effects of the War on European beetlands reached their height, cane-sugar rose to 79 per cent. of the total and, though with the revival of European beet-sugar production it has declined in relative importance since, it has remained at a level above that of pre-War years. The average proportions of cane-sugar and beet-sugar in the quinquennium ending 1932-33 were respectively 65 per cent. and 35 per cent.

The average of world production for the five years preceding the War was 17.5 million metric tons, India and Germany leading with 2.3 million each; Cuba, which produced 2.0 million tons, and Russia, with 1.7 million, were both increasing their production at a rate greater than that of the world total, while the two leading producers, India and Germany, were tending to fall behind. The world-total fell to a minimum of 15.7 million metric tons in 1919-20. Subsequently there was an increase each year until 1925-26, when 24.7 million tons was attained. In 1930-31, before the reaction to the world economic depression made itself fully apparent, a new maximum of 29.0 million metric tons was attained. In the five years ending 1929-30 the average of world production was 26.9 million tons, Cuba leading with 4.7 million (18 per cent.), followed by India with 3.2 million (12 per cent.) and Java with 2.7 million (10 per cent.), while Germany had 1.8 million and the Soviet Union and Czechoslovakia 1.2 million each. The most striking

features brought out, therefore, by a comparison of the years immediately preceding the world economic crisis with those immediately preceding the War are the increase of Cuban production by 125 per cent. and that of Java by 98 per cent., while world production increased by only 54 per cent.

The double origin of sugar—from cane and beet, from the tropical and temperate zones—means an exceptionally widely distributed area of supply. Fluctuations of world production due to climatic factors are therefore relatively small since it is rare that specially favourable or unfavourable weather will respectively prevail over a large proportion of the total area at a given time. Similarly there is little danger of shortage due to the rapid spread of diseases or pests.

The wide areal distribution of production means, too, that supplies are coming on the market in large though varying quantity throughout the year. From September to January European, Russian and North American beet-sugar production is increasing available supplies. Simultaneously the cane crop in Mauritius, in Réunion and in Louisiana is being crushed and, from November to January, the bulk of the Indian production. Between January and June output is mounting up in Cuba, Puerto Rico, the Dominican Republic, the British West Indies, Central America, Hawaii, the Philippines, Formosa and Egypt. By May the crushing season has opened in Java, Natal and Argentina and in the following month in Australia and in Fiji, all these countries continuing operations until November, or later. The distribution of the dominant producers is such that the seasonal rhythm of world production shows two maxima annually, one in the first quarter of the calendar year, due to the harvest in the Caribbean area, the other toward the end of the calendar year, due to the crops in Europe and Java.

Of the total world consumption of sugar known to commerce probably about four-fifths are accounted for in temperate lands. Europe (not including the Soviet Union) accounts for about one-third (the United Kingdom

4 WORLD SUGAR PRODUCTION AND CONSUMPTION

alone for 8 per cent.) and the United States for one-fourth. In Continental Europe Germany and France are the greatest consumers, while outside Europe the greatest absorption, after that of the United States, is by India, China, the Soviet Union and Japan. Of the international trade in sugar in 1928-31 the imports of the United States alone made up two-fifths and those of the United Kingdom about 15 per cent., the other principal importers being Japan, China, India and Canada. These are followed by France, the Netherlands, Switzerland, the Scandinavian-Baltic states, the North African territories, Chile, New Zealand and British Malaya.

The United Kingdom market has in recent years, due to the preferential tariff, been dominated from November to February by imports from Australia and Mauritius, while home beet-sugar production also plays an important role during these months. In March the Dominican Republic, Mauritius, Europe, Java and Cuba are rivals for the lead. From April to October Cuba is the dominant supplier, with the Dominican Republic or Europe taking the second place till in August the export surpluses of the southern hemisphere begin to make themselves felt.

In the United States market Cuban imports remain at a high level throughout the year but have to meet with the severe competition of duty-free supplies from Hawaii, Puerto Rico and the Philippines from February to September, of domestic beet-sugar from November to the middle of the year, and of domestic cane-sugar from November to February.

CHAPTER II

GENERAL CONDITIONS OF CANE-SUGAR PRODUCTION

THE sugar-cane is a perennial, capable of producing for many years in succession fresh off-shoots from the mass of underground stems. The first crop produced after planting is known as plant cane, and is in the ground generally from fifteen to twenty-four months, the period depending mainly on the climate of the region. The crops of succeeding seasons are termed ratoon crops, each of which is in the ground generally for twelve months; after the second ratoons, at the latest, the yield per unit area decreases and the number of ratoon crops harvested, if any, depends on the relative importance of decreased returns and of the saving of labour and other costs due to there being no fresh planting. According to Earle, eight to ten good ratoon crops are easily obtainable on reasonably good lands providing suitable strong-rooting varieties are planted.

The very numerous varieties of sugar-cane in cultivation, probably all very complex hybrids, are generally placed in two main groups, the tropical and the North Indian. The former, which are now believed to have arisen in New Guinea or Polynesia from a species allied to the wild cane, are those most commonly cultivated. The latter, of which the best-known variety is Uba, grown especially in Natal, have the disadvantages not only of smaller unit-yields of cane, but of less juice, more fibre and adherent leaves, but are more resistant to unfavourable climatic conditions and to disease.

In the field the plant is propagated vegetatively, by planting "sets" or pieces of cane with several—usually three—joints, from each of which there develops a root system and a shoot, the latter itself producing underground branches which push their way upwards as the

visible growing stems or canes. As the internodes grow older and further removed from the growing point of the stem their function becomes predominantly that of storing up the food produced by the leaves in the form of sucrose. Plants produced from seed have been found to be of very variable and generally inferior quality; planting operations are more difficult and the seedlings are delicate and take longer to mature. Propagation by seed is now, however, the principal means of producing new varieties in place of the mere selection of chance variations.

CLIMATIC FACTORS.

Moisture.—The cane requires most moisture during its period of growth in order to maintain the weight of the crop and secure a good yield of sugar per unit area; the maturing period should be relatively dry. Given the temperature requirements of the crop, it accordingly finds its most suitable natural moisture conditions in those tropical or subtropical regions where there is a well-marked alternation of a wet and a dry season in the course of the year. Only in the case of ratoons, however, with their average of twelve months in the ground, is continuous development possible, apart from regions relying on irrigation. Plant cane is generally put in the ground toward the end of one wet season so as to get at least time to establish itself; growth ceases during the ensuing dry season (unless the crop is irrigated) and makes its most rapid progress in the second wet season, while the final ripening occurs in the second dry season. For example, in Cuba, planting of the main crop (*gran cultura*), which is in the ground for fifteen months or more, begins in September, the crop ceases development in the dry months from November to April, makes its main growth during the wet season from May to October and ripens from November onward, the cutting and grinding of the crop normally beginning in January and the mills ending their campaign not later than the coming of the rains in May.

GENERAL CONDITIONS OF CANE-SUGAR PRODUCTION 7

Sugar-cane is found growing successfully within wide limits of annual precipitation, roughly from 40 in. to 100 in. The actual moisture supply depends not only on rainfall but on the amount of water lost through run-off, percolation, evaporation and transpiration. Allowing for this, the precipitation during a certain period in the plant's growth is found to be critical, determining the ultimate yield of the crop. Thus, in Java, where the cane is mostly planted from June to September, the critical period as regards moisture is October-November, especially the former month, that is, at the beginning of the ensuing wet season, when the young cane is developing most rapidly. A formula has been worked out by Tengwall and Van der Zyl, whereby a forecast approximating closely to the actual yields obtained in the ensuing campaign from May to October has been found possible.¹ Obviously investigations of this kind, enabling mathematical relationships to be established between the weather at certain periods and the subsequent yield of the crop, have very great economic significance.

Cane is particularly sensitive to drought during the period of greatest growth. Shorter and thinner canes due to drought mean a relatively greater amount of fibre, and so not only less juice but more expenditure of power in crushing and additional strain on the factory plant; the quantity of juice may also be decreased by transpiration and its quality lowered by acidity, also a great source of difficulty for the factory.

¹ The formula is as follows:—

$$X_1 = 79.75 + 0.0504X_2 + 0.0506X_3 + 0.3132X_4$$

where X_1 = production of standard muscovado in pikuls per bouw;

X_2 = precipitation in October;

X_3 = precipitation in November;

X_4 = percentage of total crop planted before 1 August.

For the twelve years 1912-23 the difference between the yield calculated by this formula and that actually obtained averages only 2.9 per cent.

Tengwall, T. A., and Van der Zyl, C. E., *Archief voor de Suikerindustrie in Nederlandsch-Indië: Mededeelingen van het Proefstation voor de Java-suikerindustrie*, 1924, No. 4.

With the onset of the normal dry season the leaves wither and growth is checked, while the ripening of the cane proceeds or, in other words, the sucrose content of the cane increases. An excess of moisture at this period results in dilution of the juice and also, with the sprouting of buds and the formation of roots, in loss of sucrose by inversion. Excessive moisture during the season as a whole is injurious, too, in that it favours the spread of cane diseases. The duration of the harvest is generally limited by the beginning of the ensuing rainy season, when growth of the standing cane recommences and ground conditions make transport to the factory impracticable.

The cane crops of very large areas depend partly, and those of some areas wholly, on irrigation. In some regions the precipitation, even in the "wet" season is marginal or even distinctly insufficient; in the former case irrigation is a necessary insurance against years of comparative drought, the more so as the smaller the average precipitation the greater the unreliability generally tends to be; in the latter case it is essential every year to ensure adequate yields. Over much of Hawaii, the west of Mauritius and the south of Jamaica, for instance, the precipitation has become marginal through reckless deforestation in the past. In a second group of cane regions, to which belong Java and India, irrigation is relied on since the young cane cannot otherwise establish itself sufficiently to survive the dry season. A third group is entirely dependent on irrigation, the coastal plain of Peru and the Hawaiian islands of Oahu and Maui being instances.

The generally higher yields per unit area in irrigated regions, especially marked in the third group, where precipitation is negligible, are due to the controlled application of moisture, the fact that plant foods have not been leached from the soil by rains and possibly also to the cloudless skies. These areas have also the advantage that the cane can be grown independently of the seasons and the factories can be operated for a much longer period—in Hawaii for ten months in the

year and in Peru all the year round except for a few weeks for repairs—thus greatly reducing overhead costs.

Temperature.—The rate of growth of the cane and therefore the bulk of the crop is determined not only by the amount of soil moisture but by air temperature. As most cane regions lie toward the margins of the Tropics variations in the latter factor are also important.

Sugar-cane for sugar production cannot, without meeting with great disadvantages, extend into areas where frost is usual. Growth, especially of young cane, is seriously checked by frost, the growing point being killed at -1.5° C. and the sprouts being killed back to the ground at -3° C. Ripening cane is seriously affected by severe frost, that is -6° C. or under, which results, with the coming of the thaw, in inversion of the sucrose and increases the viscosity of the juice, conditions which cause great difficulty in the factory. Louisiana illustrates particularly well the disadvantages of cane-growing in areas affected by frost; the Natal coastlands south of Durban, the southern part of the Australian cane belt and the cane region of Argentina, are also distinctly marginal in this respect.

During the ripening period the ideal condition appears to be just sufficient coolness to keep growth in check and allow the energy of the plant to be concentrated on the elaboration of sucrose. On this ground alone it is not surprising that some of the best cane regions lie rather toward the margins of the tropics, where part of the year is relatively cooler. In this connection, too, it is interesting that sugar content is higher in the more elevated districts of several cane regions, as in Java, Mauritius and Natal.

Other Climatic Factors.—Soil moisture and air temperature are the main climatic factors determining development of the cane, but certain others deserve mention.

Rate of assimilation of plant food is greatest in the morning; in this connection the cloudless mornings that are a feature of the Java cane region, like the comparatively sunny rainy season of many parts of the

10 WORLD SUGAR PRODUCTION AND CONSUMPTION

West Indies, may not be without significance for a crop grown for its sugar content.

Violent wind is very harmful not only because the stalks, not being deeply rooted, are liable to be blown down, but because twisting and breaking results in fermentation at the broken joints, with lowering of purity, while rind disease obtains a hold. In any case violent wind retards growth by tearing or entirely destroying the leaves; in Mauritius it has been found that renewal of the leafage does not take place till about twelve days after a hurricane. Purity of the juice is also affected by lateral budding and by the recumbent stems taking root at the nodes. A number of important sugar lands lie in the belt where hurricanes are especially liable to occur, amongst them the West Indies (including the western part of Cuba), Louisiana, Mauritius and Formosa. One of the advantages possessed by Java over other cane regions is the absence of strong winds. While much damage results to cane in many regions from this cause it is, however, more resistant to hurricanes than are alternative crops, a factor of considerable importance in maintaining the cane area in a number of these regions.

SOIL.

Within the various sugar-cane regions soils have an important influence on the distribution of the crop. The plant thrives best on a loam or well-drained clay and prefers a neutral or slightly alkaline reaction; the optimum soil conditions vary, however, with variety of cane, climate and labour costs and the same soil may not be optimum for both tonnage of cane and sugar content, over-rich soils and light sandy soils having effects on tonnage and juice similar to those of wet and dry climates respectively. In the following summary the grouping used by F. S. Earle in his brief account of cane soils is adopted.

The most popular cane soils are the red soils, developed under forest covering over large areas in the Tropics where high temperatures are associated with

moderately heavy precipitation. These soils, though sticky when wet and retentive of moisture, are porous and well drained; their friability makes them easily worked, a factor of great importance in countries deficient in labour. The Matanzas clays, for example, the chief cane soils of Cuba, can be cultivated even within a few hours after heavy rain. Being easily worked and very fertile when first brought under cultivation, the red soils were early occupied for cane-growing. Owing, however, to the leaching effect of the tropical rains, an effect accentuated when the land is cleared, they have a low lime content and are soon exhausted of their phosphoric acid, alkalis and nitrogen, while the decay of their humus has been accelerated under high temperature conditions; the need for artificial fertilizers, to which they are highly responsive, and for green manures is, therefore, soon felt. Some of the richer areas, as in Cuba, have, however, produced fairly good yields for very long periods.

According to Earle, the black soils with clay subsoils give the best yields of cane if they are properly cultivated but these heavy clay loams have not been popular owing to the difficulties involved and where they have been taken up have often been subsequently abandoned. Alluvial soils, on the other hand, have been permanently occupied by cane in many areas since they are comparatively easy to work and retain their productivity long.

LABOUR.

Cane culture makes heavy demands upon labour; there are, however, great differences between the various cane regions in the amount and kind of the labour actually expended, particularly in cultivation. On the newer lands in Eastern Cuba, for instance, little is done after clearing the land beyond planting the cane, while on the older lands, as in many other cane regions, preliminary cultivation—in this case with primitive implements drawn by oxen—is carried out. Where large-scale agriculture is practised steam-

12 WORLD SUGAR PRODUCTION AND CONSUMPTION

ploughs and tractors have superseded animal traction, especially for preliminary deep cultivation. Unless in regions where, as in Eastern Cuba, cane culture is very "extensive" in character, harrowing and several further cultivations usually follow before planting takes place. In Puerto Rico successful experiments have been made with the gyrotiller, which combines the operations of ploughing, cross-ploughing and harrowing. Planting consists in placing pieces of cane (or, in some cases, cane tops) in holes or furrows, generally according to whether manual or mechanical methods are practised. The growth of weeds is luxuriant in the temperature and moisture conditions best suited for cane and the principal work and a very large item in cultivation expenses is the subsequent weeding, which in every case involves manual labour. Besides cultivation between the cane rows, now also possible by tractor, the soil in the rows is kept open by hoeing, the young canes are moulded up and fertilizers applied, all these operations being carried out to very various degrees in different regions, the greatest intensity being found in Java, where labour is unusually cheap and all the work, from the preliminary cultivations onward, is done by hand, and in Hawaii, where, thanks to the high degree of protection in the United States market, heavy costs can be incurred. Harvesting involves even more labour, having to be carried out rapidly since the mill must, for economical working, be kept running as near as possible to maximum capacity day and night during the season and since inversion of the sucrose in the juice occurs if the interval between maturity and cutting is too long. A large central factory absorbs about 7,000 tons of cane daily and as 2½ to 3 tons is the normal amount cut daily by one man—4 tons being the work of an expert—the pressure on labour is high. Much depends on the variety of cane, the work being more arduous, for instance, with a cane like Uba, that grown in Natal, which has a dense growth of adherent, sharp-edged leaves. A machete or cutlass is used to cut the cane at the base of the stalk and to cut off the

top and leaves. The large scale of the demand for labour is illustrated by the following example from the report of a large American company owning two Cuban centrals with a combined output in the season concerned of 160,000 metric tons of raw sugar. The harvesting involved the work of 12,000 men in the fields for a hundred and fifty days, 9,000 of these being cane-cutters; an additional 1,300 men were required for work in the factories, on the railways and for administrative and other purposes. In Cuba an investigation of 25 plantations showed that harvesting costs made up 48 per cent. of the total, cultivation 16 per cent. and planting 8 per cent. In some countries, as in Hawaii and Natal, where varieties with adherent leaves are cultivated or labour shortage is experienced, the leaves are burnt off so as to make cutting easier. The possibilities of mechanical harvesting are of great importance. Until recently experiments had not been promising, but the new Falkiner cane harvester has produced more satisfactory results. A large-scale trial was first made in Florida in 1931. "Reasonably straight" cane was cut at the rate of 20 tons an hour per machine and twisted cane on wet ground was also cut successfully. The cane is cut, trashed, topped and loaded in a single operation, the stalks cut into sections and the leaves and tops separated by an air blast. It is claimed that in daylight this harvester is equal to 80 men, while in favourable conditions it can also be operated at night. Should such a machine come into use on a large scale it will, therefore, open up very great new potentialities in cane-sugar production. Mechanization is hindered where the soil is rocky or where stumps have not been removed, an important consideration where virgin land is to be opened up. In every case the relative cost of manual labour is a critical factor in determining how far machinery is to be introduced.

The indigenous population of almost all the regions in which sugar plantations were established was inadequate in quantity and quality for the labour, so arduous in itself, of an industry introduced to meet the

demands of overseas populations. This was the state of affairs throughout the West Indies, where large-scale production for export was first organized, and where the deficiency was first supplied by the slave trade in negroes from Africa. The system of slavery was succeeded in many countries by the indenture system or by the encouragement of free immigration. Java, thanks to its exceptional density of population, is almost the only cane-sugar exporting country where labour shortage has not been seriously felt. Taking cane-sugar regions as a whole the location of the industry has influenced rather than been influenced by the density of the local population.

THE FACTORY.

The production of raw cane-sugar by up-to-date methods requires a large investment of capital, of which it is estimated that 90 per cent. is invested in the factory side of the industry and only 10 per cent. in the agricultural side, proportions roughly inverse to those of the working costs in field and factory.

The heavy overhead costs of the industry are accentuated by the fact that, save in a few irrigated regions where harvesting proceeds practically throughout the year, the factory's campaign is, owing to the reduction in the sugar content of the cane if left too long in the field and to its rapid deterioration after cutting, restricted to a few months each year; in Cuba, for instance, the longest duration of a campaign (on the average of all the factories for the year) has in recent years, including the years prior to restriction, been a hundred and fifty-six days. In the endeavour to cut down these heavy overhead costs the factory must work during its limited campaign as near maximum capacity as possible. Since the cane is very bulky transport costs limit the distance from which it can be drawn so that the large modern factory must stand in the centre of a relatively compact cane area with good transport facilities.

Throughout the cane-producing lands the tendency for many years, originally stimulated by the com-

petition of beet-sugar before the Brussels Convention of 1903, has been toward the decline in the number of factories, accompanied by a rise in the average capacity for the purpose of gaining the advantages of large-scale production. Sugar-cane thus tends to become the dominant crop in districts where it is grown, often to the entire exclusion of other crops save for occasional patches of food crops for local consumption. The general absence of any system of rotation is also a factor in this dominance. The increase in average size of the factory is, however, limited by increasing transport costs as the cane must be drawn from a wider area. Facilities for export of the sugar are also important in determining the location of the factory and the continued predominance of insular areas in cane-sugar production is in large measure due to their facilities for sea transport to the principal markets. Even in Cuba, where no part of the island is more than 40 miles from the sea, some of the factories in the interior are to-day seriously hampered by their relatively high transport charges.

Most cane-sugar factories produce a raw sugar of 96 to 98 degrees polarization for subsequent refining but direct consumption sugars of over 99 degrees can be produced by carrying out the purification of the juice more thoroughly.

The relative importance of by-products varies in different regions, with different price-levels and with marketing facilities. The early trade relations of the West Indies favoured the development of what has in the past been the most well-known cane-sugar by-product, rum, the fermented spirit from the diluted molasses or "wash"; the continuance of rum production on the large scale for export in certain parts of this area, particularly in Jamaica, was subsequently favoured by difficulties in marketing the main product, sugar. In recent years, however, the rum trade in this and other areas has suffered severely from high tariffs, high consumption taxes, the use of substitutes, changes in taste and, in the United States, from the period of liquor

prohibition. The molasses itself is exported from many sugar-producing countries, but principally from Cuba, Java and Hawaii, finding its principal use in the production of industrial alcohol; its use—for motor fuel—in Natal, Queensland and Brazil mixed with petrol or ether—is of increasing importance; in some countries the mechanization of agriculture itself absorbs part of the output. The molasses may also be exported for use in the manufacture of stock-fattening foods; in some producing countries the spongy tissue of the cane itself is used as an absorbent in this connection. A wide range of chemical products can also be obtained. The United States, the United Kingdom and India are the chief importers of molasses. Where the molasses is not worked up into any other product or exported for such purposes it may be applied to the fields as fertilizer, possibly its most valuable use, as in Mauritius, Java, Queensland and Hawaii, used as fuel, as in Queensland, or run to waste. The fibrous residue of the cane—bagasse or megass—is generally used locally as fuel. In some countries, however, most notably in Louisiana, cane board for building purposes is manufactured. Paper and artificial silk are other uses in regard to which experiments have been made. The extent to which these and other possible methods of utilization may be adopted depends partly on the relative value of the bagasse as fuel, that is, on the availability of alternative fuel supplies. The difficulty of finding markets for the new products, however, is the most serious one. The filter-press cake from the mills is used as fertilizer but wax and various chemical products can be extracted. The cane-tops are used as fodder and the leaves as fodder, soil mulch or for the production of pen-manure.

CHAPTER III

GENERAL CONDITIONS OF BEET-SUGAR PRODUCTION

THE sugar-beet is in nature a perennial but in cultivation its life has been reduced to two years or even one year, the first year being normally devoted to storing of sugar in the enlarged tuber composed of the tap-root and hypocotyl, while the second year is devoted to seeding. For the commercial production of sugar the plant must therefore be allowed to complete only the first phase; the premature occurrence of the flowering phase in the first year is known as "bolting." The greatest concentration of sugar in the root is in that part where it begins to decrease in diameter. Since 1797, when Achard first extracted sugar from the root, the amount obtained from a given quantity of beet has been gradually raised by two principal lines of development: firstly, the improvement of the technical efficiency of the factory in extraction and, secondly, selection and, more recently, breeding on genetic lines of the beets. The increase in sugar-content of the beet juice, primarily an inherited quality, has been striking; in 1797 it was just over 3 per cent., by 1868 in Germany it was over 10 per cent., while it is now generally between 14 per cent. and 20 per cent., the average of the Rimpau strain being in 1922-26 about 21 per cent.

Breeding has evolved three main types of sugar-beet, of which the following are the chief features as determined by Remy and summarized by Bridges and Dixey:—

	Sugar content (per cent.)	Roots per acre (long tons)	Sugar per acre (cwt.)
Quantity roots (E) ..	16.3	14.22	46.3
Middle grade (Normal) ..	17.0	13.86	47.1
Quality roots (Z) ..	17.5	13.19	46.1

The more slowly maturing E types require a longer growing season and warm dry soils; they are the most

profitable to growers paid on a tonnage basis and also mean greater yields of by-products but their higher tonnage means that costs of labour in the field, of transport and of handling in the factory are higher. The Z types give a low tonnage but are early-maturing and therefore suitable for regions where the growing period is short, the climate cold and wet, or soils heavy, or where labour is dear. Besides weight and sugar content, breeders have also had in view other factors such as shape, which affects the ease of lifting and topping and of handling in the factory, besides indirectly affecting the first-mentioned factors and disease resistance.

Seed from the commercial beet cannot be grown with success since the plant tends to revert to a valueless form containing little sugar. The world's greatest centre of beet seed production is at Kleinwanzleben, in Saxony, where soil and climate are especially favourable, and one firm is said to produce about three-quarters of the world's seed, its activity being supplemented by that of four others in Germany, one in Czechoslovakia and one in Poland. The variety that takes its name from Kleinwanzleben has proved remarkably reliable under different conditions of growth. Like all other commonly grown varieties it is derived from White Silesian.

CLIMATIC FACTORS.

Moisture.—The ideal distribution of precipitation appears to be a period of moderate rainfall for the preparation of the seedbed and for germination, followed by one of abundant rainfall coinciding with maximum temperatures and thus favouring vigorous growth, and finally a period of gradually diminishing rainfall, the last month being quite dry, so favouring increase of sugar content and eventually ease of lifting and of haulage by road. On the whole, moderate precipitation seems to give the best results both in sugar content and tonnage of beet. Excessive moisture hampers the preparation of the soil, favours the growth of weeds, causes

fangy roots and excessively developed tops and, in the latter part of the season, lowers sugar content by increasing the amount of sap and inducing second growth; it also favours the spread of fungoid diseases, particularly *Cercospora beticola*, the fungus that causes leaf spot, the principal disease of the sugar-beet. This disease reduces sugar content by damaging or destroying the leaves and also stimulates growth of the tops at the expense of the roots. Drought, on the other hand, decreases tonnage and is conducive to bolting. The amount of moisture desirable varies, of course, with the character of the soil.

Temperature.—The lower temperature limits for optimum growth of the beet are more easily definable than the upper. Frosts at the beginning of the growing season hinder germination and cause severe injury or even death to the young plant. In the first period of growth temperatures should be just sufficient to stimulate the plant. At the time of sowing a temperature not below 40° F. is said to be necessary. Later checks to growth due to cold spells are probably one cause of "bolters," which have badly shaped roots and comparatively low sugar content. In areas where late frosts occur this is possibly an important limit to early sowing. Efforts are being made to breed non-bolting beets. In the middle period of development high temperatures are conducive to rapid growth and to increase in sugar content. In Germany, July temperatures have been found to be critical. In the latter part of the season, while low temperatures decrease sugar content by lowering assimilation, moderately cool weather appears to raise sugar content and prevents second growth and the danger of rapid deterioration; cool nights at this period are found to be especially conducive to high sugar content. Frost is not in itself harmful to the mature roots as long as they remain in the ground. Not only, however, does it cause difficulty in pulling, whether that operation is carried out when the ground is hard or during the subsequent thaw when the sodden ground means a much higher labour cost,

difficulty in haulage and irregularity in delivery, but when the beets are lifted they are liable to injury by hard frost or even by frequent light frosts, the danger of inversion and of rapid decay being increased and difficulty being caused to the factory in extraction. The danger of early frost, especially in continental regions, together with the demands of the factories and the need of preparation for other crops, prevents full advantage being taken of the possibilities of increasing sugar content by delaying harvesting. In general, five frost-free months are desired.

Light.—The bright light of direct sunshine is not necessary for sugar formation, the diffused light from a cloudy sky being found to be suitable. That a high duration of direct sunshine is not essential for good sugar content has been demonstrated by British experience.

SOIL.

The sugar-beet possesses great adaptability to soil conditions and good results are obtained on a wide variety of soils. It prefers neutral to slightly alkaline reaction and, other conditions being favourable, will, with this preference, thrive wherever the soil has depth and uniformity, is fairly easily cultivated, well drained and aerated. These conditions give the well-formed taproot desired by the factory and more profitable to the grower as having the least tare. They also make possible the extensive development of rootlets that allows the plant to draw on a wider area for food and has such a beneficial effect in improving the condition of the soil. The soil is prepared by ploughing fairly deeply, with or without previous disking in autumn or spring, and by disking and harrowing; intertilling is subsequently carried out before and after singling.

LABOUR.

The sugar-beet crop is peculiarly dependent on a good supply of labour owing to the arduous nature of the work, particularly at two periods—singling, in the spring

(generally in May or June in the northern hemisphere) and lifting, in the late autumn (between the end of September and December in the northern hemisphere)—and to the great care demanded in the former operation. As the beet fruit or seed-vessel is multiple, containing up to six or more seeds, there appears on germination a bunch of young plants ; singling consists in the removal from each bunch of all save the best plant. If women and children are available for the work this operation is generally performed by hand distinctly from and a few days after the blocking or chopping out common to other root crops and performed by skilled workers, generally men, with the hoe. It is particularly important that singling be carried out carefully and precisely at the proper time ; carelessness means a large difference in yield and delay not only difficulty but great reduction in the subsequent yield. The very heavy work of pulling the beets is generally performed by men working in gangs with or without preliminary mechanical loosening. The " top " or crown of the beet, which contains little sugar, is removed before lifting. Experimentation continues with a view to finding a satisfactory machine that will top, lift and clean beets in all weathers. Lifting must be performed rapidly while sugar content is at its best and to avoid loss and delay through rain or frost as well as to keep the factory steadily supplied. While there is an unusual strain on the labour force at these periods, cultivation must also be very thorough and each operation must be carried out punctually in order to secure the best results.

THE FACTORY.

It is generally considered that the sugar-beet factory should have at least 75,000 tons of beet available in a season ; in Germany the majority of the factories work up between 20,000 and 100,000 tons of beet. As transport becomes a limiting factor beyond a radius of 25 to 30 miles and as the factory, with its short season of generally about three months—in view of the rapid

deterioration of the beets in storage—must work night and day to reduce its high overhead charges, the industry must be located in the heart of an area in which the proportion of sugar-beet to other crops is relatively high and where facilities for the transport of the bulky raw material are good. An adequate supply of beets must indeed be guaranteed before the high capital cost of erecting a factory is justifiable.

The price paid for beet is the main element in costs, generally accounting for over two-thirds. The process of manufacture at present most widely in use is that of diffusing the sugar-containing juice from the sliced beets into warm water. Very large supplies of pure water are therefore necessary, a factory of 1,000 tons daily capacity utilizing four to five million gallons a day. The obtaining of such a supply and the discharging of a corresponding amount of effluent determines a location near a river, preferably a tidal estuary, since the tide not only carries the effluent out to sea but greatly dilutes it. The coal consumption amounts to 10 to 12 per cent. of the weight of beets and is one of the heaviest items of cost, while limestone is required in the proportion of 5 to 6 per cent. for the purification of the juice. After clarification the juice is filtered and evaporated, the resulting syrup passing to the vacuum pans, where it is concentrated to crystallization, centrifugalled and granulated. Dependence on a heavy raw material and large supplies of fuel and lime and the presence of bulky by-products make good transport facilities of especial importance and this, too, makes a river, canal or nodal rail and road location desirable.

The shortness of the factory campaign is the most serious drawback. A few British factories have attempted to neutralize this disadvantage by adapting their plant for the refining of raw cane-sugar during that part of the year when supplies of beet are not available. A number of large-scale experiments have been made with the storage of beet in a desiccated form for use throughout the year.

On the Continent of Europe, partly because of agree-

ments with refining interests, a considerable proportion of the best factories continue to produce raw sugar only—in Czechoslovakia 65 per cent., in Germany 65 per cent. and in the Netherlands 50 per cent.—but in recent years it has been found more economical to manufacture granulated sugar of over 98° polarization directly in the factory itself by a continuous process, re-melting being unnecessary and increased working costs being confined chiefly to fuel and bags; this is generally the case in Great Britain and in the United States. Many of the factories, especially in Germany, are owned co-operatively by the beet-growers. In Czechoslovakia the factories wholly or partly owned by the banks predominate.

THE PLACE OF SUGAR-BEET IN THE ROTATION.

Sugar-beet becomes the dominant crop in the rotation into which it is introduced. As with other roots its abundant leafage cleans the soil by smothering weeds, while its strongly developed root system breaks up the soil and adds to its organic content. The dependence of adequate returns from the crop on its receiving the greatest attention and the fact that prices are generally fixed beforehand on a quality basis lead to most of the manuring and cultivation in the rotation being given to the sugar-beet, the other crops receiving residual benefits. On the Continent of Europe and in the United States very notable increases in the unit-yields of other crops followed the introduction of sugar-beet. Owing to its close relationship to other crops in the rotation it is impracticable to separate its costs of production from those of other crops.

Sugar-beet has also a close relationship to the number of livestock, due to the value of the tops and factory by-products of feeding; the class of cattle that increase most rapidly on the introduction of sugar-beet is, however, draught animals, in response to the increased requirements for cultivation and for transport of the heavy crop and its by-products. On the other hand

24 WORLD SUGAR PRODUCTION AND CONSUMPTION

the increase in the cattle population makes available a larger supply of manure on the farm. The tops have a greater value per unit of weight than mangolds; they are utilized fresh, clamped, siloed or dried; fed to dairy cattle they result in a milk rich in fat. Use of the wet pulp produced by the factory generally is limited by transport costs to areas in the vicinity of the factories. In some countries a considerable part of the pulp is utilized in the wet state, but part is dried since it keeps well in this form and is easily handled on the farm. The molasses is also fed raw or used as an absorbent in manufactured feeds (in addition to its use for industrial purposes such as the manufacture of alcohol or yeast). The use of the sugar itself as a fodder is of growing importance. The tops may also be ploughed in as manure, though in that case their high carbohydrate content is wasted; the principal by-product manure is the lime residue from the filters.

CHAPTER IV

CUBA

CUBA accounted for 19 per cent. of the world's statistically known sugar production in the five years ending 1929-30. The sugar-cane was introduced early in the sixteenth century but the island did not take a prominent place as a sugar-producer until three hundred years later when, at the end of the eighteenth century, the troubled condition of Santo Domingo (Haiti) gave it the opportunity greatly to increase its export ; the re-organization of the slave system in the 'thirties and its abolition in the British West Indies, the influx of a new planter class from the revolting Spanish colonies and the decline of coffee production enabled it to maintain and strengthen this position up to the middle of the nineteenth century. Production in the latter part of the century fluctuated considerably, with the vicissitudes of the movement for independence, about the level of 600,000 tons. The abolition of slavery in 1880 caused comparatively little difficulty, the rise of the colono or cane-farming system being rapid. Thanks to this reorganization of the industry, which was a stage in the development of the "central" system, the competition of beet-sugar was not so severely felt as in other cane countries. In the early 'nineties there was a sharp rise in production to over 1,000,000 tons, but there was a disastrous fall in 1896-1900 due to the war and the revolution, and a rapid upward trend was renewed only after 1902-03, production again rising to over 1,000,000 tons in the following year. Subsequently there was little interruption, the Brussels Convention and the reciprocity treaty with the United States ensuring the further expansion of the Cuban industry. By 1913-14 production had risen to 2.6 million tons, and by 1918-19 to 4.0 million, while in 1924-25 the record of 5.2 million tons was attained ; in 1928-29, when restriction was temporarily removed, production almost regained the maximum with 5.1 million tons.

The climate of Cuba is very well suited for cane-sugar production. There is a well-marked alternation of wet and dry seasons, the wet season lasting from May to November, a period when the north-east trades are strong, and being characterized by a high degree of reliability of rainfall and by short showers and cloudless skies. Temperature throughout the year is very uniform at a moderately high level. The greater part of the cane is planted from September to November and is established before the dry season; it is cut after about fifteen months. Spring cane, planted in May or June, is, however, important in the east, where persistent autumn winds tend to dry the soil and would injure young cane planted later in the year. Irrigation has been shown to give very good results by allowing growth to continue in the dry season and autumn cane to be planted in the east; in the red soil areas only shallow wells are required to tap water. Harvesting normally begins in December or January and continues until the middle of the year. Cuba's principal climatic disadvantage is that it lies in the hurricane belt and thereby occasionally suffers severe damage to the growing crop, to stocks and to plant. The hurricanes occur chiefly between August and October.

There are extensive areas of good soil, the most important being the Matanzas clays; these are red soils, deep and uniform throughout, well-drained and easily worked; though sticky when wet they dry in a few hours after rain, so that preparation can be carried out in the wet season; they are found in the provinces of Matanzas, Camagüey and Habana. In some places cane has been growing for over one hundred years without fertilizers. Of the black soils, the Camagüey clays are best, being suitable for many varieties and giving good crops in both wet and dry years. After the Matanzas clays, the Alto Pedro clay is the most widely utilized but it is shallow, with an impervious and salty lower layer and deep ploughing is not advisable; yields rapidly decrease and it is not suited to small farms. In Cuba, as a whole, much of the cane area is flat and suited to machinery.

Great as are its advantages in soils and climate it was its proximity to the United States, a vast and growing market with one of the highest rates of per capita consumption in the world, that allowed Cuba to develop to the full its potentialities for cheap production. By the reciprocity treaty of 11 December 1902 the United States granted to Cuba a preference of 20 per cent., effective as from 27 December 1903, most of which was in the earlier years actually obtained by the Cuban producers. With the marketing position thus strengthened, the industry proved especially attractive to American capital. The extension of the railroad from Santa Clara to Santiago in 1902 made possible the exploitation of the fertile forest lands of Camagüey and Oriente. The factories were modernized and enlarged and the economies of large-scale production were realized to a degree unprecedented in the manufacture of raw sugar. The first large "central" on modern lines was built on the north coast in 1903. One-third of the factories are American-owned. It was estimated in 1929 that investment in the Cuban sugar industry totalled 1,250 million dollars, of which two-thirds to three-quarters were from the United States.

The progress of centralization continues, and with it the decline in the number of factories grinding; by 1932 the number had fallen to 133. The largest centrals are on the newer lands of the East, where modern developments have had freer play. In 1929 one of these factories; Preston (in Oriente), attained an output of 1,014,425 bags (147,116 long tons). Short branch lines lead from the main east-west railroad to the numerous ports, Cuba being well supplied with natural harbours. Though no place on the island is more than 40 miles distant from the sea there is considerable unnecessary rail haulage and some of the interior factories are seriously handicapped by high transport charges. The principal ports for the export of sugar are Puerto Tarafa and Nipe on the north coast and Cienfuegos on the south coast. The factories normally open their campaign in December or January and export reaches its maximum in March.

The greater part of the cane-land is owned or leased by the factories but from four-fifths to nine-tenths of the cane is produced by colonos, who lease holdings of rarely more than 500 acres from the factories or from third parties, by whom they are often partly or wholly financed, and are paid by the factories for their cane in raw sugar (or its cash equivalent at the average price for the month or fortnight) at a rate varying greatly with locality and depending on the costs of production of cane and on the amount of competition between the factories. The colonos are generally employers of labour rather than cultivators.

Cuban agriculturists responded to the rapidly growing demand of the mills by producing cheap cane by extensive methods. The forest was cut down and burnt and the cane planted among the stumps with very little cultivation and an almost entire absence of fertilizers. Fairly heavy yields were thus obtained for a few years on good soils and then the land was abandoned to pasture, fresh areas of virgin soil being opened up. There was little or no attempt to select the most suitable land and this has led to much inferior land being under cane. As the older lands in the west required frequent ploughing, regular cultivation and the application of fertilizers, the proportion of the total cane produced by the eastern provinces increased steadily. In the last decade, however, this eastward movement seems to have come to a standstill. The shortage of labour for the arduous work of the cane-fields, particularly acute in the East, was met by immigration from Haiti and Jamaica. Ploughing is carried out by bulls and the implements are inadequate.

Under these conditions of extensive exploitation, average unit-yields in Cuba are relatively low, ranging as a rule from two to three tons of sugar per acre. *Cristalina*, the variety generally planted, is a good all-round cane but is very susceptible to mosaic disease. Moth-borer is the chief pest. There has thus been a marked contrast in the Cuban sugar industry between the rapid introduction of modern technique and management in the factories and the continuance of old-

fashioned inefficient methods in the field. There is only one important research station, that at Central Baragua, subsidized by the Tropical Plant Research Foundation and the Cuba Sugar Club. While methods of cultivation over the greater part of the area are inadequate, much experimentation with new machinery has been carried out by the large companies.

The richness of its soil resources and the cheapness of its extensive methods of exploitation, however, enabled Cuba to take the lead in meeting the sharp rise in demand when sugar was generally decontrolled in the years immediately following the War, and the same factors helped to alleviate the situation in the years of depression following the reaction in 1920. The situation of the industry with reference to the United States market has remained, however, the crucial factor in Cuba's position. The amount of the 20 per cent. preference given to Cuba in the United States market has, of course, varied with the general tariff and has been as follows :—

\$ per 100 lb. 96°			
27 December 1903—28 February 1914	..	..	0.3370
1 March 1914—27 May 1921	..	..	0.2512
28 May 1921—21 September 1922	..	..	0.4000
22 September 1922—17 June 1930	..	..	0.4412
18 June 1930	..	..	0.5000

When the preference was first granted the United States market was still able to absorb the bulk of the Cuban output. After 1909, however, when the quantity of Cuban sugar coming on that market from January to April began to press down the price, the American refiners were able to gain a considerable part of the tariff differential. While on the one hand Cuban supplies were increasing, production within the United States tariff wall was steadily growing. As a result, while in the five years 1910 to 1914 the United States took 92 per cent. of the island's total export of sugar it took in the five years 1925 to 1929 only 78 per cent.

The decrease in the proportion of Cuba's production absorbed by its principal market is the principal factor

compelling a re-orientation of Cuba's sugar policy. The sugar industry is faced with two alternatives. Even the land at present under cane is estimated to be capable of producing six million tons of sugar. Estimates of the area unutilized for but suitable for cane vary from 330,000 to 1,000,000 acres, much depending on the solution of various land and transport problems. The greater part of the available area, which lies mainly in the East, is said to be good or potentially good soil. On the other hand there is much unsuitable land under cane and the cane area has even been declining in some parts of the West, over much of which the land is approaching exhaustion. There has, too, for some years, been a growing realization of the dangers of the present high degree of dependence on one crop, which accounts for over four-fifths of the total value of exports—in the five years 1925-29 the proportion was 83 per cent.—and there is a movement for greater diversification of agriculture. Cuba is, in fact, faced with the alternatives of continuing its present extensive methods of cane culture and even expanding its cane area when need arises or concentrating its capital resources on a smaller area, selecting the lands best suited to cane, conserving their fertility by the use of fertilizers, economizing labour by introducing machinery, controlling cane diseases and devoting more attention to research generally. The latter policy would, by limiting and even lowering the area under cane, automatically give opportunity for diversification of agriculture.

CUBA.

Production (thousand long tons).

1909	1,513	1917	3,055	1925	5,189
1910	1,804	1918	3,473	1926	4,932
1911	1,843	1919	4,010	1927	4,509
1912	1,896	1920	3,735	1928	4,042
1913	2,429	1921	3,934	1929	5,156
1914	2,598	1922	4,033	1930	4,671
1915	2,609	1923	3,646	1931	3,122
1916	3,034	1924	4,113	1932	2,603

Sources: 1909-30, *Memoria de la Zafra Azucarera de Cuba*.
1931-32, Willett and Gray.

CHAPTER V

JAVA

JAVA is, next to Cuba, the largest exporter of sugar : in the five years ending 1929-30 it was responsible for 10 per cent. of the world's statistically known production. Sugar had been manufactured in the island at least as far back as the ninth century. The Netherlands East India Company monopolized the trade in the seventeenth and eighteenth centuries, by the close of which period production had spread from its early centre in West Java to Middle Java. From 1834 to 1891 the Cultuur system was in force, whereby export products such as sugar had to be grown under European supervision on one-fifth of the land and handed over to the Government, which returned to the natives any excess of the value over the amount of the land rent ; during the period from 1840 to 1891 production increased eight and a half times to over 400,000 metric tons. In the 'eighties the competition of beet-sugar was severely felt and the spread of the disease known as sereh had a disastrous effect on the crop. In the 'nineties, however, the rate of increase in the area under cane was greatly accelerated and by 1900 the new experimental stations had produced canes resistant to sereh. In 1911 there was a sudden increase in the cane area. The first years of the War brought large profits to the industry but later difficulties in shipping were particularly severely felt by Java owing to its relatively great distance from Europe. In the years immediately following the War the Government's measures for the safeguarding of the food supply involved a reduction in the cane area, the 1918 level of 163,071 hectares being again reached only in 1924. Production, which was 1,347,000 metric tons in the five years 1910-14, rose to 2,871,000 in

the four years 1928-31, the maximum being attained in 1928 with 2,924,000 metric tons.

The greater part of the sugar-cane is now grown in East Java, particularly in the plain of the Brantas in Soerabaja and Kedin and, second in importance to the Brantas area, the principalities of Soerakarta and Djokjakarta in the south and on the northern coastal plain of Middle Java.

The climate shows a very well-marked alternation of wet and dry seasons, particularly in the east, where most of the cane is grown. The rain comes with the west monsoon from the latter part of November to the end of March, while the period from April to October is dry. The location of the sugar factories shows the avoidance not only of the wetter west but of elevations above 150 metres. The rainfall is reliable, the lowest monthly figure recorded during the west monsoon being very seldom less than 75 per cent. of the respective monthly mean. Temperatures show little variation from month to month. Planting takes place chiefly from June to September. Almost the entire cane area is irrigated, irrigation being necessary to ensure the establishment of the young cane. Water supply from the mountain streams is, however, plentiful and cheap. The rainfall in the ensuing October and November, especially that of the former month, at the beginning of the wet season, when the cane is developing most rapidly, is critical, a forecast of the yields being found possible on this basis. The cane is harvested from May to October, about 50 per cent. being cut by July, that is, after twelve to fourteen months' growth. Freedom from destructive cyclones is a notable advantage over many other sugar regions.

The cane soils are largely alluvial, in large part neutral and relatively poor in nitrogen and phosphoric acid. Only the best soils are used. On the whole neither climate nor soils are so favourable as in Cuba.

The extraordinary density of the population has made the question of ensuring the food supply a primary one for the Government, which has enforced ordinances

restricting the utilization of the land for export crops. Only a very small proportion of the total cultivated area is under cane—2·6 per cent. in 1930. In the quinquennium ending 1931 the factories themselves grew 97 per cent. of the cane milled, 2·7 per cent. was bought from other estates and only 0·3 per cent. from natives. The bulk of the cane-land is held by the factories under the Grondhuurordonantie of 1918. The companies must lease agricultural land from the native owners at a price fixed by the Government every five years on the basis of unit yields of rice obtainable and of irrigation facilities; the maximum duration of the lease is twenty-one and a half consecutive years; the amount of land leased must not exceed one-third of the total cultivated area in any one village and the same land must not be occupied for more than eighteen months, beginning on 1 April of each three years, the land to be returned to the natives for the growing in the remainder of the three years of two rice crops and two dry crops; under the Factory Ordinance of 1899 the company is permitted to plant only a certain area of cane in a specified number of villages. In the principalities former tenures may be and, under the inducement of a fifty-year guarantee, have been entirely converted into a tenure similar to that established by the 1918 Ordinance in the directly governed territory. Other tenures are not important. Under this system of land tenure ratooning is impossible, the cane having to be dug out after harvesting. Hence every effort has been made to reduce the high overhead costs by increasing unit-yields.

Thanks to the high density of population, especially in the East, labour is cheap and internal migration meets any deficiency at the period of high pressure when the land is being prepared for cane immediately after the last native rice crop is harvested. Preparation of the land, which clashes with the cane crop, is particularly laborious owing to the elaborate system of drainage and irrigation in practice. Though of poor physique the labour is industrious and docile. There is a highly developed organization of labour on the part

of the employers, the tradition of close regulation on their part being strongly established in Java. Cultivation is still mainly carried out by manual labour and not by plough, and even in the factories mechanical devices, elsewhere commonly adopted, are generally absent. Female labour is very extensively employed in the factories as well as in the fields. For certain kinds of factory work Chinese labour is almost exclusively employed.

The pressure of the dense population for a long period on the land has made the use of fertilizers essential for the obtaining of good yields. Of the total area 94 per cent. receives nitrogenous manuring, mostly in the form of ammonium sulphate; 14½ per cent. also receives phosphates; there is relatively little use of other manures. The crop rotation involved in the system of land tenure also helps to prevent exhaustion.

The most striking means whereby unit-yields have been raised has, however, been the breeding of new varieties. The first stimulus to this was the outbreak of sereh in 1882, to which the varieties then cultivated rapidly succumbed. By the end of the century the new experimental stations had produced immune varieties. The work on cane-breeding rapidly became the major activity of the stations. After 1902 the dominant varieties in cultivation were B.247 and P.O.J.100; after 1920 D.J.52 and E.K.28, while after 1927 the rapid spread of P.O.J.2878, which occupied 93 per cent. of the cane area in 1929 and 1930, brought a sensational increase in production. The rapid spread of new varieties is facilitated by the absence of ratooning. All cane diseases are kept strictly under control. The average yield in the five years ending 1932 was 130·4 metric tons cane and 14·61 metric tons sugar per hectare, that is, yields twice those of Cuba.

On the factory side there has been no attempt to develop record milling capacities as in Cuba, only one factory, Djatiroto I, in Pasoeroean, having over 50,000 tons capacity, as against more than a score in Cuba. The number of factories in operation fell from 190 in

1913 to 178 in 1931-32. The percentage of the total Superior Head Sugar made by the carbonation process has risen steadily and this process and the sulphitation process now each account for roughly half of the total of this type. The capital invested in the sugar industry is mainly Dutch, the remainder being principally Chinese, with some Japanese and native capital. The total investment is much less than that in the Cuban sugar industry. Out of the 180 factories 164 are members of the Vereeniging het Proefstation voor de Java-suikerindustrie, which controls the Sugar Institute at Pasoeroean, founded in 1907 (though a research station had existed there since 1887) and since 1924 uniting the work of the previous three separate stations. A levy fixed for three-year periods and now 5.50 florins per bouw on the cane area, gives it an income of about 1.4 million florins. The Institute is organized into agricultural, chemical and technological sections, the work of the first being subdivided into the improvement and description of canes and cytological research, agronomic research and advisory work, chemico-agro-geological research, entomology and cane diseases. The results of research at Pasoeroean are strictly enforced in field and factory by means of a system of fifteen regional inspectorates. On the other hand the Institute takes full responsibility for the results and keeps the economic aspect of the industry steadily in view. Its research and advisory capacities are kept strictly separate and the higher research personnel is free from routine duties. There is a branch station at Cheribon and a private station at Klaten.

Transport facilities in the island are excellent, there being a comprehensive railway net with main lines on either side of the mountain backbone and good roads. The chief ports of shipment are Soerabaja, which is well sheltered and up-to-date, and Semarang, where equipment is primitive and vessels have to lie in the roadstead three miles out, the port being a dangerous one during the west monsoon.

Previous to 1874 almost all the sugar was exported

to the Netherlands as raws for refining. With the abolition of the cultuur system, growth of competition from beet-sugar in the 'eighties and the abolition of the tariff preference this trade, however, fell off, and since 1884 never more than one-tenth of the sugar has been sent to the mother-country. For a time the United Kingdom and the United States took the place of the Netherlands, the former having removed all duties on sugar in 1874, while trade with the latter developed especially after 1890, but the competition of European beet-sugar proved too strong in the United Kingdom and the American market was lost when the Cuban reciprocity treaty was carried through in 1902. Since then Java has relied mainly on markets east of Suez and especially on India, China and Japan. In the quinquennium 1926-30 India took 43 per cent. of the total sugar export, Japan and Formosa 15 per cent. and Hong-kong and China 12 per cent. each. From 1903 onward the manufacture of mill-white sugar for direct consumption increased in response to the demand in the Eastern markets, where, particularly in British India, Java took the place of Germany and Austria, and this type of sugar rapidly replaced the raws formerly sent to the refineries of Europe and America. By 1913 practically the whole output went to Eastern markets. The proportion of Superior Head Sugar to the total sugar production increased steadily up to 1930, when the percentages of the various types to the total production telquel were as follows¹ :—

Superior Head Sugar, No. 25 D.S. (i.e., 99° and over) ..	68.93
Superior Head Sugar, second running	0.27
Head Sugar, No. 16 and over (i.e., 98° and over) ..	27.00
Head Sugar, Nos. 12-14 (Muscovados) (i.e., 96.5° and over)	0.10
After-products	3.70

The growth of protective barriers in the East, particularly in India since 1931 and in the Japanese Empire, have, however, had serious reactions on Java's market position.

¹ The corresponding figures for 1932 were 53.68, 0.43, 36.42, 7.90 and 1.57.

Despite the great importance of sugar Java is not so dangerously sensitive to market fluctuations in that commodity as is Cuba, production being highly diversified and sugar making up only about two-fifths of the value of the total exports. The restrictions on the extension of the cane area involve the continuance of the concentration of capital and labour on the existing area. The intensive methods of agriculture stimulated by this and other internal conditions and based on the application of research to an exceptional degree, with the result that Java is to-day the most intensively cultivated country in the Tropics, have, however, given the island exceptionally low costs of production and, together with a skilful sales policy, given its sugar industry a strong and permanently sound position on the world market.

JAVA.

	Area (thousand hectares)	Production (thousand metric tons crystal)	Yield (metric tons per hectare)
1912	140.3	1,377	9.81
1913	145.3	1,439	9.90
1914	147.5	1,382	9.37
1915	151.2	1,294	8.56
1916	157.4	1,601	10.17
1917	160.4	1,791	11.16
1918	163.1	1,743	10.69
1919	137.7	1,309	9.51
1920	156.1	1,516	9.71
1921	159.5	1,656	10.38
1922	160.9	1,776	11.03
1923	162.5	1,761	10.84
1924	172.3	1,964	11.40
1925	178.3	2,261	12.68
1926	179.7	1,942	10.80
1927	185.6	2,351	12.67
1928	194.9	2,924	15.00
1929	196.7	2,871	14.60
1930	198.6	2,916	14.68
1931	199.3*	2,772	13.84*
1932	171.6	2,560	14.92

* Excluding Wonoaseh, Pengkol and Ardjosari.

Source: *Mededeelingen van het Proefstation voor de Java-suikerindustrie. Suikerproductie- en melasse-statistiek, 1932.*

CHAPTER VI

INDIA

INDIA has been surpassed only by Cuba in its production of sugar but does not produce enough to satisfy the needs of its vast population. All but a small proportion, too, of its production is in the form of gur, the manufacture of which is a village industry and which is simply cane juice concentrated until it is solid, practically without purification, the product containing 65-75 per cent. of sucrose.

Of the total cane production about 90 per cent. is grown in the Indo-gangetic plain, that is, mainly outside the Tropics, the remainder in the tropical Peninsula and Burma. Over half the area is in the United Provinces and next in order of importance come the Punjab, Bihar and Orissa, Bengal and Madras, though the first of these has less than one-third of the cane area of the leading province. Even in the United Provinces the crop occupies less than 4 per cent. of the total cultivated area, however, and in no other province does it attain even this small relative importance. In the extra-tropical provinces only the hard, thin North Indian canes mature.

The monsoon rains last generally from June to September but cane is generally planted in February and so must establish itself in the hot dry season. Irrigation is therefore necessary. The period of active growth, between the hot dry season and the cold dry season beginning in November, is thus very short, amounting to only four or five months. Frosts occur in December in the United Provinces and the Punjab, the two leading provinces. Harvesting takes place generally between November and March.

The light alluvial loams of the Indo-gangetic sugar areas are easily worked but the red soils and black cotton soils of the Deccan give much better results both

in tonnage of cane and in sucrose content. In the general absence of fertilizers soil fertility has become stabilized at the low level maintained by the processes of natural recuperation. The problem of raising unit-yields of sugar, like that of improving the standards of Indian agriculture generally, is extremely complicated, the question of better cultivation being bound up with those of improving the breed and condition of livestock, counteracting the fragmentation of holdings, supplying nitrogenous manures, extending irrigation, providing capital and raising the standard of living of the cultivator. The most hopeful line of advance at present is in the breeding and distribution of higher-yielding, disease-resisting canes, work that is being developed particularly by the Coimbatore research station. In 1931-32, 41 per cent. of the total cane area was under the new varieties; their rapid spread over the main sugar tract is expected. The yield of gur from these varieties is estimated to average about 50 per cent. more than that from the others. A chain of new research stations is eventually to be established.

The popular taste is for gur and other crude sugars, the market for which has in the past been practically independent from that for white sugar. Over four-fifths of the total cane production is absorbed in the manufacture of gur, of which the consumption amounts to between 2½ and 3 million tons, about 15½ per cent. for planting material, for chewing, for fodder and for the production of rab, a semi-liquid product utilized for the manufacture, by the very inefficient bel system, of khandsari, a white sugar; the remainder is used for the direct production of white sugar in the central factories. Inefficient though they are, both the gur and khandsari industries play an essential part in absorbing the cane production, especially in districts where relatively poor communications or scattered cultivation and lack of capital are obstacles to the establishment of central factories.

In 1930-31 the number of factories producing sugar wholly or in part directly from cane was 29, mainly in

the United Provinces and in Bihar and Orissa. In the same year ten other factories produced white sugar from gur only, the largest number of these being also in the United Provinces. The use of gur as raw material is a speculation depending on the relative price movements of gur and white sugar. The best quality is not sent to the factories. In the five years ending 1931-32 the proportion of the total white sugar, excluding khandsari, made directly from cane was 71 per cent. The number of factories using gur has in recent years declined gradually, due to the relatively high cost of transport and fuel, and to the speculative risks involved in the fluctuations of the price-ratio of gur and white sugar. On the other hand overcrowding in a particular area of the factories using cane has resulted in difficulties in the supply of cane and consequently to limitation in their size.

The demand for white sugar is growing rapidly, especially in the urban areas and near the great ports. It was met in the years following the War mainly by the import of mill-white sugar from Java. There have, however, been successive increases in the import duty since 1916, though it was only in 1931 that protection as distinct from revenue became the prevailing motive. The Tariff Board, in its report of 1931, fearing a slump in the gur market consequent on the increased yields from the new cane varieties or on other developments, considered that it was essential to prevent any diminution in the cane area by encouraging the expansion of the white sugar industry. By the Finance Act of September, 1931, the duty of Rs. 7-4 per cwt. on sugars of 23 D.S. and above, which had been imposed on 1 March 1931, for seven years up to 31 March 1938, was extended to all sugars of 8 D.S. and above and increased by a temporary surcharge of 25 per cent. (applicable to all customs import duties) to Rs. 9-1. The Sugar Industry (Protection) Act, 1932, extended this rate to all sugars as from April 1932. The Government was given power to make further increases in the duty when it considered these necessary to ensure

adequate protection and proposals are to be made by it not later than 31 March 1938 regarding the extent of protection for a further period up to 31 March 1946. The increase in the import duty resulted in a great expansion in the area under cane in 1932 and consequently in a great reduction in sugar imports, which had previously amounted to about one million tons annually. The number of factories has rapidly increased. Though the proportion of white sugar to the total Indian production remains a small one the growth of output, given continued high protective tariffs, should enable the Indian industry to keep pace with the growth of demand for white sugar within the country. The international importance of this lies in its repercussions on the market situation, particularly in the East. Allowing for improved methods of gur manufacture and for the use of an increasing proportion of the cane by the white sugar factories, the main problem of Indian sugar production remains, however, the agricultural one, which, as indicated above, is more difficult of solution than in other cane-growing countries. Though the factories may be able rapidly to increase their efficiency, agricultural inefficiency will maintain costs of the raw material at a relatively high level, which means that the cost of protecting the white sugar industry will remain a high one, while the production of the Indian industry as a whole is likely to remain in the near future at a level that though in itself very high, is low in relation to the vast area under cane.

INDIA.

	Area of cane (000 acres)	Production of sugar (000 tons gur)*
1922-23	2,740	3,045
1923-24	2,921	3,317
1924-25	2,532	2,546
1925-26	2,680	2,977
1926-27	2,925	3,267
1927-28	2,952	3,217
1928-29	2,568	2,704
1929-30	2,513	2,752
1930-31	2,801	3,228
1931-32	2,972	3,970
1932-33	3,305	4,651

42 WORLD SUGAR PRODUCTION AND CONSUMPTION

Area under cane in principal producing provinces.

	United Provinces (including Rampur State)	Punjab	Bihar and Orissa	Bengal	Madras	Bombay (in- cluding Indian States)
1928-29	1,357	401	287	196	89	90
1929-30	1,362	307	279	198	98	92
1930-31	1,504	426	284	199	112	93
1931-32	1,593	475	282	233	117	99
1932-33	1,789	556	302	233	125	101

Average yield of gur per acre (pounds) in five years ending 1932-33.*

All-India	..	..	..	..	2,707
United Provinces (including Rampur State)	..	..	..	..	2,587
Punjab	..	..	..	..	1,619
Bengal	..	..	..	..	2,968
Madras	..	..	..	..	6,202
Bombay (including Indian States)	..	..	..	..	5,875

* In the Indian official statistics the totals of sugar production are given in terms of gur, which is equivalent to about 55% crystal sugar and, unless reduced by means of this coefficient, is not comparable with the sugar production of other countries. The figures of production and unit-yield represent the quantities that would be produced were all the cane, including that for planting, fodder, chewing, the manufacture of rab and of white sugar, utilized for gur.

Sources: *Area and Yield of Principal Crops and Indian Trade Journal.*

Production of white sugar (thousand long tons).

	Directly from cane	Refined from gur	Khandsari
1922-23	24	50	50
1923-24	38	56	50
1924-25	34	34	50
1925-26	53	38	50
1926-27	63	58	50
1927-28	68	52	50
1928-29	68	31	200
1929-30	90	21	200
1930-31	120	32	200
1931-32	159	60	250

Source: British Empire Sugar Federation.

*Imports of sugar by sea (tel quel, excluding molasses)
(thousand long tons).*

1922-23	442
1923-24	411
1924-25	671
1925-26	733
1926-27	827
1927-28	726
1928-29	869
1929-30	940
1930-31	901
1931-32	516
1932-33	369

Imports of sugar from various destinations
(tel quel, excluding molasses) (thousand long tons).*

	Java	United Kingdom	Germany	Czecho-slovakia	U.S.S.R.	Hungary	Poland
1928-29	850.8	4.8	0.3	0.4	—	2.1	—
1929-30	781.1	59.3	15.2	9.7	—	36.5	2.4
1930-31	809.7	8.4	11.7	0.5	42.6	13.8	1.6
1931-32	366.8	22.9	15.4	1.1	88.1	0.6	13.0
1932-33	294.8	34.9	0.2	0.4	8.8†	—	—

* Mainly white sugar. † Beet-sugar only.

Sources. *Annual Review of the Indian Sugar Industry; Annual Statement of the Sea-borne Trade of British India; Accounts relating to the Sea-borne Trade and Navigation of British India.*

The number of factories producing sugar direct from cane in 1931-32 was 32, that of factories refining gur was 17. It is estimated that in the 1932-33 season the number of the former was 57, while in 1933-34 it is expected to be over 100.

In the five years ending 1931-32 the United Kingdom supplied 86 per cent. of the total imports of sugar machinery by value, France 7 per cent., Germany 4 per cent. and the United States 2 per cent.

VALUE OF IMPORTS OF SUGAR MACHINERY IN THOUSAND RUPEES.

	Total	United Kingdom	Percentage from U.K.
1927-28	913	726	81
1928-29	1,752	1,630	91
1929-30	921	849	94
1930-31	1,369	1,083	77
1931-32	3,014	2,623	87
1932-33	15,311	9,148	60

Sources: *Annual Statement of the Sea-borne Trade of British India; Accounts relating to the Sea-borne Trade and Navigation of British India.*

CHAPTER VII

BRITISH EMPIRE PRODUCERS EXCLUDING INDIA

SUGARS produced in the British Empire were first awarded a tariff preference in the United Kingdom in 1919, when they received an advantage of one-sixth on the general import duty, then at 25s. 8d. a cwt. In the four full years of this preference, 1920-23, the proportion of Empire sugars in the total raw sugar import of the United Kingdom rose to an average of 28 per cent., originating chiefly in Mauritius (16·0 per cent.) and the British West Indies (9·3 per cent.), the only Dominion sugar being from South Africa (2·4 per cent.). The automatic reduction in the amount of the preference from 4s. 3·3d. to 1s. 11·3d. when the general duty was reduced in 1924 to 11s. 8d. brought a reduction in the Empire percentage, which recovered, however, in the following three years, 1925-27, when the preference was stabilized at its former value of 4s. 3·3d. for all sugars over 98° (3s. 8·8d. for 96°), to an average of 35 per cent. Australia now appeared with a share of 9·0 per cent. in the total supplies, equalling that of the British West Indies (8·9 per cent.) but still exceeded by Mauritius (13·3 per cent.), while the proportion from South Africa was 3·5 per cent. In 1928 the grading of the preference according to polarization was arranged so as to discourage imports of white sugar, preferential or other, by a high duty against foreign sugars over 98° and against all sugars over 99°, the nominal preference on the latter grade being only 5s. 10d., while that on sugars over 98° but not over 99° was 6s. 10·8d. and the rate on sugar not exceeding 96° was 3s. 8·8d. As the bulk of the sugar coming on the British market is of the lower polarization it is the preference on these grades that also determines the amount of preference received by Empire producers of higher polarization raws. In the four years 1928-31 the proportion of Empire sugars in the total raw import was 32 per cent., Australia being

responsible for 10.6 per cent., Mauritius for 10.2 per cent., South Africa for 5.4 per cent. and the British West Indies for 5.1 per cent. Thus the import of foreign raws was stimulated rather more than that of Empire raws by the 1928 tariff. By agreements of 1931 the existing preferences on South African and Australian sugars were stabilized until 15 November 1937.

In 1932 the duty on all Colonial sugars was reduced by 1s. a cwt., thus increasing the preference to 4s. 8.8d. a cwt., and on a quota of 275,000 tons by 2s. a cwt., while the duty on Dominion sugars was left at the 1928 level. The almost steady decline, both absolutely and relatively, in the imports of British West Indian sugar into the United Kingdom, despite the upward tendency of production and the preferential tariff, is due to the existence of an alternative preferential market in Canada, which first granted favoured treatment to Empire sugars in 1902 and since 1925 has given a preference of \$1.00 per 100 pounds for sugars over 95° and not over 96° (\$1.12 for sugars of 98°). The increase in the British preference in 1932, however, reversed this tendency and led Canada to draw on other Empire sources, Australia, South Africa, Fiji, to make up the deficit in the imports of British West Indian raws.

UNITED KINGDOM.

Percentages of raw sugar imports from certain countries.

	1909-13*	1920-23*	1928-31
Cuba	9.0	36.3	35.4
Dominican Republic	3.9†	1.1	10.6
Australia	—	—	10.6
Mauritius	3.6	16.0	10.2
Peru	4.4	7.1	7.0
South Africa	—	2.4	5.4
British West Indies	6.2	9.3	5.1
Poland	—	0.3	3.6
Germany	35.1	0.3	3.1
Java	12.0	16.7	2.6
Brazil	2.8	6.3	1.6
Czechoslovakia	10.7‡	0.3	0.6

* Previous to 1923 statistics of imports into the United Kingdom included those into what is now the Irish Free State.

† Including Haiti.

‡ Austria-Hungary.

MAURITIUS.

Mauritius, where sugar-cane cultivation on a commercial scale began in 1735, was the first to rival the West Indies as a source of sugar for the Mother Country. In the years since the War the crop has occupied up to almost 80 per cent. of the cultivated area, including all the best lands.

The trade winds bring a relatively heavy precipitation in the summer months from December to April. The rainfall of June-July preceding the harvest and that of November-December in the previous year are critical. The bulk of the cane is crushed in October-December, after a season of eighteen to twenty-two months for the greater part of the plant cane and of twelve months for ratoons, which account for four-fifths of the crop. The island is subject to destructive hurricanes, especially in February and March, and to droughts, which are, however, less serious.

Practically all the cane is grown on the red soils, which cover the greater part of the island save the drier west and north, where black soils occur. The canelands are on the whole highly fertilized; not only are artificial fertilizers applied intensively but the organic content of the soil is carefully maintained by the use of stable manure, factory residues, molasses and green manures.

Since the final liberation of the negro slaves in 1839 the sugar industry has relied on Indian labour. Assisted immigration was discontinued in 1910. At the 1931 census the Indians made up 68 per cent. of the total population of the island. The breaking up of the estates into small-holdings after 1910 led to an increase in the proportion of caneland held by Indians; of the total cane area in 1931 the estates retained 70 per cent., while the proportion held by Indians was 38 per cent., and that of the cane grown by Indians was 46 per cent. A scarcity of labour was felt during the post-war boom.

The total production of sugar showed an upward trend

from the 'eighties to 1914, when the maximum thus far of 277,400 metric tons was attained; since then the trend has been downward. The area under cane rose to 179,780 acres in 1921 under the influence of high prices; much of the virgin land then brought under cultivation was of distinctly inferior type and the downward trend since has represented merely its abandonment when prices made it impossible to cultivate it economically. The total of possible permanent expansion of the cane area—entirely in the irrigated districts of the west—is small. As regards unit-yields, the rise in the standard of cultivation on the estates has been neutralized by the steady decrease in the area cultivated by them; although the Indians are not unprogressive, the small scale of their operations, lack of capital and personal inefficiency all operate to cause their standards to lag behind. A serious feature in the situation is the diminution of the sugar content of the canes, which has counterbalanced the increased efficiency of the factories in the extraction of sugar. The island has come to be dangerously dependent on one variety—Big Tanna—which in 1931 covered over half of the cane area. Though fortunately free from serious cane diseases—gumming and leaf-scald affecting only 18·4 per cent. of the area—the island has a serious pest in the brown hardback (*Phytalus smithii*), which in 1931 infested 43 per cent. of the planted area. A new sugar-cane research station, with assistance from the Empire Marketing Board, was opened in 1930 to deal with the problem of finding new canes to replace Big Tanna.

Before the War India was the chief market, generally taking over 60 per cent. of the production, but since then the United Kingdom has absorbed almost the entire output. Mauritius was a pioneer in the manufacture of direct consumption sugars by the sulphitation process and prior to 1928 it mainly exported sugar of 99·5° polarization; since then, however, the Colony has been forced by the penalization of high polarization sugars in the British market to reverse this development and raw sugars of 98·5° now form the bulk of the production.

BRITISH WEST INDIES.

The British West Indies, Great Britain's "classical" sugar colonies, are on the whole climatically suited to sugar-cane, though there is a considerable variability in rainfall and Barbados and the Leewards, for instance, approach marginal conditions of precipitation. The whole region lies in the summer rain zone of the north-east trade winds, the rainy season lasting in the greater part of the area from the latter part of May to the earlier part of December, though British Guiana is sufficiently near the equator to have a double rainy season. Temperature exhibits great uniformity from month to month, especially in British Guiana. As a rule crop movement takes place from February to June, but in British Guiana the main cutting is from September to December.

Cane soils vary from the easily-worked soils of Barbados to the heavy alluvial clays of British Guiana. Deficiency in organic matter is the principal and most general soil difficulty; according to the possibilities in the various areas, attempts are being made to remedy this by green manuring, pen manuring and flooding; there is a general need for greater use of artificial fertilizers. In British Guiana the canelands are mainly below sea-level and require an elaborate system of surface drainage.

The latter part of the nineteenth century brought a series of crises to the British West Indian planters. The British preference was abolished in 1854 and the competition of slave-grown cane-sugar was followed by that of European beet-sugar; then, in 1903, the United States market was lost as a consequence of the Cuban reciprocity treaty. In 1897 the area under sugar-cane had shrunk to its smallest dimensions and the Imperial Government was forced to come to the assistance of the planters. In 1898 Canada began to give a preference, subsequently increased and embodied in a series of trade agreements, and in 1903 the Brussels Convention brought some relief in the British market.

As in Mauritius, East Indian labour is the backbone of the industry, indentured immigration having continued from 1836 to 1917. In the years immediately following the War, when the boom in sugar was shared by the British West Indian planters, labour shortage was experienced, the principal exception being Barbados with its dense population. Cane-growing by small-holders, the majority East Indians, has developed most strongly in Trinidad. The extension of mechanical cultivation, though in some areas it meets with topographical difficulties, is a primary necessity for the reduction of costs.

Thanks largely to more intensive cultivation, Barbados has the highest yields of cane in the British West Indies. Different varieties are dominant in the various areas, D.625 in British Guiana, B.H.10(12) in Trinidad, Jamaica, St. Kitts, Nevis and St. Lucia, B.6450 and Ba.11569 in Barbados. On the whole, disease is not serious, save perhaps mosaic in Jamaica, but the moth-borer is prevalent in British Guiana, Barbados, St. Kitts-Nevis and Antigua, and the froghopper (*Tomaspis saccharina*) is a very serious pest in Trinidad. Besides the work of the local departments of agriculture, which naturally pay special attention to cane, research on problems of a more fundamental nature is carried on at the Imperial College of Tropical Agriculture in Trinidad, while Barbados has been recognized as the centre of cane-breeding for the British West Indies.

While considerable advantage has been derived from the development of up-to-date factories such as are found in Trinidad, Antigua, St. Kitts and Jamaica, physical conditions such as the small size of some islands or, as in Jamaica, the scattered distribution of canelands and difficulties in transport, in addition to financial obstacles, prevent full advantage being taken of modern possibilities of reducing costs of production by large-scale production.

All the colonies except Jamaica, which produces yellow crystals, produce, mainly or wholly, dark or grey crystals of about 96° polarization almost entirely for the British

or Canadian refiners. Rum is still by far the most important by-product, particularly in Jamaica and British Guiana; Jamaica has been encouraged by the comparative profitability of the rum export in the past to neglect improvements in the recovery of sugar from the molasses. Barbados uses a large part of its cane for the production of fancy molasses, of which it has almost a monopoly.

The Canadian preference, which was raised in 1925 to \$1.00 per 100 lb. of sugar of 96°, and the British preference since 1919, have together helped to maintain and, in recent years, even to stimulate the output of sugar. Such increase in production as has occurred in recent years is, however, mainly due to increased unit-yields, areas under cane having on the whole declined through shrinkage to the more suitable tracts, accompanied to some extent by adoption or expansion of other crops.

Fiji.

In the Fiji islands sugar-cane is grown chiefly in the drier north and west of the two main islands—Viti Levu and Vanua Levu—on the alluvial coastal flats and in the lower sections of the valleys. The introduction of machinery and the encouragement of co-operative cane-farming have gone far to solve the labour problem that followed the stoppage of Indian indentured immigration in 1916. Production is controlled by a single company, owning five mills and the rail and water transport system of the Colony and carrying on research. The peak production of 122,000 metric tons was reached in 1915-16, the figure of that year not being surpassed until 1932-33. Probably at least three-quarters of the available and suitable cane-land is already under the crop. Transport is a serious limiting factor. Thanks to preferences, the British and Canadian markets now exceed that of New Zealand in importance.

EAST AFRICA.

In East Africa cane is grown chiefly in the Nyanza, Kikuyu and Coast provinces (in Kenya), in Buganda and the Eastern province (in Uganda). There are seven

small factories, five in Kenya and two in Uganda, producing sufficient mill-white sugar to supply East African demand. The local markets are protected and there is a small export to adjoining territories.

AUSTRALIA.

In Australia a series of widely separated cane districts, situated in the lower sections of the river valleys, stretches along the Queensland coast and into New South Wales as far as the thirtieth parallel. The southern part is liable to serious frost damage. The Queensland coast receives rain from the south-east trades throughout the year but with a maximum in summer. After twelve to fourteen months in the ground the cane is harvested from the end of June to December, the heavy rains beginning in the latter month. In the areas of very heavy rainfall in the north better results are obtained in the drier years but in the south losses from drought occur. Climatic disadvantages thus help to explain the tendency of the industry to move northward.

In the valleys a dark alluvial soil is found, while in certain areas deep easily-exploited red to chocolate loams predominate.

The Australian sugar industry at first depended on indentured Polynesian labour but from 1901 to 1919, in pursuance of the White Australia policy, a series of acts were passed, first forbidding further immigration of coloured labour, then stimulating the substitution of white labour by an excise drawback on white-grown sugar, gradually expelling those Kanakas remaining and finally prohibiting the employment of coloured labour in cane-cutting. The cane is mostly grown by small farmers and harvesting is done by migrant gangs of highly-paid white cutters.

The principal variety cultivated is Badila. Yields fluctuate widely from climatic causes. Almost all the serious cane diseases are present, gumming, leaf-scald,

Fiji and mosaic being the most prevalent, and the grey-back beetle (*Diatræa striatalis*) causes immense losses. There are three experimental stations: in the southern central and northern sections respectively. The yield of sugar per unit of cane has steadily increased and is now exceptionally high.

The existence of many small areas of caneland dotted along 1,000 miles of coastline has meant the survival of many small factories, especially in the south. There are in all 38 factories (1931). The chief outlet for molasses is the distilleries. A fuel alcohol plant with a product containing 15 per cent. alcohol and 85 per cent. petrol was established in 1928 but its development was checked by the smallness of the market.

In 1913 the excise was abolished and the industry given the full benefit of the customs duty. In 1915 the Commonwealth and Queensland Governments adopted joint control of the industry for war purposes, the former agreeing to purchase all the sugar at a fixed price. In 1920 a three-year agreement was made, the price paid by the Commonwealth for raw sugar being raised to £30 6s. 8d. a ton; this stimulated the putting of more land under cane, particularly in the north. Fluctuations in world sugar prices were still, however, felt severely by the Australian industry, forced to maintain high rates of wages as fixed by Government awards, and this, together with the fact that production had reached the level of Australian consumption, led the Commonwealth Government in the 1923 agreement to replace the customs duty by an embargo on sugar imports, which has been renewed in successive agreements with the Queensland Government. Under the 1923 agreement the industry was required to form a pool from which the Queensland Government Sugar Board was to purchase raw sugar at £27 a ton for sale to the refiners; the retail price of refined sugar was fixed at 4½d. per lb. and rebates were given to manufacturers for export and to fruit processors. Meanwhile productive capacity had been so stimulated that a considerable export surplus had to be disposed of after 1925, with consequent

reduction in the average price received by the growers. The losses thus experienced by the industry eventually led to the adoption as from 1930 of the Peak Year Scheme, whereby the highest output of each mill since 1915 and up to and including 1929 was to be taken as the maximum for which the average price based on the totals of these maxima was to be paid. Sugar produced in excess of the highest output of each mill since 1915 or from cane not grown on assigned land was to be taken out of the pool for purposes of the average price, placed in a separate export pool and paid the average net export price. Under the 1931 agreement the embargo was renewed for five years and the existing selling prices for three years; the price to be paid for raw sugar was fixed at from £22 a ton for a production of 500,000 tons or over to £23 on 340,000 tons, the rebate to fruit processors being, however, replaced by a payment of £315,000 per annum from the sugar industry. By the Sugar Agreement Act of 1932, which for the first time gave specific Parliamentary sanction to a sugar agreement and to the prohibition of sugar imports, this agreement was modified as from 5 January 1933, the retail price being reduced to 4d., the existing prices to be continued for the full term of five years and the contribution to the fruit industry being reduced to £200,000.

Production has remained at the high level to which it rose after 1923, following on the stabilization of conditions in the internal market. By 1931 the surplus amounted to half of the total production and in that year exports received only £9 7s. a ton, even including the benefits of the high rate of exchange and of the preference in the British market, the average price being reduced to £17 19s. 8d. While good potential cane-land is plentiful the fact that increased export means increased loss to the growers makes its utilization unlikely. The whole system rests on the maintenance of the embargo, which is defended, principally on political grounds, as a means of securing a white population on the tropical coastline of Queensland.

UNION OF SOUTH AFRICA.

The sugar belt stretches along the Natal coast-lands as far south as 31° , thus, thanks largely to the warm Mozambique current, reaching a higher latitude than the Australian cane-lands; northward, in Zululand, the belt at present extends as far as the Umfolosi River. In Natal, as in Australia, the increasing frequency of frosts is a limiting factor toward the south. Rainfall is marginal and, though it is fortunately largely concentrated in the growing season, serious droughts are experienced. Harvesting takes place from May to September after the plant cane has been in the ground for periods approaching twenty-four months in Natal and eighteen months or even less in Zululand and the ratoons for at least eighteen months in Natal and twelve months in Zululand.

The bulk of the cane is grown on the red soils of the higher and undulating country, especially in Zululand.

Owing to the disinclination of the Zulus for work on the plantations, East Indian indentured labour was introduced from 1860 to 1911. Since the breakdown of this system, however, and the abandonment of plantation work by many of the remaining Indians, the industry has been forced to rely mainly on relatively unreliable and incapable Bantu labour, drawn mainly from other parts of the South African Union. Labour shortage has been one cause of deficiencies in cultivation and in general agricultural practice.

The industry depends completely on one variety of cane, Uba, which gained its popularity through being hardy and drought-resistant, requiring little cultivation, ratooning well and being resistant to most diseases and pests, but which has adherent leaves and causes difficulty in the factory owing to its highly fibrous nature and refractory juice. Yields are higher in Zululand than in Natal proper, but on the whole low, particularly with reference to the long growing period, and are declining. Two or three ratoons are generally taken. Streak is the chief disease, while mosaic is controlled by the prohibition of other canes than Uba. Research is

mainly directed to finding a soft cane with resistance to streak and a shorter growing period than Uba.

The mills grow 28 per cent. of the cane (1933), planters producing the rest. Factory results are relatively poor, owing partly to the nature of the cane and partly to the prolonged milling season. In 1930-31 there were 24 mills; all of these formerly produced white sugar, but now most send only raw to the central refineries. For long the relations between planters and millers were chronically unsatisfactory but in 1926 the Government made the imposition of the new import duty desired by both parties conditional on their agreement.

Production increased rapidly from 1906, especially after free trade had been established between the separate colonies later to form the Union and new lands in Zululand were opened up; in 1918 it first overtook South African consumption. In 1926 protection was increased, retail prices being fixed at 3½d. per lb. and manufacturers being supplied at a lower rate and given a rebate on sugar for exports. In 1930 the customs duty was increased from 4s. 6d. to 9s., and in 1932 to 12s. 6d. per 100 lb., which, given the additional suspended duty of 3s. 6d. and subtracting the excise of 1s., gives a net protection of 15s. The retail price was reduced in 1932 to 3½d.

As in the case of Australia, exports have, since 1920-21, been at a loss, tempered by the British preference. By 1930-31 half the production had to be exported. The increase has been mainly on estates owned by the mills, but the independent planters, who in 1931 were estimated to produce 60 per cent. of the cane, are particularly affected by the consequent fall in average prices, exports being included in calculating the cane prices from sugar prices. There are considerable potentialities for increasing production both by extending the cane area and by raising yields on the existing area.

UNITED KINGDOM.

Prior to the passing of the British Sugar (Subsidy) Act in 1925, attempts to establish the beet-sugar industry in the United Kingdom had been frustrated by financial

and labour difficulties. The first factory on any considerable scale was established in 1912 at Cantley and was in operation for four campaigns, after which it was closed until 1920. A second factory was opened in 1921. Up to 1919 fiscal assistance to the industry was limited to the differential between the customs and excise duties ; in that year a rebate of one-sixth of the excise was added ; in 1922 the excise duty was entirely remitted, with the result that in the two following campaigns the industry operated at a profit for the first time. The value of the remission depending on the amount of the import duty, the position of the industry continued, however, to be dubious. Propaganda for the further development of the industry was led by the British Beet Sugar Society, founded in 1915. The most important argument brought forward was the agricultural one, that the introduction of sugar-beet in the rotation would provide a cleaning crop that would pay its own way ; in this connection the use of the by-products must, of course, be taken into account. Eventually, on 27 March 1925, the Subsidy Act was passed, giving direct assistance to the industry and re-imposing the excise duty at the preferential rate. Three subsidy periods were established : the subsidy per cwt. of sugar produced was fixed at 19s. 6d. from 1924-25 to 1927-28, 13s. from 1928-29 to 1930-31, and 6s. 6d. from 1931-32 to 1933-34 (the last period being extended in 1933 to include the 1934-35 season), and was conditional on the factories paying for washed roots of 15½ per cent. sugar content a standard minimum price fixed by contract between the National Farmers' Union and the Beet Sugar Factories Committee for each season. The subsidy was largely for the purpose of attracting capital to the industry. Foreign capital played an important part in establishing the British factories. The declining scale was intended to stimulate the acquisition of experience by growers and factories. The cost of this assistance to the industry amounted to the subsidy plus the difference between the amount of duty paid on home-grown sugar and the amount that would have been paid on a similar quantity imported. Owing to the great fall in sugar prices a

special advance of 1s. 3d. a cwt., payable on 300,000 cwt., was granted in 1931-32, abatable by the amount of any rise in sugar price above 6s. 6d. a cwt., c.i.f., U.K.

The number of factories quickly rose from two to eighteen by the end of the first subsidy period, the area under sugar-beet, which in 1924 had been 23,000 acres, rose to 349,000 acres in 1930-31 and the number of growers to 40,415. In that year of maximum 424,000 tons of sugar were produced, over one-fifth of the consumption of the United Kingdom. The area is mainly in the Eastern Counties and especially in Norfolk, Lincoln, Suffolk and the Isle of Ely, which in 1930, a year of large production, together accounted for over two-thirds. This concentration is accounted for mainly by climatic, labour and rotational factors. On the whole the climate of Great Britain is favourable, the relative infrequency of extreme temperatures permitting a high degree of continuity in growth and giving opportunity for a relatively long growing season, while the cool months at the end of the season favour quality. The rainfall rises in mid-season (June-July) to a point near the optimum, while the dry September, especially marked in the Eastern Counties, is advantageous for ripening; the danger of the subsequent sharp increase in precipitation characteristic of the British climate is least marked in the Eastern Counties. Towards the west late rains on the heavy soils cause great difficulty in lifting and transport, which generally begin in October. The crop is grown on a great variety of soils but loams show distinct advantages. The heaviest yields are obtained in the fen lands.

The predominance of the medium-sized farm, generally requiring to engage additional labour for the rush periods, makes the British labour position more akin to that of the areas of large estates on the Continent than to that of the areas of small-holdings where family labour predominates; in Great Britain, however, no large bodies of cheap migratory labour are available. Wage costs make up over half of the total and relatively high labour costs are the principal factor making costs of production higher in Great Britain than in Continental

countries. The Eastern Counties are also in this respect relatively more favourably placed than other parts of Great Britain in that wage levels are there the lowest in the country. There, too, the density of agricultural population, though less than in the Continental sugar-beet areas, is highest, and intensive farming already predominated. Labour is in Great Britain the chief limiting factor in the development of the industry. Relatively high costs of transport are also a disadvantage. Efforts to reduce costs per ton by raising unit-yields, which are relatively low in Great Britain—the maximum of 1932-33 having been 8.8 tons beet and 3,130 pounds sugar per acre—are hindered by the need to economize in labour.

British factories, with an average capacity of over 1,300 tons beet a day, are larger than most of those on the Continent, the average for Czechoslovakia being 1,000 tons and that for Germany 800 tons. All except one, which is controlled by the refiners, can produce white granulated beet, due to agreements with the refiners, the proportion of raw sugar produced has tended to increase. Some factories utilize the off-season from February to September by refining raw imported sugar.

The industry is entirely dependent on the subsidy.

In the Irish Free State beet-sugar production is subsidized both directly and by remission of excise duties. A factory has operated at Carlow since 1926.*

In Canada sugar-beet is grown especially in the Southern Alberta irrigation area and in Western Ontario and there are in all four factories.

In Australia beet-sugar is produced by one factory, at Maffra in Victoria, which gets the full benefit of the embargo since all its output is marketed in Australia.

* Under the Sugar Manufactures Bill, which provides for the establishment of an Irish Sugar Company in which the Government will, if necessary, hold one quarter of the shares and will guarantee principal and interest, three new factories are to be in operation in 1934-35.

BRITISH EMPIRE PRODUCERS EXCLUDING INDIA 59

MAURITIUS			FIJI	
	Area of cane (000 acres)	Production of sugar (000 metric tons)	Area of cane (000 acres)	Production of sugar (000 long tons)
1922-23	174	231	39	46
1923-24	171	202	42	36
1924-25	167	225	28	64
1925-26	163	241	..	101
1926-27	162	193	20	69
1927-28	158	218	49	95
1928-29	158	253	38	94
1929-30	156	238	38	88
1930-31	137	221	39	92
1931-32	135	164	39	76

Source: *The Mauritius Almanac.*

Source: International Institute of Agriculture.

BRITISH WEST INDIES.

<i>British Guiana.</i>			<i>Trinidad.</i>	
	Area of cane harvested (000 acres)	Production of sugar (000 long tons)	Area of cane (000 acres)	Production of sugar (000 long tons)
1922-23	57	101	35	42
1923-24	51	91	..	52
1924-25	49	92	..	70
1925-26	56	108	33	74
1926-27	56	98	..	52
1927-28	57	114	..	82
1928-29	53	116	44	90
1929-30	56	117	..	80
1930-31	54	128	..	99
1931-32	55	126	60	98

<i>St. Kitts-Nevis</i>			<i>Barbados</i>	
	Area of cane (000 acres)	Production of sugar (000 long tons)	Production of sugar (000 long tons)	
1922-23	6.5	11	55	
1923-24	6.5	10	47	
1924-25	6.5	16	53	
1925-26	6.8	16	51	
1926-27	6.4	18	59	
1927-28	6.8	19	68	
1928-29	7.0	14	71	
1929-30	6.9	19	56	
1930-31	6.1	12	40	
1931-32	6.5	20	83	

The total area under cane in Barbados remained practically unchanged at 35,000 acres throughout this period; the area harvested was 26,000 acres according to the Agricultural Census taken in 1929.

60 WORLD SUGAR PRODUCTION AND CONSUMPTION

	<i>Jamaica</i>		<i>Antigua</i>	
	Area of cane (ooo acres)	Production of sugar (ooo long tons)	Area of cane (ooo acres)	Production of sugar (ooo long tons)
1922-23	44	39	16.4	10
1923-24	48	34	16.5	8
1924-25	47	45	14.6	17
1925-26	44	56	13.9	12
1926-27	53	63	14.7	23
1927-28	44	53	13.8	20
1928-29	43	58	13.4	11
1929-30	42	67	14.7	18
1930-31	45	50	8.8	5
1931-32	41	58	11.3	19

St. Lucia.

	Area of cane (ooo acres)	Production of sugar (ooo long tons)
1922-23	4.4	3.8
1923-24	4.7	4.6
1924-25	4.7	5.6
1925-26	4.7	6.0
1926-27	4.7	5.4
1927-28	4.7	4.0
1928-29	4.3	5.0
1929-30	4.3	5.2
1930-31	4.0	4.6
1931-32	4.1	5.5

Source: International Institute of Agriculture.

AUSTRALIA.

	Area under cane		Production of raw sugar (ooo long tons)
	Total (ooo acres)	Productive (ooo acres)	
1922-23	217	147	306
1923-24	237	145	286
1924-25	274	175	436
1925-26	288	198	518
1926-27	285	199	416
1927-28	291	212	509
1928-29	299	222	538
1929-30	307	223	538
1930-31	312	230	536
1931-32	326	241	604

Source: Commonwealth *Production Bulletins*.

BRITISH EMPIRE PRODUCERS EXCLUDING INDIA 61

	NATAL.		Production of sugar, as refined (ooo short tons)
	Area under cane*		
	Total (ooo acres)	Productive (ooo acres)	
1922-23	211	86	159
1923-24	201	90	203
1924-25	217	87	161
1925-26	232	102	240
1926-27	245	107	243
1927-28	264	112	247
1928-29	300	130	296
1929-30	310	135	299
1930-31	289	145	393
1931-32	..	..	326

* Excluding Indian and native plantings, about 6 per cent. of the total.

Sources: Union of South Africa *Agricultural and Pastoral Production*; International Institute of Agriculture.

	GREAT BRITAIN.	
	Area of sugar-beet (ooo acres)	Production of beet-sugar (ooo cwt.)
1920-21	3	39
1921-22	8	129
1922-23	8	140
1923-24	17	266
1924-25	23	478
1925-26	56	1,036
1926-27	129	3,069
1927-28	233	3,802
1928-29	178	3,904
1929-30	231	5,841
1930-31	349	8,486
1931-32	233	5,029
1932-33	255	6,606

	Yield of sugar-beet (long tons per acre)
1927-28	6.4
1928-29	7.7
1929-30	8.7
1930-31	8.8
1931-32	7.1
1932-33	8.8

For comparison with the figures for European countries it may be stated that the average yield of sugar-beet per hectare in Great Britain in the five years ending 1931-32 was 19.3 metric tons.

Source: Ministry of Agriculture *Report on the Sugar-beet Industry*; *Agricultural Market Report*.

CHAPTER VIII

UNITED STATES PRODUCERS INCLUDING THE PHILIPPINES

SUGARS produced within United States territory, continental or insular, have been continuously protected since 1794. With the exception of the period from 1891 to 1894, this protection has been by means of an import duty. The McKinley tariff of 1890 admitted sugar not above 16 D.S. duty-free, but a bounty at the rate of 2 cents a pound on sugar polarizing not below 90° was almost immediately put into force to save the domestic industry. In 1894 the Wilson tariff reimposed the import duty at the rate of 40 per cent. *ad valorem* on sugars not above 16 D.S., the bounty having meanwhile been declared unconstitutional. Under the 1897 tariff the duty was fixed at a rate amounting to 1.6850 cents for 96° sugars, which meant, after the coming into force of the Cuban reciprocity treaty in 1903, a preferential rate of 1.3480 cents; this rate was continued in the 1909 tariff. The proportion of domestic sugars to total consumption continued to grow until 1913, after which the rapid increase in the proportion of Cuban sugars in United States imports soon made the preferential rate of duty the effective one. Under the tariff that came into force on 1 March 1914, this rate amounted to 1.0048 cents a pound on 96° sugars; under that of 27 May 1921 the preferential rate was 1.6000 cents, and under that of 22 September 1922, it was 1.7648 cents. The tariff then remained unchanged until 18 June 1930, when the effective rate became 2 cents a pound, other duty-paying sugars having now practically completely disappeared from the United States market.

U.S. PRODUCERS INCLUDING THE PHILIPPINES 63

The changing proportions to the total United States consumption of the sugars from various sources of supply may be seen from the following table of percentages, the averages being calculated for periods during which the tariff remained unchanged.

	1909-13	1925-29	1931-38
United States beet	15.1	15.9	20.8
Louisiana ..	7.9	1.8	2.9
Hawaii ..	13.9	12.0	15.5
Puerto Rico ..	8.4	8.7	12.9
Virgin Islands ..	—	0.1	—
Philippines ..	2.9	8.0	14.5
Cuba ..	47.9	53.0	32.8
Full-duty sugars ..	3.9	0.4	0.5

Production in United States territories as a whole (including the Philippines) has since 1913-14 grown at roughly the same rate as that in Java. The trends of domestic beet production and of Hawaiian and Puerto Rican cane have been roughly parallel to the general trend. The most rapid advance as regards both total production and relative position in the United States market has been that of the Philippines. Domestic beet and Puerto Rican cane have also since the 1930 rise in the import duties notably strengthened their respective positions. Louisiana, though it has shown a rapid recovery in absolute production since 1926-27, is unable to regain its pre-war relative position. The rise of production in United States territories has steadily reduced Cuba's share of the market.

UNITED STATES BEET.

Attempts to establish a beet-sugar industry in the United States date from about 1830, but they were unsuccessful until fifty years later (in 1879) a profit-making factory was established at Alvarado, California. In the north-eastern states, where the early experiments were made, the industry has disappeared, general conditions being unsuitable. The greatest development

is now in the Mountain States of Colorado, Nebraska, Wyoming, Utah, Idaho and Montana, in the North Central States (particularly Michigan, Ohio and Wisconsin), which were the leading producers at the beginning of the twentieth century, and in California.

Development was very slow until 1890, since when there have been several periods of rapid progress: first, from 1890 to 1894, a period during which the industry received a bounty of 2 cents a pound, then, following on the 1897 tariff, and lastly, the periods of sharp upward movement during and after the War, particularly in 1915-16 and 1920-21. After several years of fluctuation there was a further distinct upward step in 1930 and the total beet area rose to over a million acres in 1933. Since 1912 the domestic beet industry has been the principal source of sugar within the tariff wall.

About 70 per cent. of the beet is produced in the Mountain States, particularly in the South Platte Valley. Colorado alone is responsible for 40 per cent. of the United States crop, being the leading State both in area and production. Owing to the low and irregular precipitation the crop depends on irrigation. Yields of beet and of sugar are as a consequence high, despite the small use of fertilizers. In the South Platte Valley the beet by-products play an important part in the great lamb-feeding industry; for stock-feeding, however, their importance is outweighed by that of maize and alfalfa. Irrigation water is a limiting factor to further extension of the crop in much of this region. Disease—curly top in particular—has been especially prevalent and "nematode" is particularly serious.

In the North Central States the sugar-beet industry centres on the dark loams of Michigan. Climatic conditions are fundamentally different from those in the other two centres, there being a humid growing season from May to September, maturing of the beet being favoured by the falling-off of the precipitation in October and November. While the warm days favour rapid growth the temperatures do not, as in the Mountain

States, tend to be excessive for the crop. The industry is favoured by a central position and especially good transport facilities. Costs of production are, however, high.

In California, owing to the winter rainy season, it has been found more suitable to reverse the usual season by sowing the crop in November and harvesting it in April and May. Competition of other crops is here especially severe and this, together with the greater exposure of the area to cane competition from Hawaii and the Philippines and its great distance from markets across the Rockies, has led to a steady decline in the beet area.

Of 74 factories operated in 1933, there were 17 in Colorado, 11 in Michigan and 7 each in Utah and Nebraska. On the whole the largest capacities are in California and the Mountain States—rising to the extraordinary figure of 4,500 long tons beet per twenty-four hours in the Spreckels factory near San Francisco—and the smallest in the North Central region. The factory campaign lasts from August to November. As a rule white sugar is produced by continuous process. The beet factories have the disadvantages of having to market their production at a period when supplies from other sources are heavy and of having to send their output long distances by rail. The beet is grown by contract, there being about 175,000 growers (1930).

While there appear to be large areas of suitable soils, extension of the crop is limited not only by the severe competition of other sugars from within the tariff wall but by the competition of other cash crops for the best land (one consequence of this being very long crop rotations); in some areas, especially since the supply of cheap labour from Europe was cut off, labour has been a limiting factor, leading to increased Mexican immigration and to increased experimentation with machinery. The absence of the peculiar complex of labour conditions, strong position in the crop rotation and, in some districts, close association with the livestock industry, that gives

the crop in Europe a certain independent power of resistance to adverse economic conditions, makes the United States beet-sugar industry more dependent on tariff protection than that of Europe.

HAWAII.

The first export of sugar from the Hawaiian Islands was in 1837. Though the Californian gold-rush and the American Civil War stimulated the trade, the first notable advance in production occurred after the reciprocity treaty with the United States in 1876, which enabled Hawaiian sugar to enter the United States free of duty and greatly encouraged the entry of capital and labour. When the islands were annexed by the United States in 1898 their market was assured and the subsequent rise in production continued until 1915, when it reached 646,445 short tons. After a decline for some years, production rose very rapidly after 1922-23 and by 1932-33 was over a million tons, a rise due to increased unit-yields.

The islands lie in the zone of the north-east trade winds; they receive their heaviest rainfall in the cooler season, while their mountainous character results in the windward sides being in places, as in Hawaii and Maui, excessively wet and their leeward sides having a precipitation quite inadequate for cane. There is great annual variation in the rainfall for a given month. The greater development of the industry depends very largely, therefore, in consequence of these climatic features, on costly irrigation works, which lead water from springs, streams, reservoirs, artesian and other wells, depending on the precipitation of the windward sides, by ditches, tunnels and pipes to the leeward sides. At present nine-tenths of the cane is irrigated. On the other hand the dry sunny climate results in high sucrose content and enables the mills to grind throughout the year unhampered by rains. High yields are facilitated, too, by the fact that moisture supply is under strict control. A further advantage is the absence of hurricanes.

The islands on which sugar is produced are, in order of importance, Hawaii, Oahu, Maui and Kauai. Almost all the soil is formed by lateritic decomposition of the basaltic lavas and is predominantly composed of dark red clays and clay loams, heavy but porous, retaining considerable fine organic matter and nitrogen, but generally very weak in phosphates. There is, however, great variation in soils from field to field. The rapid advance of production and the continuous cropping has also necessitated great expense in fertilizers, of which nitrates are especially applied. As a result the available plant food in the soil has been at least maintained.

The cane is generally contracted for by the factories from the growers. Great care is taken in carrying out every operation at the proper time; this involves a well-organized labour supply. The labour force is now composed chiefly of Filipinos and Japanese but includes also Portuguese, Chinese, Puerto Ricans, Koreans and Spaniards, who have been, at various periods since the middle of the last century, introduced to make up for the inadequacy of the indigenous labour supply. The Filipinos have been introduced since 1906 on three-year contracts with the Hawaiian Sugar Planters' Association. Though much of the land, especially in Hawaii, is topographically unsuited for machinery the application of scientific methods, whether in raising unit-yields or in labour-saving devices, raised the output of sugar per man from 11.85 tons in 1910 to 17.46 tons in 1930.

Since irrigation is the predominant source of moisture there are no well-defined planting and cutting seasons and, with the growth of total production, the grinding of successive crops now overlap. Formerly most of the cane was in the ground for two years but in recent years short-cropping, the taking of two crops in three years, has become increasingly common, so that the proportion of the cane area harvested in a given year has increased. Up to five or six ratoons are taken.

The principal variety is now H.109, which covers over half of the area, while D.1135 is predominant on the unirrigated lands and at higher levels. Relative

isolation has helped to protect the region from pests and diseases, and the chief pests, leaf hopper, cane-borer and the *Anomala* beetle, are biologically controlled. The Hawaiian Sugar Planters' Association research station, founded in 1895, has sections for entomology, plant pathology, chemistry, sugar technology, agriculture and forestry. The capital invested in the industry is estimated at 175 million dollars.

Of the 47 mills 43 are controlled by five companies. The largest output of any one mill in 1931 was 77,050 short tons at Puunene in Maui. The export consists practically entirely of raws, which are refined in San Francisco, the bulk by the Californian and Hawaiian Sugar Refining Corporation at Crockett, this refinery being owned co-operatively by 33 plantations.

Most of the available and suitable land is already under cane and further extension would involve heavy costs in irrigation, the maintenance of the water-supply of the existing area being already an increasingly difficult problem. Further increase in production depends therefore mainly on increasing unit-yields, which are already at a very high level. In 1924 the average yield jumped from 4.646 to 6.110 short tons of sugar per acre and in 1932 attained 7.337 short tons. In 1933 the Ewa plantation attained the figure of 18.6 short tons sugar per acre on 50 acres.

In the five years 1928-32 sugar and molasses made up 61 per cent. of the total exports. The high costs of production and the high freight costs (Honolulu is over 3,000 miles from San Francisco) make the industry dependent on the protection of the United States tariff.

PUERTO RICO.

In the last years of the Spanish occupation the sugar production of Puerto Rico was generally below 100,000 short tons but subsequent to the annexation in 1898 and especially after 1901, when sugar was admitted duty-free to the United States, many plantations passed into American hands, new central factories and railroads

were built and production rose rapidly. By 1917 the figure of 500,000 tons was reached, but the spread of mosaic caused a relapse until 1924, when a very rapid rise began. By 1932 production was 992,000 short tons, practically all exported to the United States.

The northern coastal plain and the upland interior receive a rainfall plentiful, though unreliable in distribution, from the north-east trades; the southern coastal plain, where the greater part of the cane is grown, requires irrigation, the water being brought by tunnels from the wet windward side. The rainier months are April to December, especially September to November. Temperatures are very even throughout the year. There are two planting seasons, that for the main crop, which is in the ground for eighteen months, in September-December, and that for the spring crop, which is cut after thirteen months, in March-June. Up to five or six ratoons are taken. Harvesting generally begins in January. Hurricanes, which occur especially between July and October, are a recurrent cause of disaster, especially in the east and north; those of 1899, 1928 and 1932 were amongst the most destructive.

In the west of the southern coastal plain high yields are obtained from the light-brown calcareous San Anton soils, which are friable, well-drained and aerated and yet sufficiently retentive, with a heavier subsoil, while in the wetter east the more acid brownish-red machete loams, with clay subsoil, respond well to fertilizers. On the wet northern coastal plain drainage requires special attention. In the last decade there has been a great increase in the use of fertilizers, especially of sulphate of ammonia.

The cane is largely grown by colonos as in Cuba. Owing to the high density of the population there is a large surplus of labour but under-nourishment and disease, especially hookworm, malaria and tuberculosis, undermine its efficiency. The efforts of the Insular Government to ameliorate the unsatisfactory social conditions, due largely to over-population and to the

survival of much absentee ownership, have been hampered by inadequacy of funds. Negro slaves were introduced from the sixteenth to the eighteenth centuries.

After the annexation the numerous small mills that had survived from the Spanish period disappeared more rapidly and the sugar is now produced in 42 central factories; a number of these are quite small and about half the output is from eight mills. The largest mills are on the south coast; Guanica, the principal, produced 138,411 short tons in 1932-33. The road and rail net is fairly good and Puerto Rico has the advantage over the other United States insular producers of relative proximity to the market and freedom from the Panama canal dues. Costs of production are, however, relatively high. Grinding generally ends in May or June. March to May are the principal export months.

The rapid increase of production since 1925 has been due to higher unit-yields, brought about chiefly by the introduction of new varieties immune to mosaic, which broke out seriously after 1915; B.H.10(12), grown especially in the south and on the wetter alluvial lands, covers over half the cane area, while S.C.12(4) is predominant on the well-drained terrace lands. The disease is now practically confined to the narrow belt of the inner plains. Treatment by the removal of infected plants from the fields now enables higher-yielding though non-immune varieties to be introduced. The chief insect pest is the moth-borer, which infests up to 85 per cent. of the cane, especially on the south and east coasts. The rise in production is due to the work of the Insular Experiment Station, founded in 1901, and now comprising two stations and a sub-station.

Sugar-cane now covers practically the whole of the southern coastal plain and accounts for exactly half of the total value of island exports. As practically all suitable lands are occupied and rents are exceedingly high, increase of production depends on further raising of the unit-yields, which means increased expense in irrigation and fertilizers.

LOUISIANA.

Commercial sugar production in Louisiana dates from 1795; after rising to a maximum in 1861 it underwent a disastrous fall in the Civil War years, reaching a minimum in 1864. The abolition of negro slavery caused a fundamental change in the industry; on the one hand cane-growing became predominantly the work of comparatively small farmers, while on the other the factories began to grow in size and diminish in numbers. Production recovered slowly but steadily, though after 1891 more rapidly, until 1904-05, when 398,195 short tons were produced; after 1908-09 a rapid fall began, the minimum being reached in 1926-27, when production was the smallest since 1867 and smaller than had been attained as far back as 1828. The principal causes of the remarkable decline in production were the degeneration of the principal cane varieties grown—Louisiana Purple, Louisiana Ribbon and D.74—and the attacks of mosaic and moth-borer, which led to a great reduction in yields and in cane area. After 1926-27, however, P.O.J. varieties more resistant to mosaic and to frost—particularly P.O.J.36—were introduced and recovery was rapid, production having reached 223,000 short tons by 1932-33.

The Louisiana cane belt is distinctly marginal climatically, the risk of freezes toward the end of the season reducing the growing period to only nine months. Only early varieties can be grown. The cane is planted in March or in October-November and harvested in November-December; the planting material or the young cane, as the case may be, must be protected with earth during the winter. Spring planting means higher costs due to the special care required for the planting material. A warm spring—especially in March—is favourable in that it gives the cane an early start on its short growing season. The shortness of the growing season is to some extent compensated for by the rapidity of growth in the three to four months of

long hot days and humid nights. The rainfall in the latter part of the season tends to be too great, and there is a high negative correlation between sucrose content and rainfall in the period from July to October, especially August. Cool weather in September and October and sunshine in November raise sugar content. Much of the cane must, however, be cut immature, and the average sugar content remains low; much, too, must be windrowed, with further loss of sucrose, till the mills can grind it. The marginal climatic conditions make production subject to relatively pronounced fluctuations. Cyclones occasionally cause damage in autumn.

The greater part of the cane grown for sugar is in that part of the Mississippi flood plain south of Baton Rouge and west of New Orleans, an area of rich alluvial soils. The most important cane soil is the Sharkey clay, which, like other soils in the area, presents serious difficulties in drainage. Lack of humus is also a drawback. Only one ratoon crop is generally taken, and this is followed by maize with cowpeas or soya, these last being ploughed in.

The clash between the demand for labour in planting and harvesting is particularly acute, since a relatively large labour-force must be placed in the fields to get the cane cut in time before severe frosts occur, while windrowing makes an extra demand on labour. Though there is a dense population, almost half negro, in the sugar belt, the effects of northward migration and the cessation of immigration have been seriously felt. Both white and coloured labour is employed in the fields. Louisiana has been a pioneer in mechanical developments.

The number of factories operating in 1930-31 was 61, of which 32 had a capacity of at least 1,000 tons cane in 24 hours. The shortness of the season makes overhead costs relatively high. The research station of the Sugar Planters' Association at Audobon has been at work since 1886.

There are large areas of fertile land available but expansion does not seem probable.

PHILIPPINE ISLANDS.

The Philippines began to export sugar at the end of the eighteenth century but by the middle of the following century had not yet attained the level of 50,000 tons. The maximum export in the period of Spanish rule was in 1894-95, when 341,469 tons were exported. In the subsequent period of revolution and war there was a steep fall to a minimum in 1902. In the latter year, however, Philippine sugar was allowed to enter the United States with payment of only 25 per cent. of the full duty; in 1909 the Payne-Aldrich law allowed 300,000 tons to enter entirely free, and this last restriction was removed by the Jones law of 1916. After 1918-19 a rapid rise in production set in, by 1921-22 the 1894-95 maximum was exceeded and in 1932-33 the figure of 1,256,000 tons was reached. The increase in production in this last period has been more rapid than in any other country of the United States group.

Sugar-cane is grown mainly in the islands of Negros and Luzon, in the former on the broad western plain, much of which possesses very fertile soils, and in the latter on the central plain stretching northward from Manila and in the mountainous south-west. There is great variation in climatic conditions within the group, but by far the greater part of the present cane area is in the western parts of these islands, where there is a well-marked alternation of wet and dry seasons corresponding to the south-west and north-east monsoons respectively. The dry season is very short in the Negros area, rains being received from both the south-west and north-east monsoons, and cane is favoured only on the better-drained lands. The crop is generally planted from November to March, that is, largely in the drier season, and cut from November to April, in the following dry season; the growing season is thus very short and irrigation, which is, however, generally lacking, is desirable, especially in Luzon, to establish the young cane, which is frequently planted too late. There is very little seasonal variation of temperature.

The islands lie in the track of typhoons, which occur generally between July and November and, though commonest in the north, frequently cross the sugar areas. Droughts and locusts also cause great damage from time to time.

Cultivational methods are on the whole primitive and agricultural practices generally unsatisfactory. Fertilizers are used very little. Disease, especially mosaic, Fiji and leaf-scald, is widespread. Scarcity and unreliability of labour makes the clash between planting and cutting seasons particularly harmful. Two or three ratoon crops are generally taken. Under these circumstances unit-yields are low.

Until the American occupation almost the entire produce was in the form of muscovado. After 1909, however, there was an influx of capital, and in 1912 the first central was built. From 1921 the proportion of muscovado was less than that of centrifugal sugar, and very few of the original 1,500 to 2,000 muscovado mills now remain. The greatest development of new centrals took place in 1920 and 1921; they now number 45. The largest is Tarlac (Luzon), which has a capacity of 6,000 metric tons in twenty-four hours. The chief foreign capital is Spanish, followed by American, the latter estimated to amount to 28 per cent. of the total; the Philippine National Bank, founded in 1916, has also taken a part in financing the industry. The total investment amounts to about 483 million pesos. Of the 168 million pesos invested in the centrals 40 per cent. is American, 37 per cent. Filipino and 22 per cent. Spanish. The factories receive almost all their cane on contract, the land laws preventing them from acquiring more than a very limited area of land. Holdings are small and often sub-leased and many are deeply indebted. These conditions make it difficult to put new agricultural methods into practice. The planters have now ten co-operative associations, while in 1922 the Philippine Sugar Association, which includes research amongst its activities, was formed. The chief port of export is Iloilo (Panay), there being no good port on the west coast of Negros.

The growth of export to the United States dates from the establishment of the centrals and the consequent increase in extraction. In the last few years, however, the rapid spread of new cane varieties to replace the susceptible Negros Purple and Luzon White previously dominant has been a potent factor in bringing about larger production and, now that the factory side of the industry has been transformed, further advance in production depends mainly on progress in this and other agricultural aspects. While considerable land is available for extension of the cane area, much of it is rendered unsuitable by climate, to which is added the political uncertainty that has long been a check on the introduction of fresh capital. The prospect opened up by the Philippine Independence Bill, passed by the United States Senate in December 1932 and, the President's veto having been over-ridden in January 1933, to become law subject to the acceptance of the new constitution by the Philippine people, does not encourage further expansion. Full independence is granted ten years after the coming into force of the new constitution. In the first five years 800,000 long tons of raws and 50,000 long tons of refined—a total exceeded in 1932—will be allowed duty-free into the United States each calendar year, any imports of Philippine sugar above this amount being subject to full duty; in the sixth year the intermediate Government of the Philippine Islands shall impose an export duty equivalent to 5 per cent. of the United States import duty, increasing to 10 per cent., 15 per cent., 20 per cent. and 25 per cent. in the last four years of the transitional period. Unless some other arrangements are made by a special intergovernmental conference to be held at least one year before the attainment of full independence, the right of free entry into the United States is then completely withdrawn. Under such conditions the Philippines, with their relatively high cost of production and high freight charges, could not compete with Cuba. Sugar exports, which are practically entirely to the United States, accounted for 36 per cent. of the total value of domestic exports in the five years 1927-31.

76 WORLD SUGAR PRODUCTION AND CONSUMPTION

UNITED STATES PRODUCERS.

*United States Beet.**Hawaii.*

	Area of sugar-beet* (ooo acres)	Production of sugar (ooo short tons)	Area of cane		Production of sugar, tel quel (ooo short tons)
			total (ooo acres)	harvested (ooo acres)	
1922-23	530	675	235	114	537
1923-24	657	881	232	111	691
1924-25	817	1,090	241	122	769
1925-26	653	913	238	122	787
1926-27	687	897	235	125	811
1927-28	732	1,093	241	131	897
1928-29	646	1,061	240	129	899
1929-30	694	1,018	252	134	912
1930-31	783	1,208	253	137	989
1931-32	714	1,156	255	140	1,025

* Including in some years a small area in Canada producing sugar-beet used in United States factories.

*Puerto Rico.**Louisiana.*

	Area of cane harvested (ooo acres)	Production of sugar (ooo short tons)	Area of cane (ooo acres) †	Production of sugar, tel quel (ooo short tons)
1923-24	237	448	215	165
1924-25	240	660	162	88
1925-26	243	603	189	139
1926-27	236	629	129	47
1927-28	238	749	72	71
1928-29	251	587	115	132
1929-30	254	866	155	200
1930-31	279	783	150	184
1931-32	256	992	148	157

† Area of cane used for sugar.

Philippines.

	Production of sugar (ooo short tons)
1922-23	475
1923-24	529
1924-25	780
1925-26	607
1926-27	767
1927-28	808
1928-29	934
1929-30	981
1930-31	958
1931-32	1,102

Sources: United States *Year-book of Agriculture*; area of cane in Puerto Rico from Circular No. 98 of Insular Experiment Station and from International Institute of Agriculture.

CHAPTER IX

OTHER CANE-SUGAR PRODUCING COUNTRIES

THE DOMINICAN REPUBLIC

THE sugar production of the Dominican Republic has developed rapidly in recent years, rising gradually from 1912-13 to 1923-24 and making a sudden upward jump in 1924-25 to the level at which it has subsequently remained. Sugar makes up about two-thirds of the value of the total exports. It is exported mainly to Canada and the United Kingdom.

The island lies in the trade-wind zone and its eastern part receives abundant rainfall from May to December, while the west is rather dry throughout the year and requires irrigation for the satisfactory growing of cane. The cane is planted between June and October and cut from December to April after a growing season of up to eighteen months. The island is liable to hurricanes between July and October.

The sugar-cane area is mainly on the lower coastal plain of the south and especially in the province of San Pedro de Macoris. The most fertile section is, however, in the north, on the black loams of the Vega Real in the Cibao valley. Practically no artificial fertilizers are used; cultivation is of an extensive character and many ratoons are taken. The population is sparse but labour is imported cheaply for the harvesting season, mainly from the British West Indies. Efficiency is greatly lowered by the prevalence of hookworm; malaria and venereal disease are also very common. The older cane varieties—Cristalina and Rayada—are gradually giving way to B.H.10(12) and S.C.12(4). Mosaic is common but is more or less under control.

Most of the cane land belongs to the factories; the

cane is grown by colonos. United States capital is predominant, owning ten mills, the rest of the capital being Cuban, Puerto Rican or European. The largest mill, Romana, in the east, produces about 127,000 metric tons of sugar. The sugar is exported chiefly through the port of San Pedro de Macoris. There is an export tax.

The island is generally considered to have great potentialities for further expansion of cane production, especially in view of its very low costs of production, in which it is rivalled possibly only by Java.

In the neighbouring republic of Haiti there was a large production under French rule in the eighteenth century. Haiti has been under United States protection since 1915 and toward the end of the War there was a revival of the industry. There is one factory situated at Port au Prince. Some cane is also sent to Puerto Rico. The export of sugar is directed mainly to the United Kingdom.

PERU.

Sugar-cane was introduced into Peru about 1570, but production of sugar on a large scale dates only from the last quarter of the nineteenth century. The opening of the Panama Canal stimulated exports, which rose rapidly after 1914 to a maximum in 1920. Whilst remaining above the pre-war level, exports have not maintained the high figures of the post-war years, though production has been kept up and even increased.

The cane is grown in the narrow valleys opening on the coastal plain, half being produced in the valleys of Chicama and Santa Catalina. Temperatures are uniform; precipitation is negligible, so that the cane relies entirely on irrigation, chiefly by gravity canals. While planting is possible throughout the year, November to April, the period when the streams are in flood, is preferred. Plant cane grows for twenty to twenty-two months and ratoons for sixteen to twenty months. Harvesting also takes place throughout the year. The

valley soils are deep sandy loams, well-drained and easily worked and, thanks to the dry climate, have adequate nitrogen, phosphoric acid, potash and lime. Guano and sodium nitrate fertilizers are cheap.

Large estates, owned by or contracting for the factories, are predominant. The planters are organized in the Sociedad Nacional Agraria. Labour, which is imported seasonally from the mountains, is cheap, but its efficiency is lowered by malaria and tuberculosis. Mechanization is advanced and cultivation is very efficient. The old Bourbon or Otaheite cane is still almost exclusively grown but yields are high, thanks to the careful control of the water supply, to the abundant sunshine, the freedom from serious cane diseases and the efficient management of the estates. Moth-borer is, however, widespread.

There are 30 large mills, of which about a dozen are thoroughly modern. Over four-fifths of the output is 96° sugar for export (mostly to Chile and the United Kingdom) and most of the remainder is white sugar, while relatively small amounts of muscovado and chancaca (an unpurified product) are made. Alcohol and rum are also produced. The export season is principally from September to February. Salaverry and Chicama are the chief sugar-exporting ports, accounting together for about two-thirds of the total. In the absence of good harbours lighterage is necessary.

The smallness of the available area and the scarcity of water are the chief checks on further expansion.

BRAZIL.

The sugar industry of Brazil dates back to the early sixteenth century. In the seventeenth century Brazil was the leading producer. In more recent times, from 1880 onward, its production declined till the high prices of the War and post-war years and the protective tariff led to its revival. The producing States in the north—Pernambuco, the leading producer, Alagoas, Sergipe, Bahia and Parahyba—receive their moisture

from the north-east trades ; those in the south—Rio de Janeiro, Sao Paulo and Minas Geraes—receive it from the south-east trades ; in the former the dry season, that is, the grinding season, is from September-October to March-April, in the latter from June-July to October-November.

There are extensive areas of fertile red soils, especially in Pernambuco, and the alluvial soils of the valleys have also proved suitable for cane. Labour, though cheap, is on the whole inefficient ; much of it in the northern area is still negro, a relic of the slave system, which was abolished only in 1888 ; there is now a seasonal migration between the cotton and sugar belts. Cultivation is generally backward and there is little manuring. Gummosis is now the chief disease, though mosaic is still serious in the south ; the moth-borer causes heavy losses. The old cane varieties, such as Preta, Bois Rouge and Sem Pelo, are still predominant, though mosaic resistant P.O.J. canes have been introduced. Under these conditions unit-yields are very low.

The caneland is generally owned by the factories, of which there are about 200. Few of the factories are completely modernized and recovery is low. The mills in the south are in general more modern. The largest factory, Catende in Pernambuco, produces 14,000 metric tons. In addition there are thousands of small "colonial" mills in the interior, producing *rapadura*, a syrup concentrated to cake form. Two types of sugar are produced, a brown sugar of 91° to 96° and a white sugar of 96° to 98°, most of which is also remelted and refined. There is also a large production of aguardiente and alcohol, most of the factories having a distillery annexed. A large development of motor fuel production is projected. Exports of sugar are chiefly to the United Kingdom, Portugal, Uruguay and Belgium.

The potential canelands are very extensive but lack of transport facilities and of capital for the building of modern mills prevents their development, while the high costs of production make the disposal of the surplus over internal requirements unprofitable.

FORMOSA.

The rapid growth of production in Formosa has been of considerable importance in the Far Eastern market. While production grew steadily under the Chinese it was only under the Japanese that rapid development began, with the endeavour of Japan to supply the need of its refining industry, at least as far as home consumption is concerned, from within its own Empire.

The caneland is in the coastal areas, particularly in the south-west, where the summer monsoon conditions of June to September favour growth. The cane is cut from November to May. Damage by frost occurs, while floods and typhoons frequently cause serious losses.

The rapid growth of the industry in recent years has been made possible by means of the firm control of the Government over agriculture and by the award of bonuses for the substitution of cane for rice, the proper carrying out of planting operations, irrigation and the delivery to the mills of cane possessing high sucrose content. The new P.O.J. varieties have been introduced and now cover the greater part of the cane area, while the standard of cultivation has been greatly raised by the measures of compulsion that have been adopted. From two to four ratoons are generally taken.

Factories on modern lines have been established since 1906 and there are now 46 completely modern, while seven have been improved; 78 of the old mills still remain. The largest factory has a capacity of 3,000 short tons of cane daily. The factories possess a rail net of their own. Exports are directed to Japanese refineries, the Japanese market enabling a satisfactory profit to be obtained. Production had reached 989,000 metric tons by 1931-32.

The rapid development of the Formosan sugar industry has been achieved only at high cost and latterly the Government has been preoccupied with the question of over-production.

ARGENTINA.

Sugar-cane was planted in the province of Tucumán as early as 1646 but the serious development of the

industry dates from 1821 and especially after railway communications were opened up in 1876. Argentina has generally covered its own needs in sugar but, though production rose to 465,000 metric tons in 1926, the market has, save for spasmodic exports, remained an internal one, costs being very high and a prohibitive tariff being necessary to maintain a minimum price, which is also safeguarded by restriction of production (since 1931).

The crop is grown chiefly on the plains of eastern Tucumán, with an extension northward into Jujuy and Salta. The winter temperatures of Tucumán are distinctly marginal but the cane, which is planted between July and October, during the dry season, with the help of irrigation, is not harvested until June-September, frosts being risked for the sake of longer ripening.

The loam soils of Tucumán are rich in humus and have a good nitrogen content; practically no fertilizers are used and at least six ratoons are generally taken. Relatively highly-paid immigrant labour must be used.

The old canes were in 1915-17 completely replaced by P.O.J. varieties, resistant to mosaic, which, with top-rot, is the commonest disease, and to frost. Borers cause damage. There is an experimental station at Tucumán.

There are 38 factories in operation, some of the largest having a daily capacity of 3,000 to 4,000 tons of cane. About two-thirds of the cane is grown on factory land, mostly by colonos. Transport facilities are very poor. Four-fifths of the capital invested in the industry, which is organized in the Centro Azucarero, is Argentine.

MEXICO.

Though the industry dates from the sixteenth century it was not until the early years of the twentieth century that any notable increase in production occurred. Internal requirements are now covered, and the problem of disposing of a surplus has arisen, resulting in the establishment in 1931 of a Commission to Stabilize the Sugar and Alcohol Markets.

The chief production is on the rich black soils of the valleys in Vera Cruz and Puebla on the Gulf Coast, while another important area lies in Sinaloa, Jalisco and Michoacán on the Pacific coast. The former area has abundant rains with a summer maximum, the latter depends on irrigation. The Gulf zone is the more important for sugar production, a greater proportion of the cane in the Pacific zone being used for eating or for *piloncillo*.

Improvements of agricultural practice are hindered by apathy and lack of technical direction. On the other hand there are no serious diseases and new cane varieties are beginning to be introduced.

There are 115 mills, the largest grinding 1,500-2,000 tons of cane daily. Transport facilities are inadequate.

EGYPT.

Though the sugar industry appears to have been started by the Arabs in the seventh century and eventually gave rise to a very flourishing trade, it decayed in the Middle Ages and did not regain its former importance until the nineteenth century. From 1850 to 1898 it was under Government control but the Government interests were sold to the Société Générale des Sucreries et de la Raffinerie d'Égypte, which now owns all of the five factories and the single refinery, growing the cane itself or contracting for it with farmers.

Cane is grown for sugar in Upper Egypt; even there, however, there is considerable frost danger and the growing season is short, planting being generally carried out from mid-February to mid-March, immediately after a winter crop, and harvesting from December to April. The crop is confined to the narrow alluvial belt of heavy clays irrigated by the Nile, the floods also helping to restore fertility, though the soils are generally low in nitrogen and humus. The principal variety is now the mosaic-resistant P.O.J.105.

In 1931 the Government prohibited imports and established a Sugar Régie by a fifteen-year agreement with the Société Générale des Sucreries, the company to

84 WORLD SUGAR PRODUCTION AND CONSUMPTION

endeavour to cover Egyptian consumption and a subsidy on sugar sold being given to it by the Government.

OTHER CANE-SUGAR PRODUCING COUNTRIES.

	<i>Dominican Republic.</i>		<i>Peru.</i>		<i>Brazil.</i>	
	Production of sugar (ooo metric tons)	Production of sugar, tel quel (ooo metric tons)	Production of sugar (ooo metric tons)	Production of sugar (ooo metric tons)	Production of sugar (ooo metric tons)	Production of sugar (ooo metric tons)
1922-23	187		319		761	
1923-24	216		320		812	
1924-25	316		317		831	
1925-26	360		276		883	
1926-27	308		376		693	
1927-28	374		375		846	
1928-29	360		362		967	
1929-30	366		428		1,020	
1930-31	368		400		937	
1931-32	434		390		990	

	<i>Formosa.</i>		<i>Argentina.</i>	
	Area of cane (ooo hectares)	Production of sugar (ooo metric tons)	Area of cane planted (ooo hectares)	Production of sugar (ooo metric tons)
1922-23	111	355	106	216
1923-24	116	452	122	256
1924-25	126	480	131	249
1925-26	120	500	143	394
1926-27	84	411	156	474
1927-28	94	580	156	415
1928-29	106	789	152	375
1929-30	95	810	156	338
1930-31	96	797	149	379
1931-32	98	989	140	346

	<i>Mexico.</i>		<i>Egypt.</i>	
	Area of cane (ooo hectares)	Production of sugar (ooo metric tons)	Area of cane (ooo hectares)	Production of sugar (ooo metric tons)
1922-23	39	149	26	96
1923-24	40	167	24	72
1924-25	87	184	22	80
1925-26	89	195	22	96
1926-27	92	184	22	72
1927-28	82	186	20	91
1928-29	70	183	24	109
1929-30	77	213	23	107
1930-31	78	255	22	122
1931-32	75	234	27	147

Source: International Institute of Agriculture.

CHAPTER X

EUROPE AND THE SOVIET UNION

By far the greater part of the world's beet-sugar is produced in a broad belt stretching across the great European plain from north-eastern France through Belgium, the Netherlands, Germany and Poland to Ukraina, with a very important outlier in Czechoslovakia in the basins of the Upper Elbe and the Morava. This belt tends to suffer in the west, where maritime influences are strong, from excessive moisture and in the east, where continental characteristics are dominant, from drought and frost, which also acts indirectly through the shortening of the season ; consequently in the west sugar-beet is most successful in the areas of relatively low precipitation and in the east in areas of relatively high precipitation.

The greatest concentration of sugar-beet culture is found on the deep, well-aerated, well-drained and easily cultivated chernozyoms developed in areas where decomposition of organic matter has been checked by winter frost and relative lowness of precipitation has checked leaching of lime, as in Ukraina, parts of Saxony, in the Upper Elbe basin and in Moravia. These soils are eminently suited to the requirements of sugar-beet and have a very high and sustained productivity. From them sugar-beet culture has extended over the podzols, especially in Poland and in northern and western Germany, and the brownierths, in southern Poland, much of Germany and in the western sugar-beet regions ; in both these soil belts, and especially in the former, decomposition of organic matter and leaching have been carried further than in the chernozyoms owing to the milder winters and the greater precipitation ; much more

attention is therefore required to render and maintain them fit for sugar-beet.

The leading countries of production are Germany, the U.S.S.R., Czechoslovakia, France and Poland. These are followed by Italy and, outside the area at present under consideration, Great Britain. In Germany Saxony and Silesia are easily the leading producers, followed a long way behind by Hanover and Holstein and by South Germany. In Czechoslovakia the sugar-beet is grown mainly in Bohemia and Moravia, while in Poland the chief producing provinces are Poznań, Warszawa and Pomorze. In France production is mainly in the north, especially in the departments of Aisne, Pas-de-Calais, Nord, Somme and Oise. All but a relatively small part of the production of the Soviet Union is in Ukraina, the region on the right bank of the Dnieper leading, followed by the left bank and by the Central Chernozym Region.

The countries with the highest percentage of their total sown area under sugar-beet are Belgium, Czechoslovakia and the Netherlands, each of these being far ahead of all others in this respect.

The leading sugar-beet areas in the principal producing countries have characteristically a relatively dense agricultural population, which may in part be due to sugar-beet culture being more readily taken up in areas where there is a more plentiful labour supply but may also be the result of these being in many cases areas of especially fertile soil. The sugar-beet areas are generally also areas with a relatively high percentage of arable. In Germany there is a distinct correspondence between the density of agriculturally occupied population and the importance of sugar-beet growing, Saxony and Silesia, for instance, leading in both respects. Similarly in Ukraina Kiev and Podolia lead in the relative importance of sugar-beet and in the proportion of agricultural population to total area sown.

The great demand for labour at the periods of singling and harvesting results in the sugar-beet areas being centres of seasonal immigration, particularly of female

labour. Thus, in Germany there is an influx, though less than in the pre-War years, in the period from April to October from Slovakia and Poland. In Czechoslovakia the Czech lands still require to recruit labour from Slovakia, while in Poland the Galician lands are a source of seasonal labour for the labour-short sugar-beet areas. This migrant labour is employed by the estates and the larger peasant holdings. Since the War there has been a great increase in the mechanization of sugar-beet culture, particularly on the estates.

Much of the European sugar-beet production is, however, on peasant holdings, which rely largely on family labour, working long hours and for a mere subsistence. To these peasant growers the quick cash return from the crop is a particularly valuable point in its favour. In Czechoslovakia one-third of the beet comes from small peasants. The agrarian revolution that swept through Europe from 1917 onward, affecting most radically those countries of Eastern and Central Europe where the ownership of the land was concentrated in various degrees in the hands of a minority, did not have such a marked effect on sugar-beet culture as was expected. While there were considerable changes in ownership of the sugar-beet lands, there was only a relatively small actual transfer of land and in every country concerned reservations were made for the special benefit of sugar-beet culture, so that compact areas for the efficient production of raw material could be guaranteed for the factories. The importance of peasant sugar-beet and especially of that grown on the medium and large peasant holdings has, however, increased throughout the European lands. While the large peasant holding of over 20 hectares has, in Czechoslovakia at least, the highest proportion of sugar-beet to total arable area and, thanks to its greater expenditure on labour, livestock and machinery, the maximum unit-yields, it is the medium and small peasant holdings, generally from 5 to 20 hectares in extent, that have proved the most resistant, thanks to family labour and the utilization of sugar-beet by-products by livestock,

factors which together result in a relatively high net income per unit area. Many of the factories, particularly in Germany, are owned by the growers, who, as shareholders, are bound to supply a certain quantity of beet.

The War caused a great decline in the production of Europe, including the U.S.S.R., not only by the fact that military operations were carried out over many of the actual sugar-beet areas but still more through its effects on markets, on the organization of internal food supplies, on labour supplies and in other ways, and finally by its aftermath of agrarian revolution. The minimum production in these countries as a whole was in 1919-20. Thenceforward there was a fairly steady recovery and by 1928-29 the production of Europe, including the U.S.S.R., had risen above the pre-War level; in 1930-31 it attained the level of 10 million metric tons. Germany recovered its pre-War level in 1929-30 and in the following year its production exceeded the previous maximum of 1913-14 by 10 per cent. Czechoslovakia attained its maximum production in 1925-26, while in Poland production has risen steadily and rapidly. In the Soviet Union, which reached its production minimum two years after the other producing countries, the factory estates have been preserved intact as *sovkhosi* while collectivization is winning back the ground that was lost to small-holding economy in the earlier years of the agrarian revolution. Its area under sugar-beet has been greatly extended, the total sown area having by 1932 exceeded that for Europe. Mechanization has made great progress and production by 1930-31 exceeded the pre-war figure. According to the second five-year plan the production of sugar is to reach 6.9 million metric tons—over three times the pre-war figure—by 1937. By 1930-31 not only had the principal beet-growing countries regained their pre-war production but relatively great increases over the figures of pre-war years had been recorded in secondary countries of production such as Bulgaria, Spain, Italy, Rumania and Yugoslavia and new coun-

tries, such as Great Britain, the Irish Free State and Finland, had entered the ranks. Altogether in Europe, including the U.S.S.R., the average area under sugar-beet in 1926-30 was 23 per cent. greater than that in 1909-13.

A general decline in unit-yields of sugar-beet has been experienced, the falling-off being especially noticeable in Germany, Hungary, Italy, Yugoslavia and Switzerland. This is due mainly to the increasing preference for beets of high sugar content rather than of high tonnage. In Germany it has also been attributed to the increasing infestation of the best beet soils by nematodes.

The European sugar-beet crop is generally sown in May and mainly harvested in October or November. As the beet must be worked up immediately, the factory campaign does not continue much longer and most of the factories have completed operations by December. Movement of the European crop is at a maximum in October and November. The European countries producing a surplus of beet-sugar are, in order of importance, Czechoslovakia, Poland, Germany, Hungary, Belgium, Yugoslavia and Rumania, of which only the first three play any large part on the market, the exports of Hungary being relatively small and those of Belgium, Yugoslavia and Rumania being insignificant. Czechoslovakian sugar exports, since 1928 mainly raws, go principally down the Elbe, on which Czechoslovakia has special privileges, from the ports of Mělník and Krásné Březno, to Hamburg, the British market, though not so favourable as previously, being still the most important; the freezing of the Elbe in January and February causes a great fall in exports in these months. Large shipments are also made from Czechoslovakia through Trieste. Most of the Polish export originates in Western Poland, owing to the better transport facilities and relative proximity to markets of that part of the country; export is chiefly by way of Danzig and Gdynia; the United Kingdom is the leading market, followed by Sweden and Germany. Germany, which from the

beginning of the century until the War exported over one million metric tons of sugar in most years, experienced a sharp decline in its exports after the War; the revival dates from 1923-24, but the proportion of its production exported remains far below that of the pre-war years; the United Kingdom remains the chief market but now takes only raws. Hungary has a relatively small export, principally through Fiume and to Switzerland and Austria. The U.S.S.R. has in post-war years exported mainly to markets in the Near East, particularly to Persia.

The recovery and maintenance of European sugar production has been made possible not only by the strong position held by sugar-beet in crop rotations and the resistance of the peasant growers to unfavourable economic conditions, but by the determination shown by almost all European Governments to maintain their sugar-beet area by ever higher protective tariffs in the face of intense competition. By organization in cartels having strict control over the whole industry the various national sugar industries are able to take full advantage of the protection afforded by high tariffs and to maintain internal prices so as to subsidize the export of surplus production, which is maintained largely with a view to securing the benefits of large-scale operations. The organization of the industry in the U.S.S.R. is similar, save that it is part of the economic mechanism of the State.

EUROPE AND THE SOVIET UNION.

Area under sugar-beet (thousand hectares).

	Germany	France	Czecho- slovakia	Poland	Italy
1923-24	384	165	232	136	90
1924-25	394	203	303	163	124
1925-26	403	217	307	172	57
1926-27	403	228	271	185	80
1927-28	434	239	288	202	88
1928-29	454	251	257	234	115
1929-30	455	280	246	239	116
1930-31	483	282	224	185	112
1931-32	381	251	185	149	109
1932-33	219	250	146	116	84

	Spain	Hungary	Netherlands	Belgium	U.S.S.R.
1923-24	62	52	67	72	263
1924-25	179	68	74	81	379
1925-26	114	66	66	72	534
1926-27	72	63	62	64	538
1927-28	62	65	70	71	665
1928-29	59	67	65	64	770
1929-30	61	79	55	58	771
1930-31	80	74	58	57	1,036
1931-32	112	54	37	52	1,376
1932-33	82	42	40	53	1,264

Production of beet-sugar (thousand metric tons).

	Germany	France	Czecho- slovakia	Poland	Italy
1923-24	1,146	496	1,011	385	358
1924-25	1,564	834	1,428	491	425
1925-26	1,599	754	1,507	581	158
1926-27	1,663	713	1,045	558	312
1927-28	1,675	863	1,255	561	283
1928-29	1,864	906	1,056	745	393
1929-30	1,985	917	1,036	916	450
1930-31	2,547	1,178	1,142	776	426
1931-32	1,595	859	814	493	379
1932-33	1,083	994	630	417	323

	Spain	Hungary	Netherlands	Belgium	U.S.S.R.
1923-24	169	123	226	296	190
1924-25	256	202	320	395	362
1925-26	246	166	300	327	451
1926-27	218	175	281	230	1,044
1927-28	195	187	254	269	955
1928-29	215	220	315	275	1,221
1929-30	224	247	260	248	958
1930-31	289	234	288	278	1,489
1931-32	361	125	165	201	1,525
1932-33	218	105	230	248	1,000

Unit-yields of sugar-beet; average for five years ending 1931-32.

(metric tons per hectare.)

Netherlands	32.6	Spain	25.9
Belgium	29.0	Italy	24.3
Czechoslovakia	26.8	Poland	20.7
Germany	26.7	Hungary	20.4
France	26.2	U.S.S.R.	11.9

Source: International Institute of Agriculture.

CHAPTER XI

THE REFINING INDUSTRY

THE crystals produced by most cane-sugar factories and by the majority of the beet-sugar factories are of a brownish-yellowish or greyish colour and of polarization generally varying from 94° to 99° and must undergo a further process of purification before they can meet the demand of the consumer for an attractive white product consisting as to practically 100 per cent. of sucrose. The necessary refining process is generally carried out in a specialized establishment.

THE TREATMENT OF THE RAW SUGAR.

The processes by which the small amount of non-sucrose remaining in the raw sugar is removed are briefly as follows. The film of molasses that surrounds the raw crystals and contains most of the impurities is first dissolved by spraying with syrup or the washings from sugar previously dealt with. The crystals separated centrifugally from the adhering liquor are already 99 per cent. sucrose and the principal work of the refinery is the removal of the remaining 1 per cent. non-sucrose. The washed crystals are first melted and the fluid pumped to the "blow-up" tanks on the top floor of the refinery, where it is thoroughly mixed with the aid of compressed air and the insoluble and suspended impurities are defecated by a precipitate and then filtered with the aid of kieselguhr or diatomaceous earth. The essential process of decolorizing follows. This is accomplished by filtration through bone-char, which removes both mineral salts and colouring matter by adsorption. The small margin of profit makes it essential and the large scale of operations—itsself intimately related to the

former factor—makes it economic thus to eliminate the entire mass of impurities from the juice. The liquid is then concentrated and boiled at low temperatures in the vacuum pans, the crystals that are so formed being separated in the centrifugals. Drying and hardening in the granulators and screening to secure uniformity gives the granulated sugar which forms the bulk of the refinery production, fine granulated being the standard grade. After repeated treatment of the syrup has given three or four crops of granulated sugar, soft or brown sugars are obtained, and finally edible and non-edible syrups. Powdered sugar is made by grinding granulated sugar and cubes by moulding the dampened and pressed granulated.

For twelve refineries in the United States in the ten years 1922-31 the duty-paid raw sugars accounted for 94 per cent. of the costs of production, the next items in importance being packages at 3 per cent. and fuel at 1 per cent.

THE ACCESSORY MATERIALS.

Of all the accessory raw materials used in modern refinery practice bone-char plays the most prominent part. It is produced by destructive distillation of bones and contains from 75 to 80 per cent. of calcium phosphate in a hard granular form, and from 8 to 12 per cent. of finely divided carbon; the bones of cattle are preferred since they have a relatively high amount of hard tissue and so give the resulting char the hard grain that is desirable for the prevention of waste through pulverization in handling. British bone-chars are, owing to their especial hardness and their high percentage of carbon, considered to be the best. Since the carbon at the best forms only a small percentage, the quantity of bone-char to be used is very large, generally at least half the weight of the raw sugar. The heavy expense of this item leads to its being used over and over again, generally for a period of from three to five years, its adsorptive efficiency being revived, after it is first thoroughly washed of impurities, by heating to redness in closed retorts or

revivification kilns, which are an important adjunct to the refinery, so as to remove all traces of organic impurities. The other bulkier accessories used are kieselguhr and lime. As beet-sugar has a slightly alkaline reaction it may, in refineries using principally cane-sugar, be mixed in the solution for the purpose of obtaining a neutral reaction.

The demand for large supplies of fuel for steam-raising, principally for the evaporation process, and for revivifying the bone-char—it is estimated that sugar requires for refining 25 per cent. to 33 per cent. of its own weight in coal, should this be the fuel adopted—means that good supplies of coal or oil must be readily accessible. In the largest American refineries oil has now replaced coal. Large quantities of pure soft water must also be available, particularly for the melting.

TRANSPORT RELATIONS.

For an industry handling a bulky commodity like sugar and using large quantities of fuel very good transport facilities are essential. From the beginning, therefore, refining has been mainly carried out at the ports. To-day in Great Britain the refineries are at the three leading ports, London, Liverpool and the Clyde, where they reap to the full the advantages of cheap ocean transport, two being in the London area, four in the Liverpool area, and four in the Clyde. Similarly in the United States, of the 21 refineries 13 are on the Atlantic coast—at New York (6), Boston (2), Philadelphia (3), Baltimore and Savannah—six are on the Gulf Coast—at New Orleans (4) and Galveston (2)—and two on the Pacific coast, in the San Francisco area. To reduce handling to a minimum the great refineries are located at the actual quayside and raw sugar is discharged directly from the ship's hold or from the lighter to the refinery. The raw sugar generally arrives in Great Britain in cargo vessels of 6,000 to 7,000 tons but it has so far been found impracticable to load it in bulk owing to the greater ease with which any moisture damage spreads when the sugar is not in bags. Coal and other

bulky materials are also unloaded directly into the refinery. Sugar-refining is thus a typical seaport industry and has gradually been concentrated in the ports where freight facilities are best. The tendency for the best shipping facilities to be limited to fewer ports has been one of the factors favouring the process of concentration and along with this, partly as cause and partly as effect, the increasing size of cargoes. Considerations of transport have led, especially in the United States, to the tall constructions enabling gravity to be utilized as far as possible in the passage of the raw material from one process to another.

SCALE OF OPERATIONS.

By the middle of the nineteenth century London, the Clyde and Liverpool had become the dominant centres of British refining. The diminution in the number of refineries throughout the country and the great increase in consumption of sugar in the latter half of the century meant a great increase in the size of the typical unit. In fact the conditions of the refining industry are such that only the large-scale unit can survive. The margin of profit in the industry is very small, there being very little difference between the prices of raw and refined sugars. In the United States this margin has been estimated as little over one cent a pound, from which, after all expenses of refining, including depreciation and overheads and the 7 per cent. shrinkage in the value of the raw sugar during refining, have been allowed for, there remains for the refiner a profit of 0.25 cent a pound. Given such small margins a large turnover is essential, and this has been the greatest stimulus to concentration. Not only, too, must the refinery operate on a large scale, but it must as far as possible operate continuously and as near capacity as market conditions will allow in order to reduce its overhead costs as far as possible. More than most other chemical industries, sugar-refining requires much expensive machinery and capital costs are high, while highly-skilled labour must be employed and very strict control of operations by highly-trained

chemists is essential. The price of the raw material, too, undergoes fluctuations that are very large relative to the margin of profit, so that a large capital reserve and considerable operations on the terminal market are necessary. There are, however, limits to the growth in size of an individual refinery even purely from the point of view of operating conditions. According to P. G. Wright, "a detailed study of costs and prices would seem to confirm for the refining industry the economic concept of an optimum size, that is, that the economies of large-scale production prevail up to a certain point, after which there is little or no gain in increasing the size of the plant." The largest refinery in the world is at Crockett, near San Francisco; its melt capacity is 2,200 long tons in twenty-four hours.

LOCATION WITH REFERENCE TO MARKET.

The geographical condition for fulfilment of these economic necessities is situation in the heart of a great market where the refining unit may expand to its optimum capacity with comparative assurance of finding an easy outlet for its large output and facilities for the distribution of that output at as little additional cost as possible. Hence, for example, London's advantage as a refining centre, located in the heart of an area of dense population, amounting, if to the metropolitan conurbation are added the satellite areas, to over 12 million in 1931, while the 14 south-eastern counties as a whole have $13\frac{1}{2}$ million inhabitants, about one-quarter of the total population of Great Britain. The leading place occupied by New York as a refining centre in the United States may be compared with this, the population of the New York-North-eastern New Jersey metropolitan district in 1930 having been 10.9 millions. Next to London in the United Kingdom comes Liverpool, with the densely populated hinterland of Northern England and the Midlands—about 20 millions, of which 9 millions are within a 50-mile radius of Manchester—while the Clyde refineries lie at the entrance to the densely

populated midland belt of Scotland and are conveniently situated with reference to the Belfast area, the chief centre of population in Ireland. Each of these three centres has, from its very nature, unrivalled transport facilities radiating through its hinterland. Close touch with the market, in this as in other industries, makes possible rapid adjustment to changes in both quantity and quality demanded. This has an added importance where, as particularly in London, the needs of a great internal and export market in derivative products such as confectionery must be indirectly catered for. The internal market in the United Kingdom for refined sugar is not sufficiently extensive in area to have brought about any specialization in the type of product according to regional tastes so as to differentiate London from Liverpool or Greenock. All the British refineries manufacture the same range of products, though some have become popularly identified with particular ones, such as the cubes of one London refinery, the cubelets of a Liverpool refinery, or the golden syrup of a Greenock one. A practical limit to the size of the refinery, depending on the facilities for distribution of the finished product, may be encountered before the limit to the economies of large-scale production is reached. Distribution is more economic from the three centres of the industry in the United Kingdom, for example, than it would be from one, say, in London. It happens that the three market conglomerations in the United Kingdom are about equally spaced one from the other, a circumstance favouring transport economy. In the period following the War, when the revival of Continental competition and the growth of that from North America were felt acutely by the British industry, the centre that suffered most was the Clyde, which had a larger number of refineries than either London or Liverpool, despite the fact that it was in the smallest of the three sections of the market. By the end of 1927 only one of its five refineries was in operation, and in that year its total production was only 39 per cent. of the post-war maximum of 1919.

CAPITAL CONCENTRATION.

The necessity for large-scale operations has made not only geographical concentration a characteristic of modern refining, but also concentration of capital. In the United Kingdom this concentration of capital has practically attained the maximum, the large refineries in the three centres of production, responsible for 80-90 per cent. of the output, being now under the same control. The merging of capital was practically completed in 1929, the period of acute depression in the refining industry, just prior to the coming into operation of the 1928 tariff, having proved too much for the smaller concerns. Of the total United Kingdom capacity about two-fifths is in the Liverpool area, over one-third in the London area, and the remainder on the Clyde. In the United States the largest concern, controlling five refineries with a joint capacity of 7,031 long tons, was responsible in 1930 for 28 per cent. of the total melt. The vastly greater territory with the greater differences in sources of supply of raw materials and in market conditions is a geographical obstacle to such concentration of capital as is seen in the British industry. Of the total United States melt capacity (21 refineries) of 7.9 million long tons raw sugar (8.2 million short tons refined) on the basis of a working year of 300 days, 68 per cent. is in the Atlantic group, 19 per cent. in the Gulf group and 13 per cent. in the Pacific group. The small fraction of the raws that is of domestic origin is naturally refined by the Gulf group, while almost the entire output of Hawaii is taken by the two refineries on the Pacific coast, one of which—Crockett—is owned by the Hawaiian planters. The refineries on the Atlantic seaboard draw their supplies of raws from Cuba, Puerto Rico and the Philippines.

PROSPECTS OF COMPETITION FROM THE TROPICS.

In addition to the competition of direct consumption sugars manufactured by many of the beet-sugar factories—the proportion differing considerably in the various countries—of cane-sugar manufactured by the beet-

sugar factories in their off-season, there is that of mill-white sugars produced by cane-sugar factories using the carbonation or sulphitation processes. The tropical mill-white sugars, the production of which was greatly stimulated by the temporary falling-off in beet-sugar supplies after the War, are not of a grade permanently to command the same market as refined sugars, and find their chief use, as far as Western countries are concerned, in manufactures. Even then their inferior keeping qualities and their colouring matter and viscous colloids are said to militate against their use in certain branches such as jam, confectionery and condensed milk. The most serious competition, however, and one that has rapidly increased in recent years, is that from refineries situated in the cane-sugar producing regions. The competition of the products of the tropical refineries is directly felt. The considerable increase in tropical production of refined sugar in these years has been largely stimulated by the desire of the cane-sugar producers in a period of low prices to increase their profits or decrease their losses by obtaining for themselves the refiners' margin. The greater freedom of marketing enjoyed by the manufacturer of the finished product has also been a stimulus. The saving of brokerage charges on raw sugar may also be mentioned. In quantity, however, the production of tropical refined sugar remains relatively very small.

That the temperate zone refineries have remained so long unchallenged by tropical competitors has been due partly to the nature of the commodity and partly to the existence, at least until recently, of serious obstacles to the industry in tropical countries. In the first place, despite the increasing quantity of the raw material operated on, transport costs have not been a factor encouraging the establishment of the refining industry at the source of the raw material, since the loss of weight in refining is comparatively small. From 100 lb. of raw sugar of 96° polarization there are commonly obtained 93 lb. of granulated sugar—the exact percentage depending not only on the amount

of sucrose but on the proportions of the various impurities in the raw sugar, a high percentage of mineral salts (that is, of ash) preventing complete crystallization—molasses accounting for 4 lb., and impurities, together with sugar lost in refining, for 3 lb. As the molasses must also be marketed overseas the difference in weight is only 3 per cent. What is more, the freight rates on refined sugar, which is, of course, principally consumed outside the cane-sugar producing countries, are higher than those on raw sugar and the liability to loss, whether of a mechanical or a chemical nature, as regards both quantity and relative value, in transit from the tropics is greater than that on raw sugar. Should refining at the source of raw material develop beyond a certain point the refineries would suffer also from the circumstance that local supplies are generally produced only during a few months of the year, the grinding season of neighbouring countries, too, being probably during the same months. The temperate zone refineries, with their excellent transport facilities and trade connections, are better situated to draw large quantities of raws from all parts of the world. They are thus enabled also, without incurring large expenses in storage, to secure the continuous and fairly regular supply all the year round that is essential for reducing the large overhead costs. Owing to the greater moisture which is the chief condition for the development of the micro-organisms that bring about deterioration by causing inversion, storage is in any case more difficult in the tropics than in the temperate zones, particularly for refined sugar. In this connection it may also be mentioned that raw beet-sugar stands storage better than raw cane-sugar owing to its lower moisture content and slight alkalinity, which is less favourable to the organisms that cause deterioration. On the other hand, where refining is carried on by the raw sugar factory in its off-season, there is an economy through the cutting down of overhead expenses of the joint concern, plant and personnel, otherwise idle for a large part of the year, being continuously utilized.

The temperate zone refineries have also the advantage of being situated in the heart of the market, with the best transport facilities, of being in closest touch with the quantitative and qualitative changes in demand and able to give special attention to details of packing and general attractiveness that are particularly important in a product that, being practically 100 per cent. pure, offers in itself comparatively little competitive possibilities. The United States refining industry is notable for the great development of "brand" sugars marketed in packages, half the output of some refineries being composed of such sugars. The large scale on which the temperate zone refineries operate enables them, also, to produce a range of products beyond the capabilities of the relatively small tropical refineries. The development of local markets in the cane-sugar producing countries is, however, a promising element in the situation from the point of view of tropical refining.

An obstacle of considerable importance in the past has been the fact that the working of a bone-char plant meant costs disproportionate to the small scale of operations involved in refining at the source of raw material, costs further increased by the absence of good supplies of bone-char in tropical countries and the consequent necessity of importing them. The development of vegetable carbons has, however, gone far to remove this difficulty. These, though in some instances capable not only of decolorizing but of adsorbing impurities, are generally employed in practice for the former purpose only, the elimination of impurities on the small scale being considered to be more economically carried out in the raw sugar factory by allowing them to pass into the molasses. Vegetable carbons, though very powerful in their action—only 1-2 lb. of one well-known carbon, for example, being required to 100 lb. of raw sugar—and requiring a much smaller capital for the installation of plant than bone-char, still, in fact, involve, from the point of view of the tropical central, a high initial cost, on the reduction of which their wider use largely depends.

The absence of cheap fuel and of good water supply are in some cases serious obstacles to the refining of sugar in tropical countries. Where, however, refining is carried out on the spot, whether only during the raw sugar campaign or continuously throughout the year, the more economic utilization in the furnaces of the bagasse, which is produced in excess of full requirements for raw sugar production, together with the economies due to refining being carried on in the same establishment as raw sugar production, goes far to solve this problem. The very small percentage of vegetable carbons required means, too, relatively small requirements of water for washing it ; as all the sweet water can be used for melting the raw sugar, none of it need be evaporated, and thus there is here also an economy of fuel.

The temperate zone refineries have some advantage in being situated in areas where skilled labour is abundant and technical supervision more easily obtainable and where facilities for quick repairs can be carried out. This is particularly important in an industry in which, given the small margin of profit, great loss would be incurred if the plant were brought to a standstill. On the other hand the tropical refinery has the advantage, besides that of smaller initial cost of the plant, of a cheaper site and lower wages, the latter being reflected both in costs of installation and in those of operation. It also obtains, particularly where refining is carried on only during the raw sugar campaign, the benefits of various savings in handling, in processing of the sugar, due to the elimination of considerable duplication of operations that is involved in bringing the raw sugar up to 99° polarization when the raw and refined sugar are produced by separate concerns, and in administration. The saving due to the elimination of bags for raw sugar is in itself a very considerable item.

Whether refining even on the small scale can be profitably taken up by the raw sugar producers depends very largely on local conditions in the cane-growing countries, differences in market location and possibly in internal conditions such as labour supply being

sufficient to turn the balance. The Cuban refineries have the advantage that the transport costs to parts of the south-eastern states of the United States are smaller than those of the United States refineries. General conditions, such as the price-level of sugar, are also of vital importance, the stimulus toward tropical refining being greater in a period of low prices. Whether capital will be attracted to the development of tropical refining more readily than it has been so far, depends both on the further improvement in technique and on the market situation. The relatively small stimulus to the migration of the refining industry to the tropics and the great advantage possessed by the refineries of the temperate zone of location in the heart of what is at present the principal market make it probable that the latter will retain their predominance, though the expansion of tropical markets may ensure continued development of the new processes in these countries.

UNITED KINGDOM SUPPLIES OF REFINED SUGAR.

In the five years 1909-13 the proportion of the United Kingdom consumption of refined sugar supplied by imports was 58 per cent., the absolute level of imports being very steady and averaging for the period 893,000 long tons, the chief sources being Germany, Austria-Hungary and the Netherlands. In the years immediately preceding the War European competition did not, however, attain the strength it had in the years prior to the Brussels Convention of 1903, when foreign refined supplied over 70 per cent. of British needs. As practically all of the import came from the Continent of Europe the War naturally brought a great decline, which was most rapid after 1916 and reached its nadir in 1918. Subsequent to the War the import of refined rose again rapidly but not to its pre-war level, the average proportion of foreign refined in British consumption for 1923-27 being only 39 per cent. and the absolute figure 582,000 long tons, mainly from Czechoslovakia and the Netherlands. During the period when European supplies had been cut off the capacity of the British refineries had

been expanded to 1.4 million tons or over. The return of competitive power to the European countries brought to the enlarged refineries a period of difficulty. The British market, a large one, unprotected and within easy reach of Hamburg and Rotterdam, offered a very convenient outlet for Continental refiners, who, having stabilized their home markets by artificial means, desired to dispose of the surplus which they produced in order to retain the advantages of large-scale operations, even though such disposal were at relatively very low prices. To the European competition was added increasingly strong competition from Canada and the United States. Such competition was, of course, felt very keenly by an industry working on very small margins of profit. While the competition from all outside sources together was in proportion considerably less than in pre-war years, the British industry was striving, on the other hand, to maintain its greatly enlarged, almost doubled, war-time capacity in operation. The economic situation made this impossible, though their total melt remained greater than before the War. The gradual closing down of a large proportion of the British refineries was therefore not surprising. The demand of the refineries for some form of assistance led to the tariff change of 1928, by which the differential between the import duty on foreign sugars above and below 98° was increased by a reduction in the latter and at the same time the competition of sugars polarizing above 99° from within the Empire was discouraged by a manipulation of the preferential tariff scale. As a result the imports of refined sugar were drastically cut down, the average for 1929-31 being only 56,000 long tons, amounting to 3 per cent. of the total consumption, principally from Czechoslovakia, the Netherlands and the United States, Continental countries being forced to send the greater part of their exports as raws. The refineries were able not only to work up to their war-time capacities but to extend them. For the first time exports of refined exceeded imports, the average for the same three years being 184,000 long tons, the Irish

Free State being normally the principal destination, but the Scandinavian and Baltic countries, Uruguay and British India being also important.

UNITED STATES SUPPLIES OF REFINED SUGAR.

The United States refining industry received protection from its origin in the earlier part of the eighteenth century until 1913 through a tariff differential between raw and refined sugar. Until 1925 the effect of the omission of this differential from the 1913 tariff was not felt. The refiners had the advantage of getting raw sugar from Cuba at the 20 per cent. preferential rate. Since that year, however, imports of refined sugar, especially from Cuba, have increased. By 1932 total imports of refined and mill-white sugars mounted to 11 per cent. of the total United States consumption, including the white sugar produced by the domestic beet factories. Under the present tariff the duty on 100 lb. of refined sugar is in fact less than that on the 107.5 lb. of 96° sugar required for its manufacture. Cuban and other insular refiners have taken full advantage of this defect in the polarization scale. The capacity of the United States refineries in 1932 was over 50 per cent. in excess of their record production for domestic consumption in 1926. The United States exports of refined, which rose to a maximum in the War and early post-war years, have fallen off sharply since 1928, mainly owing to the change in the British tariff.

CHAPTER XII

THE COMPONENT FACTORS OF CONSUMPTION

ON the basis of the figures of per capita consumption the principal countries for which statistics are available may be placed in three groups of high, medium and low rates of consumption respectively, the division between the second and third groups being much more clearly marked than that between the first and second. For this purpose the figures published in the League of Nations Memorandum on Sugar may, with a few modifications, be conveniently taken since they have the advantage, in covering the five-years 1923-24/1927-28, of referring to a period preceding the intensification of the economic crisis. All the data have been averaged for the five years and are in kilograms per capita.

In the group of high-rate countries are the following :—

Australia ..	58·6	Canada ..	40·9
U.S.A. ..	51·0	Cuba ..	40·4
Denmark ..	50·4	Switzerland	37·9
United Kingdom	41·2	Sweden ..	36·3
New Zealand ..	41·0		

To these may be added Iceland and the Irish Free State. In brief, the group may be said to consist of the English-speaking lands, Scandinavia and Switzerland. Cuba's position as a great producer gives it a peculiar place.

The countries with a medium rate are as follows :—

South Africa (Europeans only)	32·0
Argentina	30·7
Netherlands	29·4
Austria	27·1
Czechoslovakia	26·9
Belgium	24·4
Germany (1924-25/1927-28) ..	23·5
Brazil	22·7
France	22·4

Norway, Latvia, Finland and Estonia may be added. Roughly, then, this is a mid-European and Baltic group with South Africa and part of South America.

There is a wide gap between the rates of consumption of the second group and those of the third group, which are as follows :—

Mexico	..	11·8	Peru	..	8·3
Spain	..	11·2	U.S.S.R.	..	6·4
Hungary	..	10·6	Japan	..	6·0
Poland	..	10·3	Java	..	5·5
Italy	..	8·8			

To this group may be added Portugal, Lithuania, Greece, Yugoslavia, Rumania, Turkey, Bulgaria and Albania and, probably lowest of all, China, for which all statistical data are of small value but which is placed at 2·2 according to the publication indicated. This group is predominantly that of Southern, Eastern and South-eastern Europe, with the Oriental countries still lower.

In what follows, the countries in these three groups will be referred to as belonging to the high, medium and low groups respectively. The value of the figures is, of course, very approximate, the data from which they are calculated being generally themselves indirectly calculated, as in the case of total consumption, or estimated, as in the case of population; they serve, however, to indicate the general grouping.

THE DEVELOPMENT OF TOTAL CONSUMPTION IN RELATION TO POPULATION AND PER CAPITA RATE.

The development of total consumption in the different countries since 1913-14 shows considerable variations. In general, however, there was in European countries a marked downward movement due to the War, while in both Europe and the U.S.A. there was a general upward movement in 1921-22 (1922) as also in 1924-25 (1925), with a slowing down in 1925-26 (1926), while 1928-29 (1929) was generally the end of a rise. The most rapid and steady increase in total consumption is in Poland, where both population and per capita consumption have

risen comparatively rapidly, the latter due, no doubt, in part to intense propaganda operating in a country with a low rate. Countries with a moderately rapid increase in total consumption are France, Italy, Spain and Belgium. In France, though fluctuations have been very pronounced, the general trend has been rather sharply upward. In Italy there were great fluctuations during and after the War but the total has remained at or above the high level reached in 1921-22. In Spain, also a country of low rate, the upward movement has been steady, especially since 1922-23. In Belgium there has been a slowing-down and, since 1924-25, even a tendency to decrease. Countries with a slow rate of increase in total consumption are Germany, Sweden, the U.S.A., the United Kingdom, Czechoslovakia and the Netherlands. In Germany the rate of increase from the 1919-20 minimum closely corresponds to that of per capita consumption, as might be expected from the relatively low rate of increase of population and consequently small influence of the latter factor. In Sweden the increase has been fairly steady since the recovery in 1918-19. The increase in the U.S.A. has been fairly steady since 1918 but has tended to slow down since 1925 with the fall in per capita consumption. Total consumption in the United Kingdom has been steady since 1922, when, with allowance for the separation of the Irish Free State, it regained its slow upward trend. Czechoslovakia and the Netherlands have, on the whole, experienced a slow increase.

Total sugar consumption depends on two components, population and per capita consumption. In the nineteenth century the increase of population in Western Europe and in the United States was relatively rapid, and this growing population satisfied its demand for sugar by importing increasing quantities from the cane zone and developing the beet zone. Since the beginning of the twentieth century, however, while production has maintained its rate of increase, there has been a tendency of serious import for sugar consumption for the rate of increase of population, particularly amongst

those countries that have a relatively high rate of per capita sugar consumption, to fall off as fertility declines. In northern and western Europe the stationary condition is coming about much more rapidly; natural increase of population in these countries is becoming steadily smaller. Thus, of the annual increase in population in Europe outside of the Soviet Union, Yugoslavia and Greece, the greater part is in countries of low per capita consumption and only a very small part in those of high, while in the Soviet Union, where the rate of consumption is very low, the annual increase of population is almost equal to that of all these countries together. The United Kingdom is the only country in the high group and Germany the only medium-rate country where there is at present a considerable annual increment of population, in both cases thanks to their already large numbers. In all the countries of high and medium consumption rates the decline in the rate of natural increase since 1901-05 has been very rapid. The increase of population amongst high consumption countries depends mainly on extra-European lands (the United States, Canada, Australia and New Zealand).

The effect on sugar consumption of this slackening of the increase of population in countries of higher consumption rate is probably accentuated by the fact that it means a relative and eventually an absolute decline in the numbers of the lower age-groups, which are probably of special importance for sugar consumption. In the United States, for example, the working of the process is seen in the decline between 1920 and 1930 in the number of the population under 5 years of age, while the number of those over 50 increased by 25 per cent.

DIETARY CUSTOM.

The second component of total sugar consumption is the per capita rate. Any attempt to analyse the factors in the wide range of consumption rates must start from the fact that sugar is used in human consumption for different reasons. In the first place there is, of course,

its food value as a source of energy, as which it is in the physiological sense highly economic, 98 per cent. of its energy being available to the human body. In this respect it competes with other carbohydrates and with fats. The amount of such energy foods necessary varies considerably with locality and season, with occupation, race and individual. While, however, its generally realized value in this respect makes sugar a staple article of diet in many countries, it is doubtful if variations in the rate of consumption of sugar as between different countries are determined to any extent by such considerations, though the amounts of fats and carbohydrates as a whole may be so determined. Variations in the use of sugar as between country and country appear to depend rather upon its use as a flavouring substance and so, apart from its cost, very largely on local customs in diet, though these are probably to a large extent the result of such factors as taxation. Thus, while in most countries the use of sugar, if even in small quantities only, has come to be regarded as a necessity, as indicated by the relative inelasticity of consumption, it still retains sufficient of the character of a luxury to be to a peculiar extent the subject of Government taxation for revenue purposes.

The low standards of sugar consumption in Mediterranean countries such as Italy and Spain are thus not due directly to climate but, apart from the important effect of taxation, for instance, to differences in dietary customs. The consumption of sweets at meals in these countries is, for example, largely replaced by that of fruit and wine, of which their climatic conditions do, of course, ensure an abundance. In this connection there must, on the other hand, be mentioned the important absorption of sugar in some cold temperate countries in fruit-preserving, one of the chief uses of sugar in the United Kingdom, for example, that is not very important in continental Europe and particularly in the Mediterranean countries, where the local supply of fresh fruit is maintained throughout the year. In some countries the association of sugar with other products is particu-

larly important, as in Australia, where the world's highest rate of 59 kilograms per capita is attained, thanks largely, it is said, to the general use of very strong tea. So, too, the rapid rise of sugar consumption in the United States has been stated to be due to an increase in the consumption of sweets and soft drinks in the period of prohibition of the alcoholic liquor traffic, though the period of general prosperity following 1921 and shown distinctly in statistics of per capita purchasing power probably also had a considerable effect. The decreasing proportion of foreign-born population, used to lower standards of sugar consumption, may also have had some bearing on the trend of United States consumption. Thus, while it is certainly true that the countries with high rates of sugar consumption are in the cold temperate zone and that the countries of the tropical and Mediterranean zones have low rates of consumption, examination of the facts shows that these differences may be explained by factors belonging to quite other categories.

THE TREND OF PER CAPITA CONSUMPTION.

The trend of per capita consumption shows in the high, medium and low groups a general falling-off in the last ten years. The remarkable recovery to the normal trend line in 1922 was not maintained. Even before the War the rate of increase in the United States was greater than in the United Kingdom, the former country definitely taking the lead in 1908. The United States are exceptional in showing a distinct acceleration in rate of increase in the first post-war period, up to 1921, afterwards, however, slowing down. It may be noted in this connection that by 1928 purchasing-power per capita had risen to 23 per cent. above its pre-war level. The United Kingdom appears to have returned since 1925 to its slow upward trend. In Denmark, Germany and Italy, representing respectively countries of high, medium and low rates of consumption, a similar tendency is found in all when the extreme fluctuation caused by the War is ignored; there is a slowing-down in the post-war period as compared with that between

1903 and the War, especially noticeable in Italy, where the pre-war rate of increase was, however, especially rapid. Despite the slowing-down, not only Italy but Spain shows a very great advance in recent years on the pre-war level, amounting to over 60 per cent. and over 70 per cent. respectively. The general result appears to be that, while the rate of increase in the low-rate countries is still relatively greater, the post-war rates of increase in the three groups are much more alike than the pre-war rates.

THE RELATION OF CONSUMPTION TO MONEY INCOME.

The extent to which sugar consumption may be increased by increase in purchasing-power is shown by the statistics available for certain countries concerning the levels of consumption in different classes or in different grades of the same class. One of the most detailed investigations was made in 1927-28 in Germany, where the expenditure of three types of urban household, those of manual workers (Arbeiter), general clerical and commercial workers (Angestellten) and officials (Beamteten) respectively, was studied. In all three types the elasticity—i.e., the tendency to purchase more of the commodity as income rises—was found to be smaller for sugar than for meat, cheese, vegetables and milk and much smaller than for butter, fruit and eggs. While the elasticity is comparatively small inside each type of household, there is a distinct difference between the types, the increase in consumption of sugar between the lower and higher income groups of manual workers being 26 per cent. against 18 per cent. between the corresponding groups of clerical and commercial workers and 11 per cent. in the case of officials. These differences, which are to some extent cumulative, indicate scope for raising consumption either by increase in the income of the lower grades and classes or by the maintaining of sugar at low price-levels.

In Sweden the average rate of consumption for each adult equivalent in middle-class households was found in 1923 to be 35.1 kilograms, while that in the households

of manual workers was 30·8; as in Germany, a steady increase in rate of consumption was found as income rose, from an average of 26·2 kilograms in households of manual workers earning annually 825 crowns or under per adult equivalent to 40·1 kilograms in middle-class households earning 3,300 crowns or over per adult equivalent; the most common rate of consumption per adult equivalent for working-class households was between 25 and 30 kilograms and the most common for middle-class households between 30 and 35 kilograms.

In the U.S.S.R., according to a study made in autumn 1924 and autumn 1925, a similar class distinction in sugar consumption exists, the daily per-capita consumption in the families of manual workers and of officials having been found to be respectively 27·9 and 37·9 grams.

In both the United States and the United Kingdom studies of diet also indicate that sugar plays a relatively greater part in the diet of the higher income groups.

THE CONSUMPTION OF RURAL AND URBAN POPULATIONS.

An inspection of the general economic character of the countries enumerated in the three groups of high, medium and low consumption rate respectively shows a significant relationship. In the countries with low per capita consumption a large proportion of the population subsists from agriculture: in the U.S.S.R. 83 per cent., in Lithuania 79 per cent., in Bulgaria 75 per cent., in India 69 per cent., in Poland 66 per cent., in Hungary 56 per cent., in Italy 52 per cent., to take examples for which such data are available. On the other hand, in all countries with high consumption rates, with the probable exception of Cuba and the Irish Free State, less than 40 per cent. of the population subsists from agriculture. The data refer to the Census of 1930 or nearest date.

The peasant's income takes the form very largely of produce from the land and, apart from other factors in his low standard of living, he often has very little cash income to expend on such comparative luxuries as sugar. The effect of great dependence on agriculture in reducing

purchasing power is, of course, greatly accentuated by a comparatively severe decline in prices of agricultural products. The relapse in sugar consumption after 1928-29 was no doubt in part due to the intensification of the agricultural crisis in those years. On the other hand, in countries with a comparatively small proportion of the population dependent on agriculture, the fall in sugar prices doubtless helped to maintain consumption at a higher level than would otherwise have been possible. Figures of per capita cash income reflect this characteristic of predominantly agricultural countries; thus there is a correspondence also between these figures and those of per capita sugar consumption, particularly well marked in the Balkans and Eastern Europe. While Spain and Italy stand relatively high amongst agricultural countries as regards per capita income, their high taxation and Mediterranean diet probably outweigh this in their influence on sugar consumption. The high rate of consumption in the Irish Free State despite its typically low per capita income is probably due to close contact with the dietary customs of the United Kingdom.

In the towns, on the other hand, conditions affecting purchasing-power are quite different. Cash incomes per capita are not only relatively high but family incomes may be proportionately even higher in view of the fact that the wife or other members of the urban family may also be bringing in cash to the household, while the smaller number of children as compared with rural families also means an increase in the average income per family member. The almost world-wide tendency to increased urbanization of the population is thus of great significance for sugar consumption. With migration to the towns new tastes and higher standards of living are quickly acquired. Statistics of the proportion of total population subsisting from agriculture at the date of the last pre-war census and at 1930 or nearest date show a decrease in almost every case, the only important exception being Italy. In the towns, too, the influence of organizations such as trade unions in maintaining standards of living is much stronger than

in the country; for political reasons Governmental steps to maintain and raise the general standard of living by means of social legislation are also felt more effectively in the urban areas. The influence of social organization, governmental or other, may also be traced in the differences in consumption between countries. This is also certainly a factor of great importance in maintaining the level of consumption in many countries during years of depression. Purchasing-power has thus been increased much more than would appear from figures of average income per head, which in Europe show only a slight rise as against pre-war years.

THE EASTERN MARKETS.

In the densely populated countries of monsoon Asia, containing half the world's population, standards of living, and of sugar consumption in particular, are lower than in even the most backward Western countries. While crude products of local origin, such as the gur of India, are eaten in the cane-growing areas, factory or refinery sugar is consumed only in relatively insignificant quantities, not as a regular part of the diet but as an occasional sweetmeat, particularly in the cities. Such investigations as have been made in the East show that there also the towns play the leading part as sugar consumers and that there is a rise in the quantity consumed as income rises. There has been a great increase in consumption of factory or refinery sugar in India and China since pre-war years. In India consumption, as indicated by the data of distribution, increased steadily in recent years up to 1929-30, after which the effects of the economic crisis began to make themselves apparent; in 1929-30 the figure attained was 1,325,000 long tons, about double that of five years previously, the distribution in 1924-25 having been 709,000 long tons. The principal type entering China is now mill-white, which rose from 1909-13 to 1927-31 by 306 per cent. to an average of 301,000 metric tons; imports of refined rose in the same period by 103 per cent. to 245,000, those of brown by 58 per cent.

to 146,000, and those of candy by 40 per cent. to 18,000 metric tons. It is obvious that with improvement in general conditions, particularly in China, there is immense scope for increased consumption of sugar in the East. The realization of these possibilities in China depends on a cessation of the chaotic conditions that have hindered trade for so many years, the industrial development of the country, the opening-up by improved communications of the vast areas still out of touch with world trade and restricted to the consumption of local produce and lastly on an improvement in the value of silver.

THE EFFECT OF TAXATION ON CONSUMPTION.

Sugar has been a special object of Governmental attention, not only on the side of production, but on that of consumption and the consumption of few other commodities in general use has been so much affected by taxation. What Governments have given with one hand they have to some extent taken away with the other. While production has been peculiarly encouraged by customs duties, consumption has undoubtedly been considerably reduced, not only by the high prices resulting in many cases from these duties but also by revenue duties. Many producing countries with little or no import of sugar make up for the absence of revenue from customs duties by the imposition of consumption or turnover duties. The relatively high taxation of sugar is encouraged by the fact that it is still in many countries regarded as more or less of a luxury, a point of view dating from the period when it was consumed only by the wealthiest classes. The fact, too, that despite its semi-luxury character, sugar is used, though even in comparatively small quantities, so very widely, makes it all the more suitable as a source of revenue for needy Governments. From the administrative point of view also, its well-defined and relatively simple character makes it a commodity comparatively easy to tax.

A survey of the rates of taxation of sugar in the various

countries shows a picture more or less in harmony with the grouping of these countries according to rate of per capita consumption. Some of the outstanding facts as regards taxation may be mentioned. New Zealand, which occupies a high place in per capita consumption, has the distinction of the lowest sugar taxes in any important country. The high position of Switzerland in per capita consumption, second only to Denmark amongst the countries of continental Europe, may be traced at least in part to the fact that it has the lowest sugar taxes in Europe, though allowance must also, of course, be made for its large exports of chocolate, condensed milk and other sugar-containing products. Amongst Scandinavian countries the high rate of consumption in Sweden as compared with that in Norway seems in the main explicable only by the difference in the rates of taxation. That the Netherlands, despite their high standard of living, with the highest per capita income in Europe, excepting the United Kingdom, in 1928, appear only in the group of medium-rate countries seems due largely to the high consumption tax. The Mediterranean and Balkan countries, in the lowest group for consumption rates, are also amongst the countries with the highest rates of taxation, Italy having the highest sugar taxes in Europe and Rumania, Bulgaria, Spain, Portugal and Yugoslavia being also distinguished in this respect. Comparative lack of taste for sweetened articles in some countries has probably been inculcated by long years of severe taxation.

CHAPTER XIII

PROSPECTS OF CONSUMPTION AND PRODUCTION

FROM the middle of the nineteenth century until 1913-14 there was a fairly steady upward movement in world production of sugar, the demands of the growing industrial populations in north-western and central Europe and in the United States being met by greatly increased investment of capital in the development of tropical canelands, by the intensive culture of beet in Europe and Russia and the opening up of the American beet regions. The average annual increase in that period has been calculated at about 3·5 per cent.; production thus doubled every twenty years. This long-period trend may, of course, be taken to represent not only production but consumption. By 1909-10/1913-14 it had reached an average of 17·0 million long tons. After falling to 15·5 million in 1919-20 it rose to 28·5 million in 1930-31.

THE RELATION OF PRODUCTION TO CONSUMPTION.

A closer study of the development of world production shows periods of very rapid upward movement alternating with periods during which production remained more or less stationary. As a marked upward step in production was usually followed by a fall in prices, which did not recover until the relatively steady upward trend of consumption had regained the level of production, these alternating periods were reflected in cycles of boom and slump in the sugar trade, years of high prices in which production tended to be deficient alternating with years of low prices when there was a tendency to glut.

With the outbreak of the War in 1914 there set in a

decline in world production, due principally to the drastic fall in Europe, and by 1919-20 the world total had fallen to the lowest level since 1909-10. In 1920-21, with the revival of European beet-sugar production and the coming into full production of new cane plantations stimulated by the great rise in prices after the War, there began a rapid recovery of production, which continued with little interruption until 1925-26, by which date over-production and the accumulation of stocks had again set in, leading to an unprecedented depression in world sugar prices. In the period since the War, however, while there have been cycles in the production-consumption ratio analogous to those of the pre-war period, the underlying economic trends appear to be of a different character, such as to increase the importance of consumption studies.

THE DEVELOPMENT OF CONSUMPTION.

Rates of sugar consumption in different countries are due, it has been seen, to a complex of factors. Three groups of countries have been distinguished from this point of view, having respectively high, medium and low rates of per capita consumption. While the countries with higher rates are roughly those with a relatively highly urbanized population, high standards of living and low rates of taxation of the commodity, the countries with lower rates of consumption are predominantly agrarian, with generally low standards of living and high rates of taxation. Dietetic habits appear to be also a factor of importance. Each country, in fact, has its individual complex of factors affecting consumption.

As regards the development of consumption there are two components, increase of population and rate of per capita consumption, which vary in relative importance in the different countries. In countries with a high rate of consumption a process of saturation appears to take place, while in both these and a number of medium-rate countries a kind of population saturation is also appearing and rate of increase in numbers is also slowing down. In these countries increase of sugar

consumption is obviously a relatively difficult matter, probably rendered more so by changing age proportions in the population. In the countries with low and medium rates of consumption and even to some extent in those with higher rates there are more or less considerable possibilities of increasing total consumption by raising the per capita rates of the lower income groups toward those of the higher income groups of the population. Growth of population seems likely to remain the dominant factor in the development of total sugar consumption in the low-rate countries for a much longer time than in the countries with higher rates of consumption. The prospects of rapid increase in total consumption thus appear in all directions to be more favourable in these low-rate countries. In certain countries differences in taste appear to be particularly significant as factors determining rate of sugar consumption. In a great many countries taxation of the commodity is the dominant depressing factor. The difficult financial position of many of these countries and the natural reluctance of their governments to give up such an easy source of revenue make alleviation of this burden an unlikely prospect in the near future. The raising of the general standard of living, though a slower process and especially difficult in times of depression, is a factor that must continue to operate once the present period of international economic disorganization is past. The radiation of higher standards from the urban centres to the agricultural areas, aided by the general tendency to increased urbanization of the population, is another most important factor in the long run.

THE TASKS OF PROPAGANDA.

The more or less natural tendencies towards increased consumption can undoubtedly be greatly accelerated by means of well-directed propaganda. Such propaganda is especially urgent in view of the factors that have been seen to operate in reducing the rate of increase in the countries where per capita consumption is at present comparatively high. The most important

aspect of sugar from the dietetic point of view is its use as a flavouring material; that is, given the ability to purchase, its use is a matter of taste, its value as an energy-producer being normally quite incidental. In any case as standards of living rise the demand for energy-producing foods slackens, since the advance of mechanization in many branches of labour reduces the necessity for heavy physical exertion, while the improvement in general heating facilities in winter also reduces the need for fuel foods. On the other hand there is a steadily growing demand for greater variety in diet, and food habits are less conservative in regard to the adjuncts of diet than in regard to the staples. Though even as an energy food sugar can retain its place more easily than others by virtue of its small volume and absence of residue, a fact suggested by the contemporaneous rise in sugar consumption and fall in cereal consumption in the United States, the facts as a whole show that the emphasis of propaganda must lie on its flavouring capacities. What people think they must have becomes more important than what from a strictly dietetic point of view they really must have. One of the most hopeful aspects of the situation is the well-known psychological fact that it is much easier to establish a habit than to break it. The hardship that was felt when the exigencies of war caused a reduction of sugar consumption in the countries used to relatively high rates of consumption illustrates this. In this connection it is also interesting to note how the British Dominions, particularly Australia, have, despite higher prices than those in the United Kingdom, retained the taste for relatively highly sweetened foods and drinks as part of their social inheritance from the Mother Country. The influence of social inheritance may similarly be seen in the United States, where a study of consumption by various groups of the immigrant population showed that South Europeans used only 65 per cent. as much sugar per capita as North Europeans.

In the countries of low per capita consumption the task of propaganda is relatively simple, given an upward

movement in purchasing power. It consists mainly in bringing the simpler uses of sugar within the reach of lower strata of the population and extending its use to areas where it is more or less unknown. The rapid growth of per capita consumption in Poland in recent years illustrates the possibilities of propaganda in countries of low consumption; the National Council of the Polish Sugar Industry has been particularly active in the use of films, exhibitions, lectures, newspaper articles, brochures, school propaganda and samples. Its apparent success may be repeated elsewhere. Were the governments of some countries with very high rates of taxation on sugar to support such propaganda by reducing the rate of taxation they might well find the total yield of the tax increased by the larger consumption, while at the same time they would benefit by the improved position of the producers.

In the countries of high consumption rate, and especially in those where the taste for sweetened articles might be increased, the main line of investigation appears to lie in extending the uses of sugar as a flavouring agent, particularly in manufactured goods. Even in most European countries the use of jams, sugar-containing cakes and table sweets is relatively small. A number of countries at present in the medium-rate group could probably be raised to the high-rate group by development in this direction alone. The possibilities of finding uses for sugar outside the field of human consumption form, of course, another line of development common to all groups of countries.

Above all, however, there is the need for improving the statistical basis of consumption studies. Nowhere is there anything like adequate statistical information and in many countries such information is entirely lacking as, indeed, is information even of the most general type regarding sugar consumption.

While the great productive potentialities opened up by the advance of science and on the other hand the recognized tendency for the rate of increase of population in many countries to slow down have caused the quan-

titative problems of production to lose some of their urgency and have accentuated the importance of market studies, the question of the relative position of cane-sugar and beet-sugar in supplying future demand remains of fundamental interest.

EXPANSION OF THE CANE AREA.

Further increase in production of cane-sugar or beet-sugar can be brought about either by extension of area under the crop or by increase of the yield per unit of area. In the preceding chapters the position in the principal producing areas has been summarized. Cuba, the world's leading producer, at least of sugar as consumed by Western populations, still has much good soil unutilized and has far to go in raising unit-yields so that on the whole a further very large increase in production is there possible. In Java, on the other hand, the land policy of the Government prevents further extension of the cane area and intensive methods have already brought unit-yields to a high level so that further expansion of production in response to a growing demand would there be more difficult. Within the British Empire the regions where conditions are most favourable (Mauritius for example) are also those where there is little scope for expansion, while the British West Indies are unlikely to sacrifice the advantages they are beginning to gain by the diversification of their crops; in Queensland and Natal, though large areas are still available, high costs are likely to prevent their utilization in response to external demands and, even with a high measure of Imperial preference, considerable expansion of the cane area in these two countries is checked by the losses on export. In India, while the rapid increase in production of white sugar under the protection of a high tariff is likely to keep pace with local demands, production for export is likely to be kept in check by high costs, as in Australia and South Africa, though an entirely different complex of factors is involved. The United States producers are dependent on the United States tariff. Given this protection, increased

production is possible in the case of United States beet-sugar. Hawaii, however, has little or no fresh areas to be developed and has an agricultural technique already at a high level. In Puerto Rico further increase depends on heavy expenditure on irrigation and fertilizers. In Louisiana the marginal climatic conditions make extension improbable. In the Philippines the agricultural improvements that are needed for further development are hindered by political uncertainty. Like the British countries, the American countries can supply a greater part of their own needs, but will continue to require large imports from foreign sources. Amongst the remaining cane countries the greatest immediate potentialities appear to be in the Dominican Republic and the greatest total possibilities, provided the problems of capital, labour and transport are solved, in Brazil. In Mexico and Haiti political instability makes shortage of capital a severe check and in the latter high costs of production also operate. Argentina, climatically marginal, has also high costs of production and suffers from the high transport costs due to the situation of the sugar belt within the country and, as regards possible export, from the situation of the country with reference to external markets. Peru is to-day the most important South American producer; while its costs are very low and its technique advanced, expansion is checked by limitations of area and of the irrigation water on which the industry is wholly dependent.

In all there is no lack of potential caneland, whether immediately utilizable or requiring the action of continued demand to bring to bear on it the necessary resources of capital and labour. Shortage of labour and lack of facilities for transport are generally the main obstacles to be overcome.

THE SUGAR-BEET AREA.

The intensity of competition between cane countries has made many of them dependent on tariff protection. Beet-sugar production has, however, without exception, owed its development and, with the sole exception

of the Netherlands from 1897 to 1930, its maintenance to tariffs and subsidies, which have enabled it to withstand the competition of the tropical product. There seems little doubt that were this protection to be withdrawn its production would shrink to very small dimensions and in many countries disappear. The intimate relation of sugar-beet to other features of the farming system, especially in Europe, also maintains a relative stability in the area under the crop. Thus in Germany, Czechoslovakia, Poland, Hungary, Austria, the Netherlands, Belgium and France together the area under sugar-beet has been as follows in hectares :—

1909-13	1,370,000 (Czechoslovakia 1914 only)
1923-27	1,280,000
1928-30	1,420,000

In Europe the sugar-beet area depends not only on sugar prices as reflected in beet prices but on a whole complex of agricultural factors. The competition of other crops for the fertile land is more acute in the temperate zones and the relation to prices of other agricultural products not only of beet prices but, thanks to the importance of beet by-products as feeding-stuffs, of livestock prices must also be taken into account. The difficulty of finding alternate root crops to take the place of sugar-beet in many countries acts as a check on decline in areas. On the other hand the great pressure on the labour force involved in sugar-beet culture checks any great expansion in area. It is not surprising, then, that the area under sugar-beet in Europe (including, in the figure, until recently, the Soviet Union) has remained comparatively stable. In the exporting countries and in the countries which supply the bulk of their own requirements any great expansion in area is also limited by the fact that the inevitable result of such an increase would be an increased burden on their national finances owing to the need to export the surplus sugar in competition with the lower-cost cane sugar. Apart from beet-sugar production within the United States tariff wall, the greatest potentialities in the beet

intensive methods. Throughout the beet-growing regions, therefore, cultural methods are relatively advanced, high-yielding varieties are in general use and breeders appear to have approached the limits of possible increase in sugar content. In the principal producing countries beet yields have for a considerable period shown very little increase. In the Netherlands, for instance, where the effects of the War were not felt as in the other leading beet lands, the following are the averages for decennial periods :—

	Metric tons per hectare		Metric tons per hectare
1871-80 ..	26.3	1901-10 ..	30.4
1881-90 ..	24.9	1911-20 ..	30.7
1891-1900 ..	30.1	1921-30 ..	33.1

In the raising of unit-yields, as in the extension of area under the crop, there appear, therefore, to be comparatively small possibilities in the case of sugar-beet.

POTENTIAL YIELDS.

According to the law of the inverse relation of nitrogen content of plants to their potential yields,* the maximum potential yield of sugar-cane with 0.084 per cent. nitrogen content (like the present P.O.J.2878 or H.109), that is, the penultimate yield, is, excluding tops and trash, 163 short tons (146 long tons) per acre, which means, with normal sucrose content, 25.5 short tons (22.7 long tons) of sugar per acre. The highest yield in the field so far recorded—18.6 short tons per acre by a company in Hawaii—is thus 73 per cent. of the potential, while on a smaller scale a yield approximating closely to the penultimate has been attained in a Queensland experiment. The penultimate yield for sugar-beet of the normal average nitrogen content as lifted, namely, 0.2 per cent., is 53 short tons (47 long tons) per acre (1,200 quintals per hectare) cleaned and topped beet, which means 8 short tons (7 long tons) of sugar per acre. The highest yield so far actually obtained—34.91 short tons (31.17

* For a discussion of this question see O. W. Willcox: *Principles of Agrobiolgy*, 1930.

long tons) of beet per acre (783 quintals per hectare) on an irrigated field in Utah—is thus 65 per cent. of the potential. These penultimate limits can be exceeded only by breeding varieties of cane and beet having smaller nitrogen content. Thus, with existing penultimate limits and even allowing for the fact that the crude yields indicated above for cane-sugar must for strict comparability be reduced to yields per annum, cane being generally in the ground for from eighteen to twenty-four months, the potential unit-yield of sugar from cane is much higher than that from beet. Field results have, so far, at their maximum shown a utilization of a higher percentage of the growth power of existing varieties of cane than of beet. The average yields of cane-sugar in all countries are, however, much farther than those of beet-sugar from the respective maxima, so that there is much greater leeway to be made up in the case of cane. There is also a much greater range in average yields between different regions of the cane zone than between different regions of the beet zone. In cane culture, too, future progress is largely a matter of spreading the technique already put into practice in a small portion of the zone—in the use of high-yielding varieties adapted to the particular environment, the conquest of cane diseases and pests, the improvement of cultivational methods, the proper use of fertilizers and the raising of the efficiency of labour—whereas in beet culture progress involves the raising of a level already generally high—a much more difficult matter. There are still, too, greater possibilities in the cane zone in the utilization of by-products and, in some regions, in the improvement of factory practice.

THE WORLD SUGAR PROSPECT.

A survey of the possibilities of extending the area under sugar crops and of raising their unit-yields shows that, while production may in some years drop below the gradually rising consumption line, a real shortage of sugar is out of the question. Comparison of the costs of production of cane-sugar and beet-sugar is rendered

difficult by the importance of by-products, particularly in the case of beet-sugar. Through the value of its by-products in the feeding of livestock the sugar-beet has enormously strengthened its position in crop rotations, particularly in Europe. The high residual value left in the soil has had the effect, too, of spreading a considerable part of the cost of production over other crops in the rotation. In conjunction with these features must also be taken into account the fact that the sugar-beet crop occupies the ground for a considerably shorter time than does the average cane crop. But, when all these factors are taken into account and approximate net costs of production are compared, there seems no doubt that the actual and prospective position of cane is very much stronger and that, were the high protection of beet withdrawn, its production would shrink to very small dimensions and in many countries disappear. Consideration of the potentialities of cane-sugar and beet-sugar production strengthens the view that the proportion of the world's total sugar consumption supplied by cane is likely to show a continued upward trend. While the advantages mentioned may, with the continued assistance of tariffs and other measures of protection, maintain the beet area, there are limits to the costs bearable in the countries concerned by public funds and domestic consumers in the attempt to neutralize geographical realities.

APPENDIX.

WORLD SUGAR PRODUCTION.

	<i>Willott and Gray.</i>			<i>Mikusck.</i>		
	Million long tons tel quel			Million metric tons raw		
	Total	Cane	Beet	Total	Cane	Beet
1909-10	14.9	8.3	6.6	15.6	9.0	6.6
1910-11	17.0	8.4	8.6	17.7	9.1	8.6
1911-12	15.9	9.0	6.9	16.8	9.9	6.9
1912-13	18.0	9.0	9.0	19.0	10.1	8.9
1913-14	18.4	9.8	8.6	20.1	11.1	9.0
1914-15	18.5	10.2	8.3	19.5	11.2	8.3
1915-16	16.9	10.6	6.3	18.0	11.9	6.1
1916-17	17.1	11.3	5.8	18.4	12.6	5.8
1917-18	17.4	12.4	5.0	18.7	13.6	5.1
1918-19	15.8	11.9	3.9	17.5	13.1	4.4
1919-20	15.5	12.2	3.3	16.9	13.6	3.3
1920-21	16.6	11.9	4.7	18.4	13.5	4.9
1921-22	17.6	12.7	4.9	19.4	14.3	5.1
1922-23	18.4	13.2	5.2	19.7	14.4	5.3
1923-24	20.3	14.4	5.9	21.5	15.4	6.1
1924-25	24.0	15.9	8.1	25.1	16.8	8.3
1925-26	24.3	16.0	8.3	26.2	17.6	8.6
1926-27	24.1	16.4	7.7	25.0	17.1	7.9
1927-28	26.1	17.1	9.0	26.8	17.7	9.1
1928-29	27.5	18.1	9.4	29.0	19.4	9.6
1929-30	27.4	18.2	9.2	28.3	18.9	9.4
1930-31	28.5	17.2	11.3	29.5	17.6	11.9
1931-32	26.3	17.8	8.5	27.2	18.3	8.9
1932-33	24.3	16.5	7.8	26.3	18.4	7.9

World sugar statistics are very crudely calculated and at the best give only a rough idea of the trend of production over a period of years. It should, for instance, be noted that the total production of India, mainly gur, is included without reduction to terms of sugar in the strict sense.

132 WORLD SUGAR PRODUCTION AND CONSUMPTION

WORLD SUGAR CONSUMPTION.

According to Dr. Mikusch, world consumption in the years indicated was as follows in million metric tons, raw sugar value:—

1923-24	21·6	1928-29	27·7
1924-25	23·5	1929-30	26·8
1925-26	24·8	1930-31	26·9
1926-27	25·2	1931-32	26·1
1927-28	26·8	1932-33	26·3

Dr. Mikusch estimates that, in addition, between 150,000 and 200,000 metric tons per annum disappear through loss in transit and in other uncontrolled ways.

UNITS OF MEASURE.

To facilitate comparison with the current estimates published in the official reports of the various countries and in the periodical press, the data in the statistical notes have been given in the original measures.

The following table, compiled from the *Recueil de coefficients et d'équivalences* published by the International Institute of Agriculture, shows the mutual relations of the three principal tons.

	Long ton	Short ton	Metric ton
Metric ton ..	0·98420	1·10230	1·00000
Short ton ..	0·89285	1·00000	0·90718
Long ton ..	1·00000	1·11999	1·01605

1 long ton = 2,240 pounds.

1 short ton = 2,000 pounds.

1 metric ton = 2,205 pounds.

1 cwt.=112 pounds=0·05080 metric ton=0·05600 short ton.

1 hectare = 2·47109 acres; 1 acre = 0·40468 hectare.

BIBLIOGRAPHICAL NOTE.

THE sources of information for the study of the economic and geographical aspects of sugar are scattered in innumerable periodical publications and official reports and in works dealing primarily with other subjects. It would, therefore, be impracticable within small compass to give anything like an adequate list of references or even to indicate the sources of the material utilized in this volume. It may, however, be useful to some readers to indicate here a few of the more recent works of reference dealing with other aspects of sugar. As has been indicated in the preface, the books that have been published concerning sugar deal mainly with the technical side of sugar production. One or two books on certain general aspects that are outside the scope of this volume are also indicated below.

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INDEX

Numbers in heavier type indicate principal references; the details of such references are in general not separately indexed unless in other connections.

- AGRARIAN revolution, 87, 88
Aguardiente, 80
Albania, consumption, 107
Alberta, beet, 98
Alcohol, cane, 16, 52, 80; beet, 24
American producers, *see* United States producers
Anomala, 68
Antigua, *see* British West Indies
Archipelago canes, 127
Argentina, 81-82; area cane, 84; consumption, 106; frost, 9;
production, 3, 84, 124
Assimilation, plant food, 9
Australia, 51-53; alcohol production, 16; area cane, 60; beet,
58; consumption, 106, 110-111, 121; export to U.K., 4, 44-45;
frost, 9; molasses production, 16; population, 109; produc-
tion, 3, 60, 123
Austria, consumption, 106; import, 90
Austria-Hungary, export to U.K., 45, 103
- B. 247, 127
Badila, 51
Bagasse, 16, 102
Bahia, *see* Brazil
Balkans, consumption, 114, 117; taxation, 117; *see also separate
countries*
Baltic States, consumption, 106-107; imports, 4, 105; *see also
separate countries*
Barbados, *see* British West Indies
Belgium, consumption, 106, 108; import from Brazil, 80; *see
also Europe*
Bengal, *see* India
B.H.10 (12), 49, 70, 77
Big Tanna, 49
Bihar and Orissa, *see* India
Black Cheribon, 127
Bois Rouge, 80
Bolting, 17, 19
Bombay, *see* India
Bone-char, 92, 93-94
Borer, 28, 49, 68, 70, 71, 79, 80, 82

- Bourbon, 79
 Brazil, 79-80; alcohol production, 16; consumption, 106;
 export to U.K., 45, 80; production, 1, 84, 124
 British Guiana, *see* British West Indies
 British Malaya, imports, 4
 British West Indies, 48-50; area cane, 59-60; export to U.K.,
 44-45; production, 3, 59-60, 123
 Brown sugars, 93
 Brussels Convention, 25, 48, 103
 Bulgaria, agricultural population, 113; consumption, 107, 117;
 production, 88; taxation, 117
 By-products, beet, 23-24, 125; cane, 15-16, 129
- CALIFORNIA, *see* United States beet
 Canada, beet production, 58; consumption, 106; export, 104;
 import, 4, 79; population, 109; preference, 45, 48
 Cane board, 16
 Cane tops, 16
 Cantley, 56
 Capital, beet, 23, 118; cane, 14, 118, 124; refining, 98, 101;
see also separate countries
 Carbohydrates, 110, 121
 Carbons, vegetable, 101-102
 Carlow, 58
 Caribbean, 1, 3; *see also separate countries*
 Cartels, 90, 104
 Catende, 80
 Central America, 3; *see also* Mexico
 Chancaca, 79
 Chicama, 78, 79
 Chile, import, 4, 79
 China, consumption, 4, 107, 115-116; import, 4, 36, 115-116;
 production, 1
 Cienfuegos, 27
 Climate, beet, 18-20; cane, 6-10; influence on world production,
 3; *see also separate countries*
 Clyde, refineries, 94, 95, 96-97, 98
 Colonial sugars, *see* Empire sugars
 Colorado, *see* United States beet
 Competition of cane and beet, 14-15, 125, 129-130
 Consumption, dietary custom, 109-111, 121-122; Eastern, 115-
 116; elasticity, 112-113; per capita, 106, 109-115, 119-120;
 propaganda, 120-122; prospects, 129-130; relation to money
 income, 112-113, 114, 120; relation to production, 118-119;
 relation to rural and urban populations, 113-115, 120; taxa-
 tion, 116-117, 120; total, 107-109, 118-119
 Cristalina, 28, 77
 Critical periods, Java, 32; Louisiana, 71-72; precipitation, 7
 Crockett, 68, 96, 98

- Cuba, 25-30; consumption, 106; costs of cane, 13; exports, 4, 45, 62-63, 105; factories, 14, 15, 34; growth of cane, 6; hurricanes, 10; labour, 11-12; market, 98; molasses, 16; reciprocity, 48; refining, 103, 105; soils, 10-11; production, 1, 2, 3, 123; transport, 15
- Cubes, 93
- Cultuur system, 31
- Curly top, 64
- Czechoslovakia, beet seed, 18; consumption, 106, 108; export, 43, 45, 103, 104; factories, 23, 58; production, 2; *see also* Europe
- D.625, 49
- D.1135, 67
- Damage, 94, 100
- Danzig, 89
- Denmark, consumption, 106, 111
- Desiccation, beet, 22
- Deterioration, beet, 20, 22; cane, 8, 9, 10, 14
- D.I.52, 127
- Diet, 109-111, 120-122
- Direct consumption sugars, *see* mill-white sugars
- Diseases, beet, 19; cane, 8, 10, 127, 129; *see also separate countries*
- Diversification, Cuba, 30; Java, 37
- Dominican Republic, 77-78; export, 4, 45, 77, 78; production 3, 77, 84, 124
- Drought, beet, 19; cane, 7; *see also separate countries*
- EAST AFRICA, 50-51**
- Eastern Counties, 97
- Effluent, beet, 22
- Egypt, 83-84; production, 3
- E.K.28, 127
- Embargo, Australia, 52-53
- Empire sugars, 44-61; 104, 123; *see also separate countries*
- Energy foods, 109-110, 121
- Estonia, consumption, 106-107
- Europe, 85-91; beet area, 125; beet, effect on other crops, 23; consumption, 3-4, 106-115, 117; export to U.K., 4, 103-104; production, 2, 3, 118, 124-126; taxation, 116-117
- Extensive methods, Cuba, 28, 30; general, 126
- FACTORY, beet, 17, 18, 19, 21-23, 98-99; cane, 12, 14-16, 129**
- Fats, 110
- Feeds, beet, 24; cane, 16
- Fiji, 50; cane area, 59; export, 45; production, 3, 59
- Fiji disease, 52, 74
- Filter-press cake, 16

- Finland, consumption, 106-107 ; production, 88-89
 Fiume, 90
 Food value, 109-110
 Formosa, 81 ; cane area, 84 ; hurricanes, 10 ; production, 3, 84
 France, consumption, 106, 108 ; import, 4 ; machinery export
 to India 43 ; *see also* Europe
 Froghopper, 49
 Frost, beet, 19 ; cane, 9, 51, 54, 71, 72, 81, 82, 83
 Fuel, beet, 22 ; cane, 16 ; refining, 94, 95, 102
- GERMANY, beet strains, 17 ; consumption, 106, 108, 111, 112 ;
 export, 43, 45, 103-104 ; factories, 21, 23, 58 ; machinery
 export to India, 43 ; population, 109 ; production, 2 ; tem-
 peratures, 19 ; *see also* Europe
 Granulated, 93
 Great Britain, *see* United Kingdom
 Greece, consumption, 107
 Greenock, *see* Clyde
 Greyback, 52
 Growth, beet, 17 ; cane, 5-6
 Gummosis, 47, 51, 80
 Gur, 38, 39, 40
 Gyrotiller, 12
- H.109, 67
 Haiti, 78, export to U.K., 45, 124 ; production, 1, 25
 Hamburg, 89, 104
 Hardback, 47
 Harvest, beet, 18, 19, 20-21 ; cane, 8, 12-13, 14 ; seasons, 3
see also separate countries
 Hawaii, 66-68 ; cane area, 76 ; export to U.S.A., 4, 63 ; irrigation,
 8 ; labour 12, 13 ; market, 98 ; molasses, 16 ; production,
 3, 63, 76, 124 ; yields, 128
 Historical development, 1-2 ; *see also separate countries*
 Holland, *see* Netherlands
 Hungary, agricultural population, 113 ; consumption, 107 ;
 export, 43, 89, 90
 Hurricanes, 10, 26, 69, 77
- ICELAND, consumption, 106
 Iloilo, 74
 Imperial preference, 44-45, 123
 Indenture system, 13-14, 46-47, 49, 50, 51, 54
 India, 38-43 ; agricultural population, 113 ; consumption, 4, 115 ;
 import, 4, 36, 47, 105, 115 ; irrigation, 8 ; molasses import, 16 ;
 production, 1, 2, 3, 123
 Intensive methods, 37, 126-129
 Inversion, beet, 20 ; cane, 8, 9, 14

- Irish Free State, consumption, 106, 114 ; import, 45, 104-105 ;
production, 58, 88-89
- Irrigation, 6, 8, 14, 26, 32, 38, 64, 69, 78, 81, 82
- Italy, agricultural population, 113, 114 ; consumption, 107,
108, 110, 111-112, 114, 117 ; production, 86, 88 ; taxation, 117
- JAMAICA, irrigation, 8 ; production, 1 ; rum, 15 ; *see* British
West Indies
- Japan, consumption, 4, 107 ; import, 4, 36
- Java, 31-37 ; assimilation, 9 ; consumption, 109 ; critical
periods, 7 ; export, 4, 43, 45 ; irrigation, 8 ; labour, 12 ;
molasses, 16 ; production, 1, 2, 3, 123 ; sucrose content, 9 ;
varieties, 126-127 ; wind, 10
- Jones law, 73
- KANAKAS, 51
- Kauai, *see* Hawaii
- Kenya, *see* East Africa
- Khandsari, 39, 42
- Kieselguhr, 92, 94
- LABOUR, beet, 17-18, 19, 20-21, 125 ; cane, 11-14, 129 ; refining,
95-96, 102 ; *see separate countries*
- Latvia, consumption, 106-107
- Leaf-hopper, 68
- Leaf-scald, 47, 51, 74
- Leaf-spot, 19
- Leewards, *see* British West Indies
- Light, beet, 20 ; cane, 9-10
- Lithuania, agricultural population, 113 ; consumption, 107
- Liverpool, refineries, 94, 95, 96, 97, 98
- Livestock, relation to beet, 23, 64, 87-88, 125, 130
- Locusts, 74
- London, refineries, 94, 95, 96, 97, 98
- Louisiana, 71-72 ; cane area, 76 ; cane board, 16 ; frost, 9 ;
hurricanes, 10 ; market, 98 ; production, 3, 63, 76, 124
- Luzon, *see* Philippines
- Luzon White, 75
- MACHINERY, beet, 21 ; cane, 11-12, 13, 50, 72 ; import to India,
43
- McKinley tariff, 62
- Madras, *see* India
- Maffra, 58
- Manure, beet, 24 ; tops as, 24
- Matanzas clays, 26
- Maui, *see* Hawaii

- Mauritius, 46-47; cane area, 59; export to U.K., 4, 44-45; hurricanes, 10; irrigation, 8; molasses, 16; production, 3, 59, 123; sucrose content, 9
- Mediterranean, consumption, 116-117; taxation, 117; *see also separate countries*
- Mexico, 82-83; cane area, 84; consumption, 107; production, 84, 124
- Michigan, *see* United States beet
- Millwhite, Chinese consumption, 115-116; competition with refined, 98-99; Indian consumption, 40, 115; Java, 36; Mauritius, 47; production, 15
- Moisture, beet, 18-19; cane, 6; *see also separate countries*
- Molasses, beet, 24; cane, 16, 50, 52, 100
- Mosaic, 28, 49, 52, 54, 69, 71, 74, 77, 80, 82, 83
- NATAL, *see* South Africa
- Negros, *see* Philippines
- Negros Purple, 75
- Nematode, 64, 89
- Netherlands, consumption, 106, 108, 117; export, 103-104; factories, 23; import, 4; production, 124-125; taxation, 117; yields, 128; *see also* Europe
- New South Wales, *see* Australia
- New York, refineries, 94, 96
- New Zealand, consumption, 106, 117; import, 4, 50; population, 109; taxation, 117
- Nipe, 27
- North Africa, import, 4
- Norway, consumption, 106-107, 117; taxation, 117
- OAHU, *see* Hawaii
- Ontario, 58
- Otaheite, 79
- PANAMA CANAL, 70, 78
- Payne-Aldrich law, 73
- Peak year scheme, Australia, 52-53
- Pernambuco, 79, 80
- Persia, import, 90
- Peru, 78-79; consumption, 107; export, 45; irrigation, 8, 9; production, 84, 124
- Pests, 127; *see separate countries*
- Philippines, 73-75; export to U.S.A., 4, 63, 98; production, 3, 63, 76, 124
- Phytalus, *see* Hardback
- Piloncillo, 83
- Plant cane, 5, 6
- Planting, 12
- P.O.J. canes, 71, 80, 81, 82, 83, 127, 128

- Poland, agricultural population, 113; beet seed, 18; consumption, 107-108, 122; export, 43, 45; *see also* Europe
 Pool, Australian, 52-53
 Population, 108-109, 119-120
 Port au Prince, 78
 Porto Rico, *see* Puerto Rico
 Portugal, consumption, 107, 117; import, 80; taxation, 117
 Powdered sugar, 93
 Precipitation, 6-9; *see also separate countries*
 Preta, 80
 Price, beet, 22, 23
 Prices, sugar, 118-119
 Processes, beet-sugar, 22; refining, 92-93
 Prohibition, liquor, 111
 Propaganda, 120-122
 Puerto Rico, 68-70; cane area, 76; cane import, 78; export to U.S.A., 3, 63, 98; machinery, 12; production, 3, 63, 76, 124
 Puerto Tarafa, 27
 Pulp, beet, 24
 Punjab, *see* India
 Purity of juice, 10

QUEENSLAND, *see* Australia

- RAB, 39
 Rainfall, *see* Precipitation
 Rapadura, 80
 Ratoons, 5, 6
 Raw sugar, 92; damage, 94; co-efficient, 99-100
 Rayada, 77
 Reciprocity, *see* Cuba
 Refining, 92-105; accessories, 93-94; in beet factories, 22, 58; capital, 98, 101; costs, 93; fuel, 94, 102; labour, 95-96, 102; margin, 95, 104; market, 96-97, 101; processes, 92-93; scale of operations, 95-96; transport, 94-95, 99-101; tropical competition, 98-103
 Réunion, 3
 Rio de Janeiro, 80
 Rotations, beet, 23, 56, 65, 90, 125, 130
 Rum, 15, 50
 Rumania, consumption, 107, 117; export, 89; production, 88; taxation, 117
 Russia, *see* U.S.S.R.

- ST. KITTS-NEVIS, *see* British West Indies
 St. Lucia, *see* British West Indies
 Salaverry, 79
 Salta, 82

- San Pedro de Macoris, 77, 78
Santa Catalina, 78
Santo Domingo, 1, 25; *see also* Dominican Republic
Sao Paulo, 80
S.C.12 (4), 70, 77
Scandinavia, consumption, 106; import, 4, 105; *see also separate countries*
Seed, beet, 17-18, 21
Semarang, 35
Sem Pelo, 80
Sereh, 31
Short-cropping, 67
Singling, 20-21
Slavery, 13-14, 25, 46, 70, 71, 80
Soerabaja, 35
Soils, beet, 19, 20; cane, 10-11; *see also separate countries*
South Africa, 54-55; alcohol, 16; cane area, 61; export to U.K., 44-45; frost, 9; consumption, 106; labour, 12, 13; production, 3, 5, 61, 123; sucrose content, 9
South Platte Valley, 64
Spain, consumption, 107, 108, 110, 112, 114, 117; production, 88; taxation, 117
Spreckels, 65
State control, Australia, 52-53
Statistics, inadequacy of consumption, 122
Streak, 54
Subsidy Act, British, 55-56; Irish Free State, 58
Sucrose content, beet, 17, 18-19, 20, 128; cane, 14, 128
Sulphitation process, 47
Sweden, consumption, 106, 108, 112-113, 117; import, 89; taxation, 117
Switzerland, consumption, 106, 117; import, 4, 90; taxation, 117
Syrups, 93, 97
- TARIFFS, Australian, 52; Canadian, 45, 48, 50; European, 90, 125; Indian, 40-41; South African, 55; United Kingdom, 44-45, 47, 50, 53, 55, 104; United States, 62-63, 64, 75, 105
Taxation, revenue, 110, 114, 116-117, 120
Tea, 111
Temperature, beet, 19-20; cane, 9; *see also separate countries*
Top-rot, 82
Tops, beet, 21, 23-24
Transport, beet, 21-22, 24; cane, 14; sugar, 94-95, 99-101
Trieste, 89
Trinidad, *see* British West Indies
Tucumán, 81, 82
Turkey, consumption, 107
Typhoons, 74, 81

- UBA, 5, 12, 54**
 Uganda, *see* East Africa
 Ukraine, *see* U.S.S.R.
 U.S.S.R., agrarian revolution, 87-88; agricultural population, 113; beet area, 86, 91; climate, 85; collectivization, 88; consumption, 107, 113; export, 43, 90; labour, 86; land tenure, 87; organization, 90; population, 109; production, 85, 86, 88, 91, 118, 125-126; soil, 85; War, 88; yields, 91
 United Kingdom, beet area, 61; beet production, 4, 55-59, 86, 88-89; consumption, 3, 103, 106, 108, 110, 111, 113, 121; export, 43, 104-105; factories, 22, 23; import, 4, 36, 44-45, 46, 89-90, 103-105; machinery export, 43; market, 96-97; molasses import, 16; population, 109; refinery capacity, 98, 103-104; refinery capital, 98; refinery location, 94, 95; tariff, 44-45, 47, 50, 53, 55, 56, 57, 58, 104; yields, 61
 United Provinces, *see* India
 United States, beet, 63-66; beet area, 76; beet production, 76, 118; cane, 63, *see* Louisiana; consumption, 4, 63, 105, 106, 107, 108, 110, 111, 113, 121; export, 104, 105; factories, beet, 23, 65; import, 4, 29, 36, 62-63, 75, 105, 124; machinery export, 43; molasses, import, 16; production, 3, 63, 123, *see also* U.S. beet and Louisiana; reciprocity, *see* Cuba; marketing, 4; population, 109, 111, 121; refiners' margin, 95; refinery capacity, 98, 105; refinery capital, 98; refinery location, 94; refining costs, 93; tariff, 62-63, 64, 66, 68, 73, 105, 123
 United States producers, 62-76, 123-124
 Urbanization, 114-115, 120
 Uruguay, import, 80, 105
 Utah, *see* United States beet

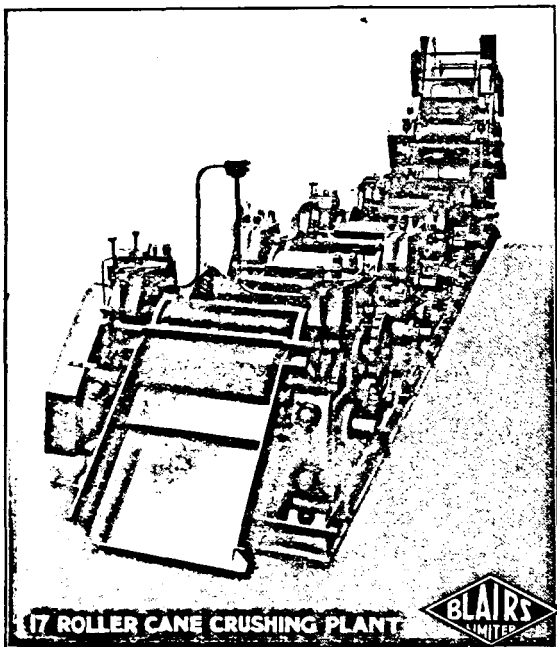
VARIETIES, beet, 17-18, 19, 89, 128-129; cane, 5, 126-129; *see also separate countries*
 Victoria, 58
 Virgin Islands, 63

WAR, 2, 31, 88, 103, 107, 111, 121
 West Indies, historical development, 1; hurricanes, 10; plant food assimilation, 10; rum trade, 15; *see also separate countries*
 Wilson tariff, 62
 Wind, effect on cane, 10

YEAST, 24
 Yields, beet 17-18, 89, 126-129; cane, 5, 8, 126-127, 128-129
 Yugoslavia, consumption, 107, 117; export, 89; production, 88; taxation, 117

ZULULAND, *see* South Africa

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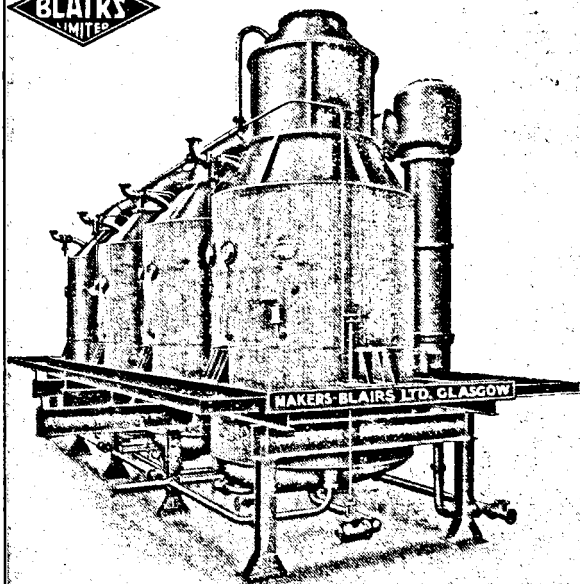
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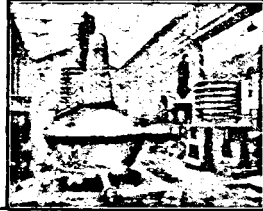
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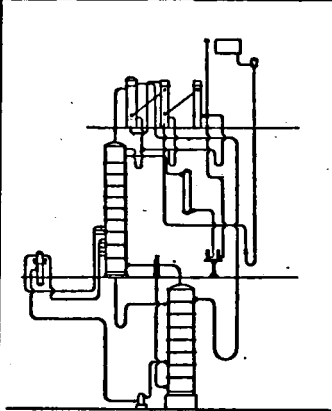
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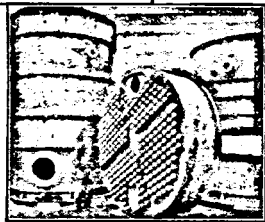
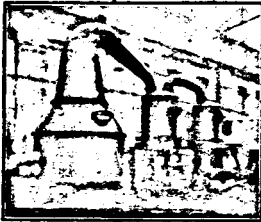
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