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REPORT

ON THE

PROSPECTS OF CINCHONA CULTIVATION IN INDIA

BY

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ASSISTED BY

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Officers on Special Duty for this enquiry under the Imperial Council of Agricultural Research, India.

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INTRODUCTION

1. This report has been prepared under the following circumstances. The Indian Research Fund Association suggested to the Central Advisory Board of Health that an investigation by an officer experienced in cinchona cultivation should be made to determine—

(*a*) what areas in India are most suited to cinchona cultivation; and

(*b*) what would be the cost of production in such areas.

2. These proposals were welcomed by the Central Advisory Board of Health and passed as Resolutions at a meeting held in July 1937.

3. The Government of India accepted the recommendation of the Central Advisory Board of Health and agreed that the investigation, subject to the approval of the Governing Body, should be carried out under the auspices of the Imperial Council of Agricultural Research. The Governing Body of the Imperial Council of Agricultural Research agreed to meet from its research funds the cost of the Enquiry.

4. I was appointed to conduct this Enquiry in a communication from the High Commissioner for India (No. G-116-11-29, dated 11th September 1937) and Dr. T. J. Mirchandani, M.Sc., Ph.D., Agricultural Chemist to the Government of Bihar, was associated with me as Soil Chemist. Dr. Mirchandani is responsible for the description of the soil profiles and for the analytical data in this report. The writer is under a great obligation to Dr. Mirchandani for his loyal support and helpfulness during a prolonged tour in outlying parts. Dr. Mirchandani joins with me in thanking Rao Bahadur B. Viswa Nath, F.I.C., Director of the Imperial Agricultural Research Institute, for very welcome assistance in connection with the soil survey and especially for placing facilities for analytical work at the free disposal of the Enquiry.

5. *Acknowledgments.*—Of the many officers who have maintained the liveliest interest in this mission must first be mentioned Sir Bryce Burt, Vice-Chairman of the Imperial Council of Agricultural Research and Col. A. J. H. Russell, Public Health Commissioner with the Government of India. To the members of the Cinchona Sub-Committee, acknowledgment is made for their helpful advice. Lt.-Col. A. T. Gage, C.I.E., I.M.S. (Retired), who, it will be recalled, conducted a similar cinchona investigation in 1917, has been exceedingly helpful as well too as Mr. C. C. Calder, late Director of the Botanical Survey of India and Mr. P. T. Russell, formerly of the Bengal and Burma Plantations. On tour much assistance was given by Mr. B. J. Gould, Political Officer in Sikkim, Gangtok, Mr. C. F. Waterfall, Chief Commissioner of the Andaman Islands, Mr. P. S. Viswanatha Iyer, I.C.S., of Orissa, Mr. R. N. De, Silviculturist, Assam, Mr. K. R. Narayana Iyer of Travancore and Rao Bahadur C. J. Paul, Secretary to the Government of Madras. The officers of the Tocklai Research Station of the Indian Tea Association rendered the most useful service, while Mr. C. R. T. Congreve, President of the United Planters' Association of Southern India, laid his intimate knowledge of cinchona growing in South India freely at my disposal. Among others who were exceedingly helpful can be numbered

Mr. Eric Johnson and Mr. D. A. Sladden of the Bombay Burma Trading Company, Mr. J. H. Cantlay of the Madras Tea Estates, Cumbum, Dr. C. H. Harler, Scientific Officer of the Kanan Devan Hills Produce Company, Limited, Mr. Francis, General Manager of the same Company, Mr. C. S. Rajan of Messrs. A. V. Thomas and Co., Ltd., Alleppey and Mr. Dominic Joseph, Honorary Secretary of the Indian Planters' Association of Kerala. It is pleasing to record also the ready help given by Mr. L. G. Gallaher, President, Mysore Planters' Association, Mr. Humphreys, President of the Coorg Coffee Association, Mr. McLennan, President of the Assam Branch of the Indian Tea Association and Mr. Durnford, President of the Darjeeling Planters' Association. This record would be incomplete were mention not made of the help rendered by Mr. H. Wheatley of the Government Cinchona Department, Madras and Mr. S. C. Sen of the corresponding Department in Bengal, and, indeed, of all the officers connected with the Cinchona Departments in India. Finally, I wish to record my appreciation of the most loyal services of Mr. Mohd. Sanaullah, my Stenographer, who accompanied me on my long tour of about eight months throughout India.

Preliminary Information.—It is convenient before the results of the investigation are considered that useful information should be given particularly regarding the terms in frequent use in this report.

Cinchona.—This name is applied to a genus of trees indigenous to South America. The trees are found in the dense forests of Peru, Bolivia and Ecuador at heights ranging from 2,500 feet to 9,000 feet above the level of the sea. These which are later referred to contain the alkaloid, Quinine, as well as others such as Cinchonidine, Cinchonine, and Quinidine, all of which are of service in the treatment of malarial fevers, although Quinine is assuredly the most important in commerce.

Cinchona Ledgeriana.—This species yields "Yellow or Ledger bark" and is easily first in importance. The bark is used for the manufacture of Quinine to such an extent that the area under other species is of minor importance. Cinchona Ledgeriana is therefore the principal variety cultivated in Java which produces nine-tenths of the world's quinine. It is grown practically to the exclusion of the other species in the Bengal Cinchona Plantations and on an increasing scale in the corresponding plantations in Madras. It will grow in India at elevations ranging from 5,000 feet down to 1,500 feet, but 4,000 feet can be assumed to be the most desirable elevation so far India is concerned.

Cinchona Calisaya is now regarded as a hybrid form of Cinchona Ledgeriana. Chinchona Calisaya was highly esteemed for its quinine contents but suffered a total eclipse when the merits of Cinchona Ledgeriana became known later. At first, then, the term Cinchona Calisaya was used for all varieties of "Yellow Bark".

Cinchona officinalis.—This species gives the "Crown Bark" of commerce. It is cultivated at very high elevations in the Nilgiris of South India from 8,000 feet to 7,000 feet, where it grows vigorously. It is suitable for the manufacture of quinine, but the bark is inferior in quinine content to that of Cinchona Ledgeriana.

Cinchona succirubra.—This species gives "Red Bark". The bark of this species is not employed for the extraction of quinine on account of the low content of that alkaloid. It contains, however, such a quantity of other

alkaloids—namely, Cinchonidine, Cinchonine and Quinidine—that it is by no means to be despised. In fact, Cinchona succirubra is the species which the League of Nations Malarial Committee had in view as the source of "Totaquina"—a standardised preparation of all the alkaloids of cinchona bark—which was officially recognised in the British Pharmacopoea of 1932. This species is of vigorous habit and grows from 6,000 feet down to 2,000 feet above sea level.

Cinchona robusta.—The origin of this kind is uncertain but it is presumed to be hybrid between Cinchona succirubra and Cinchona officinalis. This species grows well at Naduvattam on the Government Cinchona Plantation there at elevations ranging from 6,000 feet to 3,500 feet.

It is employed for the extraction of quinine but is not so rich in quinine as Cinchona Ledgeriana. It contains Cinchonidine, Cinchonine and Quinidine in fair quantities as well, which suitably compounded form the modern "Totaquina". Thus, in a way, Cinchona robusta can be considered as an improved type of C. succirubra.

Distribution.—For a variety of reasons it is not possible to give the probable distribution of these species on a plantation scale in the world. It is understood, however, that there has been considerable experimental planting in the Belgian Congo, East and West Africa and perhaps too in Indo-China of which there is no definite information. Taking all the plantations in the world into consideration, probably not less than ninety-four per cent. is occupied by trees of Cinchona Ledgeriana and its hybrids—a figure which eloquently shows its commanding position—three per cent. by Cinchona succirubra, two per cent. by Cinchona robusta and the balance or one per cent. by Cinchona officinalis. If India only is considered, the proportions are as follows:—

Cinchona Ledgeriana—72 per cent.,

Cinchona robusta—22 per cent.,

Cinchona officinalis—5 per cent., and

Cinchona succirubra—1 per cent.

Cinchona bark.—It is only from the bark of the cinchona tree that the valuable alkaloid—Quinine—is obtained. Cinchona bark therefore has a definite place in commerce. Naturally, as will be appreciated later, the different species of cinchona yield varying quantities of quinine and associated alkaloids. Mere weight of bark therefore is no criterion to the worth of a consignment. The quinine manufacturer buys cinchona bark from the planter at a definite rate per unit.

Unit.—The unit employed in the trade is the percentage of quinine (reckoned as quinine sulphate) which is contained in the bar. It is 1/100 lb. of quinine sulphate in 1 lb. of cinchona bark. The determination is made by chemical analysis in a laboratory. The unit rate is the market price of a unit. Thus a quantity of cinchona bark of 5 per cent. quinine sulphate is said to contain 5 units or 5/100 lb. of quinine sulphate in each pound of bark. From this the planter, who deals in pounds of bark, knows that he will get 5 x 2 or 10 annas per lb. for his bark (assuming that 2 annas is the unit rate).

Cost of quinine sulphate in bark form.—The manufacturer in turn knows that if 2 annas is the unit price, one lb. of quinine sulphate in the

raw material, unextracted, will cost him $2 \times 100 =$ Rs. 12-8 no matter what percentage of quinine sulphate is in the bark. Thus, if a consignment contains only 2 per cent. quinine sulphate it will require 50 lbs. of cinchona bark to yield 1 lb. of quinine sulphate; for 3 per cent., 33 lbs.; for 4 per cent., 25 lbs.; for 5 per cent., 20 lbs. and so on. Naturally, the richer the bark is in quinine, the fewer pounds of bark will be needed by the quinine manufacturer to produce 1 lb. of quinine sulphate in his factory thus saving in chemicals, transport and storage. On this account it has been the practice for nearly forty years in South India to add a bonus to the unit rate to the bark supplier with rising percentages of quinine in the bark.

Cost of Extraction.—This term is applied to the cost of the operation in the Quinine Factory from the arrival of the cinchona bark—the main raw material—until the finished article, quinine, is produced. It takes regard of all expenditure assignable to the Quinine Factory and the outturn in terms of pounds of quinine sulphate. The cost of extraction is thus obtained by dividing the expenditure by the outturn in pounds.

Cost of Manufacture.—The term refers to the total of the cost of quinine sulphate in bark form *plus* the cost of extraction.

Cost price of bark.—The cinchona grower ordinarily tries to obtain seed of as high a quinine sulphate strain as he can. The better the strain, the more expensive is the seed. Thereafter he concerns himself with the maximum outturn of cinchona bark per acre. The cost price of bark is thus the quotient of the estimated total expenditure and the number of pounds of bark produced.

Meaning of pH.—This is a term used in modern chemistry and does not admit of a simple explanation. *p*H is the effective acidity or alkalinity of a solution as opposed to the total acidity or alkalinity. The hydrogen ion concentration is measured in terms of *p*H from 1 to 14. *p*H 7 means a solution which is neither acid nor alkaline. As the values go below 7, they indicate increasing acidity; as they go above 7, they indicate increasing alkalinity.

Soil Profile is the unit of study in soil work and refers to a vertical section of the soil from the surface to the parent material. It represents the sum total of the chemical and physical changes which have taken place in the entire soil mass, and a number of soil layers or horizons are often recognisable.

"*Jhuming*" is the name applied to shifting cultivation as practised in Assam and the north of India. The corresponding term is "taungya" in Burma and "kumeri" in South India. It is responsible for the loss of millions of acres to cultivation. While this method of cultivation must be deplored, it has proved impossible to suggest an alternative suitable to the primitive people of the hills, who, for the most part, practise it.

A. WILSON

PART I.

CHAPTER 1.

EARLY HISTORY.

From the Forest to the Plantation.

1. Although an annotated account of how the cinchona tree from the wilds of the Andes found its way to plantations in Java and India is unnecessary in a report of this kind, yet a survey of the main happenings will not only, it is hoped, be of general interest but also will lead to a readier appreciation of the state of things in India today.

2. The bark of the cinchona tree was long ago recognised as a fever-freeing drug. It was employed as a decoction and the classic patient who was cured of an attack of fever by its agency was the Countess of Chinchon, wife of a Spanish Viceroy of Peru, about 1639. A hundred years later, Linnaeus, the great Botanist, perpetuated the memory of this noble lady by giving the genus the name *Cinchona*. No real effort was made to cultivate cinchona trees in the South American forests and still less to maintain supplies by replanting, even though a substantial revenue was obtained by taxing the exports of bark. Consignments found their way to the seaports of Europe and cinchona bark thus became world famous for its virtue as a cure for fever. It was not however till 1820 that quinine as the main alkaloid of cinchona bark was isolated by French chemists. Soon after this discovery of quinine, the sulphate of that alkaloid drove out of fashion, to a very large extent, the powders, tinctures and decoctions which had established the reputation of the bark.

3. As long ago as 1835 Dr. Forbes Royle, the Superintendent of the Botanical Gardens at Saharanpur, suggested to the East India Company that efforts should be made to introduce cinchona into India and he selected the Nilgiri Hills in South India and the Khasia Hills in Assam as likely localities for plantations. "The probability of entire success in the cutivation of cinchona trees in India", he wrote, "seems to admit of hardly any doubt, if ordinary care is adopted in the selection of suitable areas". Of the many names which are worthy of record in influencing the initiation of cinchona planting in tropical lands, pride of place must be given to Dr. H. A. Weddell, who spent the period from 1845 to 1848 in investigating the natural occurrence of the cinchona trees in South America, the description of the species and the methods by which cinchona planting might be commenced. Commenting on the recklessness with which the primeval cinchona forests were cleared without any check and fearing that one day the tree would disappear from the forests, he wrote, "There remains the resource of cultivation and it must be employed..... If there is a tree worthy of acclimatization, truly it is cinchona and posterity will bless those who shall have carried out such an idea". Dr. Forbes Royle in India continued a like advocacy up to his death in 1857 by which time he had persuaded the East India Company to despatch an expedition to South America to obtain cinchona seeds and, if possible, plants. Mr. Clements Markham was selected for the work of scouring the forests for seed and a happier choice could not have been made owing to his knowledge of the Andes and his ability to speak the language.

THE COMMENCEMENT OF PLANTING IN INDIA MAINLY IN THE SOUTH, 1861.

4. Returning with his seeds and plants to India in 1860, the services of Mr. Markham were utilised in determining the suitability of all the accessible uplands of South India for cinchona. The Nilgiri Hills had, as stated above, been mentioned as a very promising place for the experiment of raising cinchona seedlings and founding regular plantations, and an area called Dodabetta, near Ootacamund, was made ready by W. G. McIvor, then Superintendent of the Botanic Gardens at Ootacamund.

5. Approved of by Mr. Markham, work commenced in 1860 to raise seedlings and to make cuttings from the imported plants; later innumerable experiments were carried out in all phases of plantation management. A second experimental station was selected at Naduvatam, Nilgiri Hills, at an elevation of about 5,800 feet to experiment with species requiring a lower altitude. It is interesting to record that these old plantations are still in existence—Dodabetta being one of the few centres in the world where Cinchona officinalis is cultivated and Naduvatam, a much larger plantation, is the home of countless thousands of Cinchona robusta trees although, as will be seen later, it was as a centre of distribution of Cinchona succirubra trees that this plantation became noted.

The Cinchona Departments of Madras and Bengal have emerged from the experimental stations in the Nilgiris district of South India—briefly referred to above, and the Mungpoo area in the north of India, later developed between the years 1860 to 1864. The records show that it was never the intention that these experimental stations should be in any sense competitive plantations in relation to those which Government actively encouraged private enterprise to embark on.

6. The Government plantations tackled the problems of sorting out the miscellaneous parcels of seed of all descriptions and kinds, which came to this country through organised expeditions, and by the kindness of scientists throughout the world. There were introduced into planting procedure the most ingenious methods of germinating the small seeds of cinchona and of the after care of the seedlings, until these were fit for a permanent location in the plantation. Experiments were initiated to establish the correct elevation for each species and generally to ascertain the conditions for successful cultivation of the innumerable species and varieties to be tested. It was the work of the plantation management to distribute freely, and at the lowest cost, seeds and seedlings of suitable varieties for the experimenter. Generally, as a reference to the literature of period will show, Mr. McIvor brought to bear on his work a professional competence of a high order.

7. From the commencement of cinchona planting, the livelist interest was maintained in the work by the Secretary of State for India and it is largely due to the broad vision of Sir Charles Wood that the importance for India of a home-grown cure for malaria was not allowed to be forgotten. Two years after cinchona planting had been in progress in South India there was, in the official view, an absence of that expected enthusiasm to plant up the hill ranges by private enterprise. As a result it was decided to enlarge the area of the cinchona plantations on the Nilgiris "while extending every legitimate

encouragement to private enterprise". Although the Secretary of State approved of a planting scheme of 150 acres annually for ten years, at the same time, he focussed the attention of the administration in India on what he regarded as the main object of cinchona growing in India. "Cinchona cultivation should be introduced into the hill districts of your Presidency as well as in Coorg. The two great objects of the experiments are—the provision of an abundant and certain supply of bark for the use of hospitals, troops and the spread of the cultivation throughout the hill districts, in order to bring the remedy within the reach of frequenters of jungles and of the population generally.....the experiment cannot be regarded as a mere money speculation nor are the commercial advantages that may be derived from it to be considered as other than a secondary consideration; though, of course, a return for the outlay and the spread of cinchona cultivation by private enterprise, are very desirable in themselves".

CINCHONA PLANTING IN THE GOVERNMENT PLANTATIONS IN NORTH INDIA, 1863.

8. So far the record pertains to the development of cinchona in South India but during this time the need to test the northern areas in India was fully realised. "A beginning was made under much less favourable circumstances than in Madras. No plants were sent hither from South America nor was the experience of Mr. Markham available in the selection of the most hopeful localities in the Himalayas or the Khasia Hills". Cinchona seeds were obtained from Kew Gardens and from these a small number of plants were raised at Sibpur in 1861 but a suitable place to test the plants was not then decided on. Favourable accounts of the success achieved by the Dutch in Java had reached India, so Dr. Anderson of the Royal Botanic Garden, Sibpur, visited that island in that year. He exchanged some of his Java bred cinchona plants and seed for South India plants and seeds with Mr. McIvor at Ootacamund. Misled, however, by the estimation of the various travellers in South America of the coolness and moisture needed by the cinchona tree, Dr. Anderson began his experiments on the exposed mist-laden air of Senchul, above Darjeeling. But failure overtook the work as conditions were much too rigorous at this high altitude. Most of the available forest land in Darjeeling district had been taken up for tea cultivation and after a prolonged search, owing to the absence of roads, Dr. Anderson finally selected a long spur running from the main ridge of Senchul but at a distinctly lower elevation to that of his previous experiment. This began in 1863, fully three years behind the work in South India. On this same ridge today can be seen the flourishing Cinchona Plantation of Mungpoo as well as the Government Quinine Factory, bearing out the wisdom of the choice. By 1864 there were 523 cinchona plants on Mungpoo ridge, as it may broadly be called while there were over 165,000 plants in the corresponding plantation in the South.

9. By 1865-1866 there was a stock of over 175,000 plants while Mr. McIvor was able to report over one and a half million plants of all ages of which 40,000 were planted out in the permanent plantation. Obviously therefore the extension of cinchona in India was proceeding apace. Both in the North as well as the South effort was concentrated on the propagation of Cinchona succiruba and Cinchona officinalis. But it became apparent that while Cinchona officinalis was happy in its new home in the south, it was more or less a failure in the environment of Mungpoo. In Mungpoo, Cinchona

Calisaya was known to be the best of the medicinal cinchonas and promised well but Cinchona succirubra was easier to cultivate, was less stringent in its requirements of soil and situation so that Calisaya was accordingly cultivated on a restricted scale. Later the appointment of a Quinologist—a chemist to deal with problems in quinine manufacture and allied analytical work—focussed attention on the relatively high value of the Calisaya variety compared with the others then cultivated. The Mungpoo plantations are unique in affording areas at an elevation of as low as 800 feet and as high as 6,000.

10. A small quantity of the famous seed of Ledger had been secured from Ootacamund in 1865. Although the especial virtues of this kind were not immediately recognised, still such progress was made with Cinchona Calisaya at Mungpoo that the administration was prevailed on to sanction the discontinuance of the planting of Cinchona succirubra altogether! In the language of the order of 1874, "The chemist's analyses confirm the fact that succirubra bark, of which the plantation at Mungpoo mainly consists, is greatly inferior to Cinchona Calisaya in the quantity of quinine which it contains while it presents at the same time peculiar obstacles to the extraction of the alkaloid therefrom".

11. The action of the Government of Bengal in stopping the planting of Cinchona succirubra was emphatically condemned by the Secretary of State at the time (the great Marquis of Salisbury). His objection took the line that the object of introducing cinchona cultivation into India was not a commercial one but one having reference solely to the supply of a cheap febrifuge to the people of India. The question to be considered was not what kind of bark fetched the highest price on the London market and was most sought after by quinine manufacturers but which kinds yielded the largest percentage of alkaloids which had been proved to be efficacious in the cure of fever. If the alkaloids of Calisaya were more easily separated than in succirubra and the percentage of yield was about equal, this was certainly a reason for preferring Calisaya. Naturally the rigorous exclusion of succirubra could not be pursued as a policy after this!

12. It is noteworthy however that, with the years, the staff at Mungpoo ferreted out the reasons why Calisaya was relatively a weak plant compared with Cinchona succirubra. With the inauguration, in the late eighties, of the manufacture of quinine sulphate—perhaps not very pure but still an achievement of great merit—the insistence on succirubra gradually was relaxed. Writing in 1937 on this point the head of the Cinchona Department in Bengal (Mr. C. C. Calder) stated in an interesting review of twenty five years work, "There is a widespread belief that Cinchona succirubra is more tolerant of Indian conditions than the richer Cinchona Ledgeriana. If the Bengal Cinchona Department's experiences may be taken as an indication of what may happen elsewhere it is time, in the writer's opinion, that this old theory was exploded. The truth is that while there are areas here that suit the red bark type better than the other, there is nothing to choose in the matter of difficulty of their cultivation, while from the point of view of the alkaloid content, Cinchona Ledgeriana is to be preferred. The idea that Cinchona succirubra is more easily grown and that its cultivation would allow of the employment of many more areas is not true as regards the first point and is true to a very limited extent as regards the second. Cinchona succirubra grows quicker and does

better than the other in damper localities but when it comes to a real test of drug for money, Cinchona Ledgeriana stands clearly the best in the light of our experience in Bengal". Certainly any one visiting the impressive stretch of Cinchona Ledgeriana at Mungpoo in 1938 must admit that there is more than a grain of truth in the pronouncement.

PLANTING IN THE EARLY DAYS BY PRIVATE ENTERPRISE IN THE SOUTH.

13. From the above can be appreciated the early activities of the state in Cinchona planting, whether that was in south or the north of India. But although perhaps tardily, it was not long before private persons were attracted to this new cultivation in the upper ranges of the Nilgiris and throughout the many hilly tracts of South India. In accordance with the orders of the Home Government, plants and seeds were freely given and facilities were provided for visitors to inspect the nursery and plantation work on the experimental plantation of the Government.

14. In the Wynaad district of South India, the coffee planters put out many trees of Cinchona succirubra as shade. On many plantations on the Nilgiri Hills, Cinchona was grown, mostly Cinchona succirubra, although Cinchona officinalis was also tried. There are records to show that Cinchona was tried besides in the following places in the south:—

(1) In 1869, a small plantation was formed at Nagoole in South Kanara at 2,500 feet but later abandoned. (2) On the Mahendra Mountain in Ganjam district there is reference about 1871 to an experiment. (3) On the Nallimallai Hills, the Forest Department attempted to grow Cinchona in cleared portions of the forest but the experiment had to be abandoned owing to hot winds over long periods. (4) In Coorg, there was opened an experiment in 1863 with Cinchona succirubra but of its ultimate fate there is no record although it is believed to have produced trees of 39 feet in height and of an average girth of 28 inches in 1875, that is twelve years after planting. (5) In 1862 at an elevation of 3,000 feet near Peermade, Travancore, a plantation of cinchona was opened by Travancore Government and was reported in 1870 as "looking generally very well". It was visited by Mr. Markham in 1865. (6) In the Pulney Hills, cinchona received much attention principally from Roman Catholic missionaries. (7) In the Tinnevelly Hills experimental plantations were made at various elevations from about 2,700 to 4,300 feet and under various conditions of exposure and soil. Some trees were planted on virgin forest land. "The position of the Tinnevelly Hills, where the plantations are situated, being practically uninhabited, the experiment cannot be said to have had the amount of attention that it merits". (8) Shevaroy Hills. Plants of Cinchona succirubra were planted as early as 1866 and "seem to have done very well". (9) In Mysore, Cinchona succirubra was extensively planted in coffee plantations. It can thus be realised that an enormous acreage of land in widely different elevations and under varying climatological conditions was brought under contribution in the great experimental work.

PLANTING BY PRIVATE ENTERPRISE IN NORTH INDIA—RISE OF JAVA.

15. *Darjeeling.*—It was inevitable that the experiments to raise cinchona seedlings in Darjeeling District should attract the attention of owners of land in the neighbourhood of the Government plantations. A cinchona plantation

financed by a private company began almost simultaneously with that belonging to Government. Throughout the tea gardens also, cinchona was extensively grown. But there was perhaps less enthusiasm for the new cultivation than in the South of India, although the extent of the private planting is far greater than is supposed. (*See* Table I.)

16. *Khasia Hills.*—Great hopes were entertained for this part of Assam. It had been stated to be a locality offering as great prospects of success as any in India and thus it was that the Khasia Hills were experimented with in a more thorough manner than was the case in many of the trial plantings. In 1867 a cinchona plantation was opened at Nungklo on the slope of the Khasia Hills. This was stocked with 600 plants of Cinchona succirubra and 50 of another species. The plantation remained under the charge of an officer of the Mungpoo Cinchona Plantation for over three years during which time he experimented with cinchona at altitudes varying from 4,585 feet above sea level down to the level of the plains of Assam. By 1869 there were in all 27,000 cinchona trees mainly of Cinchona succirubra but as the plantations in Mungpoo were much more promising, the work was left in the hands of a small Indian staff. The general findings from this work seem to have been that Cinchona succirubra trees will grow in this latitude as low as 800 feet and as high as 4,800 feet; above that they suffer from frost while at lower levels they present a sickly appearance, thus confirming the conclusions arrived at, in other places, of the unsuitability of level ground for cinchona cultivation.

17. *Hills of the U. P.*—Assistance was given by the Mungpoo Cinchona Plantation to the Superintendent of the Saharanpur Gardens with the object of acclimatizing cinchona near Dehra Dun and generally in Kumaon. Experiments were made at elevations of 2,500 feet at Chand Wallah, of 4,500 feet at Chegun in Garhwal and of 6,500 feet at Mussoorie as well as Hawal Bagh (Kumaon), Ranikhet and Urkulli. Frost killed most of the plants so that the general conclusion arrived at was that these parts of India "are not fitted for the cultivation of cinchona plants for commercial purposes".

18. *Kangra valley.*—No one in India was more enthusiastic about cinchona experimentation than Col. Nassau-Lees of the Kangra Valley in 1863. But unfortunately frost, as in the U. P. Hills, killed all the plants.

19. *Bombay.*—In the Mahableshwar Hills an experiment was made in 1864 at Lingmulli on the banks of the Yenna stream. Ten years after, the Bombay Government asked Mr. McIvor to visit the plantation and report on their condition. McIvor recommended that the plantation should be abandoned even though the soil, exposure and cultivation were favourable. The adverse factor was the heavy rain followed by a long period of draught.

20. Further afield in Ceylon, cinchona was taken up with a much greater degree of zeal than in India. The progress of planting in India was, however, followed with the keenest interest. Ultimately planting policy resolved itself into a scheme of growing Cinchona officinalis at elevations of as low as 4,000 feet (lower it will be noted than is found profitable on the Nilgiris) and Cinchona succirubra at any elevation from 2,000 feet to 4,000 feet.

21. In Java, which now holds such a commanding position, a start in cinchona planting was made fully eight years before India. The early work is a chronicle of the most intensive application on the part of the experimenters

coupled with very indifferent results owing to the worthless varieties which were cultivated. By 1864 it is stated that criticism took the line "that these costly experiments should be ended". This attitude, if it was general, was but the reflection of the disappointing results in the face of great natural advantages of soil. The apprenticeship, which Java served in the early days of frustration, was later revealed when a portion of Ledger's rich seed came into the hands of the Dutch in 1865. From then to the present day, the work of the Dutch experimenters has been attended with the most complete success which has placed that small island in a well-nigh impregnable position in cinchona cultivation.

WORLD PLANTING IN 1880 AT THE HEIGHT OF THE BOOM.

22. By 1880, the position of planting in the world can be readily understood by reference to the following figures. It must be remembered that the plantations were, for the most part, in an immature condition, thus accounting for the low yields:—

TABLE 1.

Estimated production of Cinchona Bark of all kinds with area planted and number of trees in the world—1880.

	Area cultivated.	No. of trees planted of all kinds.	Average estimated produce in dry bark per annum.
	Acres		lbs.
India—			
Mungpoo (Government plantations)	2,400	5,000,000	400,000
Darjeeling (Private plantations)	1,800	1,500,000	150,000
Nilgiris (Government and private)	2,200	2,000,000	300,000
Wynaad, Mysore and rest of India	3,600	6,000,000	100,000
Ceylon	33,500	50,000,000	1,000,000
Java	7,500	9,000,000	450,000
Jamaica	800	600,000	50,000
Mexico	50	20,000	..
South America—			
Columbia and New Granada	Large area covered with indigenous trees.		12,400,000
Peru and Bolivia			3,500,000
Ecuador			2,500,000
Rest of South and Central America	..	..	1,000,000
Total	..	..	21,850,000

Total (apart from S. America), 51,850 acres; 74 million trees.

As an indication of the progress of planting in Ceylon, figures from 1867 to 1880 are given below:—

TABLE 2.

Cinchona planted.

	1867	1869	1870	1872	1873	1874	1875	1876	1877	1878	1879	1880
Acres	50	100	200	500	1,500	2,000	3,000	4,200	5,578	10,000	20,000	33,568

All bark in Ceylon was grown purely for export and it is interesting to record the progress of exports from 1869 to 1880.

TABLE 3.

Exports of Cinchona Bark from Ceylon.

		Value
		Rs.
1869	28 oz.	50
1871	80 packages	313
1872	11,547 lb. and 694 packages	64,102
1873	44,836 lb.	32,667
1874	40,354 lb.	25,277
1875	19,152 lb.	17,963
1876	14,932 and 1 package	14,720
1877	72,127 and 1 package	88,738
1878	186,797 lb.	171,292
1879	507,368 lb.	519,086
1880	1,161,989 lb.	Say 1,200,000

It was estimated that from about 1885 "Ceylon should be able to send three to five million pounds of bark per annum into the home market provided falling prices or local utilization of the bark for the extraction of the alkaloids do not interfere too much". In 1887 it is recorded that the exports of bark from Ceylon were no less than 16,000,000 lbs.

23. The table at paragraph 22 shows that in 1880, Ceylon had double as many acres of cinchona—33,500—as in India and Java combined, and that there was no organised planting in any other part of the world on an extensive scale, save in Jamaica.

Before 1890 had been reached, however, the market for cinchona bark crashed in a manner similar to the more recently remembered incidents of October 1929 on Wall Street. The state of things is well described by Lt.-Col. Gage,—"After the introduction of Cinchona into India and Ceylon, the large profits made by the earliest private plantation led to an indiscriminate rush by planters and planting companies in India—especially South India— and Ceylon, into the new industry. An enormous acreage, very much in excess of the actual requirements or, at least, demands of the time, was planted with cinchona, chiefly Cinchona officinalis and Cinchona succirubra, species with a relatively low quinine content. Much of the cinchona was also undoubtedly planted on land unfitted to receive it. The result was, between 1880 and 1890, a stupendous over-production of bark—from Ceylon alone, between 1885-1887, about 30 million pounds of bark were placed on the market. This in turn caused a great drop in prices and a heavy decline in the acreage under cinchona. Had there been in existence an efficient Bureau of Planting Intelligence, supplying information as to the then and probable future demand for bark ..... the disaster might have been avoided ....." Col. Gage goes on to show that even after this crash, it might have been possible to rehabilitate the industry by applying scientific methods. "However", he remarks, "neither Government nor the planting community in South India made anything beyond the feeblest attempts to do so".

24. From the wreck of this great industry only Java survived. It is difficult to estimate the monetary loss which was involved in the depression just described. Certainly no fewer than 5,000 acres of cinchona belonging to private enterprise in India went out of cultivation. In Ceylon the corresponding acreage amounted to perhaps 30,000 acres. If any further figures are necessary to bring home the danger of uncontrolled trading in a substance like cinchona so essential to public health, comparison of the exports of Cinchona bark in Ceylon for three years will suffice.

TABLE 4.

Exports from Ceylon.

1891 . .	5,589,550 lbs.	Cinchona bark.
1912 . .	111,918 „	„ „
1925 . .	18,592 „	„ „

25. In the same period Java, as a producing centre, rose from a figure of about 1,000,000 lbs. in 1891 to 20,000,000 lbs. or so in 1925 and even for 1937 the figures are doubtless equally flattering (despite the quota of 52 per cent.

of the standard assessment which is imposed on the industry). The power to weather this storm on the part of Java was due mainly to (1) the close scientific control which had been exercised from the time that the valuable Cinchona Ledgeriana came into the island about 1865, (2) the substitution of low yielding varieties of Cinchona by better and richer kinds, (3) the possession of a soil immeasurably better suited to cinchona than the average land brought into cultivation in India and Ceylon, and (4) an even distribuition of rain throughout the year. If it were conceivable that some power could offer to the planter of Cinchona in India that condition of success which most appealed to him, without a doubt he would ask for the last—an even distribution of rain.

Ascendency of Java and formation of the Kina Bureau.

26. Although the cinchona planting in Java survived the slump of the end last century, there were anxious days for the Dutch industry. Especially was this the case just before the Great War when the price of cinchona bark fell so markedly between 1909 and 1912. Clearly something had to be done and in 1913 there was formed an association of persons interested in cinchona on the producing side—the planters—and on the manufacturing side—the quinine makers,—which, by agreement, guaranteed the producer a fairer share of the market value of quinine than he had previously enjoyed. It is outside the purpose of this report to refer in detail to the measures adopted to regulate and improve cinchona trading.

27. There is no doubt however that the formation of the Kina Bureau came at a critical period in the history of cinchona and at an opportune time to prevent the Cinchona Plantations of Java from sharing the fate of the Ceylon and Indian plantations. All monopolists are suspect and it is no part of this report to praise or to blame. But it is worthy of note that throughout the recent depression of the 1930-1935 period, cinchona was one of the few great plantation industries which did not call for public legislation to preserve its identity, as was the case in tea and rubber. There was no slump in prices and what planning was necessary in the recent crisis had its origin in the measures of rehabilitation taken by the industry itself in 1913. The widely accepted view that the Kina Bureau was formed solely to force up prices is not in keeping with facts. In the light of what is stated, it is more correct to say that the action of the cinchona industry in 1913 merely pointed the way to those schemes of rationalization and of organised planning of which so much is heard of in these days when the economic doctrine of *laissez-faire* is less an article of faith than in Victorian times. It is true that very recently Government regulations in Java have been employed to ensure that measures of control are more widely effective and these are to operate for a period of ten years. But these in essence only amplify the planning scheme which, with modifications from time to time, has preserved the integrity of the industry since 1913.

28. The catastrophe, which overtook the cinchona industry in India so elaborately built up on the experimental work of McIvor, was one which must have caused dismay in the minds of students of public health. That any active efforts were made by the State to retrieve the situation is extremely unlikely: these were the days of *laissez-faire* when any semblance of interference in industry was taboo. "The State had only to keep out of the ring in order

to ensure the best results", was the economic law in force. Agreement on a line of policy is much easier to reach in Java, one fancies, than in the India and Ceylon of the eighties. The main centres, Darjeeling, Nilgiris and Ceylon, were thousands of miles apart and any concerted action was especially difficult to achieve, were that thinkable in those days.

29. It is an argument of the Kina Bureau that the so-called monopoly of the Netherlands Indies has come about in an entirely natural way, the way which led to the "survival of the fittest". While admitting the fact that the Java plantations were equipped with better planting material and enjoyed other advantages over India and Ceylon, one is tempted to think that the "survival" of Java is not so easily explained. To the onlooker the position resembled a hurdle race in which Ceylon and India stumbled and fell early in the race. That Java could have stayed the course, if the last hurdles had not conveniently been removed, is open to question. In other words, the position of the Java planter in 1909 when the unit rate fell to 3 cents was a precarious one.

The shrewd brain which conceived the idea of the Kina Bureau brought with it the means to save the Java cinchona plantations from the same fate which had overtaken the Indian and Ceylon cinchona planter but twenty years or so before.

PRE-WAR CONCERN OVER QUININE SHORTAGE IN INDIA: COL. GAGE'S REPORT OF 1918.

30. When rumours of retiral from the industry altogether, on the part of Java planters, reached India, there was palpably need for some action on the part of authority in India. The first step was (1) to build up a Quinine and Bark stock from cinchona bark available at very low prices in the Java market. The aim was to ensure a stock in India at any time of 300,000 lbs. of quinine equal at that time to about five years' consumption of quinine by the state hospitals of India. (2) At the same time, Madras and Bengal Governments were requested with due expedition to prospect for new land and to extend the area of the Government cinchona plantations so that the stock would be preserved, if not actually increased. It is not clear what action was taken in Bengal, on whose existing plantations further planting was feasible, in a manner impossible on the more circumscribed areas of the Government Plantations in Madras. Areas were selected on this stimulus in Assam, the most noteworthy being a large expanse of land near Nongpoh to which the name Nongkhyllem Reserved Forest is given.

31. The outbreak of the War in 1914 prevented the extension scheme from being put into force although, fortunately for India, a large stock of quinine and cinchona bark was safely in store in India. This most fortunate purchase was of the greatest service in the assistance which India gave during the War. No one however could forecast how long the War would last and in the meantime planting in the south India was carried out on a very limited scale. In 1916 there was a change in the administration of the Government plantation in the Nilgiris. Attention was directed to the need of embarking on a scheme of new planting without delay. Forest land in the vicinity of the existing plantations was examined but this was rejected in favour of a large block of forest land in the Anamallai Hills. Pending a settlement on this scheme every possible acre was planted up on the existing plantations.

The scheme for developing a reserve of 22,000 acres in the Anamallai Hills was approved in 1916 but not ultimately sanctioned till 1925. Difficulties were met with at the beginning but lately there has been such a marked improvement that further extensions in the area can be made with little or no risk The quinine percentage of this new plantation is higher than any other plantation of Government in India. In connection with any scheme of Cinchona planting which may later be considered practicable, this Anaimalai Cinchona Plantation will be a source of high grade seed of Cinchona Ledgeriana. The high germinating capacity of the seed is demonstrated by an inspection of the nursery work mentioned at para. 37.

32. In 1917 Lt.-Col. A. T. Gage, C.I.E., I.M.S., one of the greatest experts in Cinchona of his time, was selected to conduct a comprehensive tour of India and Burma to find land on which to cultivate cinchona on an extensive scale. The duties which devolved on him were—

(1) The possibility of obtaining enough suitable land within the Indian Empire to produce cinchona bark to supply the whole requirements of India and the greater part of the needs of the rest of the British Empire in the matter of quinine;

(2) The necessity or otherwise of reorganising the present system of cultivation of Cinchona and manufacture of quinine;

(3) The question of whether it would be possible to extend cultivation by means of private agency or whether it would be necessary for Government to retain the entire management in its own hands.

It will at once be recognised that the investigation covered not merely the needs of India but also the rest of the British Empire in the requirements of quinine. This investigation occupied practically the whole of 1917 and the findings of Col. Gage are published in an exceedingly interesting Report, of which a perusal is recommended. The main result was a recommendation of Tavoy, as possessing hill ranges likely to furnish all the quinine needed for the British Empire. A second recommendation was that the plantation should be under the direct control of the State and that all effort in cinchona in India should come under one central authority. It was suggested however that the desirability of employing private agency to manage the new plantations or to develop fresh areas, could be discussed after fifteen years when financial data were collected.

33. Following this report, a start was speedily made in Burma but those plantations in the Tavoy district were destroyed by heavy rains in 1921 and 1922; in 1923, a new plantation was begun in Mergui district. This too proved unsuitable because of the low elevation of the hills and of an abnormally long dry season. "Considerable difficulty was experienced with labour and the work has been handicapped by exceptional periods of drought alternating with exceptionally heavy down pours .....". These latter plantations were closed down in April 1937 when the new Constitution came into force.

CHAPTER II.

RECENT WORK.

WORK IN CINCHONA BY PRIVATE ENTERPRISE AND PROPOSALS FOR RESUSCITATION OF THE INDUSTRY.

34. In any development of cinchona which is possible in India, it must be evident that there can only be three agencies, considered separately:—

(*a*) the State can, by extending its present activities, shoulder the entire responsibility for the production and distribution in future,

(*b*) or, the professional planter, for whom the growing of cinchona represents but a variation in method from his ordinary occupation,

(*c*) or the small grower.

In the last case the provision of capital and of forest land would be necessary.

35. Much has been stated about what the state has done and regarding private enterprise it is shown that a paralysing blow was received. In the South, however, there still lingered a feeling among some members of the planting associations that it was possible to revive planting again given some assurances from Government. From 1895 therefore it is noteworthy that the planters in South India signified their willingness to relieve the Government of any need to continue state plantations if in return the state would guarantee a minimum price. This proposal was repeated at various times. Finally, it was discussed at Madras, in 1917, at a meeting of persons interested in the industry. The upshot was that Government could not see their way to enter into a long-term contract. At the same time Government agreed to continue to purchase cinchona bark, at the London market unit rate, from private owners to a substantial extent of the needs of the Government Quinine Factory at Naduvatam.

36. Many factors were responsible for the issue being forced in 1917: perhaps most significant was the scarcely believable news that parcels of cinchona bark from the Anaimalai Hills had received an analysis of nearly 11 per cent. of quinine sulphate and that on a substantial consignment. As these results were obtained by Mr. C. R. T. Congreve on Castlecroft and the late Mr. G. A. Marsh on Puthototum, two of the most successful and enterprising planters in the South, it is not surprising that the rejection of the planters' request did not altogether dampen enthusiasm. There was accordingly formed about this time a joint stock company, the main object of which was to plant a large purchase of forest land adjoining Karamalai Tea Estate with cinchona. Although such high analyses were not obtained in the new venture, still when mature the cinchona bark contained well over 6 per cent. of quinine sulphate: but before the trees had reached a full exploitable age, the unit rate had fallen. Consequent discouragement resulted in, perhaps, an untimely dissolution of the company about 1925. Puthototum and Korangumudi have continued the planting of cinchona on a limited scale to the present day.

37. Elsewhere the recent depression of 1930-1935, which has so adversely affected plantation crops, has stimulated an interest in cinchona in the Anaimalais and various companies in the past five years have experimental blocks of from

five to perhaps fifty acres. Many of these concerns, alas! have but inferior land to work with but to those interested in public health, the prospect of even a minor resuscitation of the industry is a pleasing one for India. The most noteworthy effort in cinchona experimentation however is that in operation on the Singampatti Group of Estates of the Bombay Burma Trading Co. These estates are about 50 miles from Cape Comorin. Trials began in 1932 and, as elsewhere, the cinchona seed required an uncommon degree of coaxing to ensure success. But perseverance was shown with the result that in 1938 there was undoubtedly the finest nursery of cinchona plants of the highest grade—Cinchona Ledgeriana—that the writer has seen in twenty years' experience.

38. On the famous High Range of Travancore, Cinchona robusta has been cultivated during the past thirty years or more and well over one million pounds of cinchona bark have been consigned from those hills to the Government Quinine Factory at Naduvatam. Elsewhere in the Nilgiris—from such estates as Wellbeck, Liddellsdale, Marlimund, Ossington, and Cairnhill—in the Anamalais—from Stanmore and Valparai and from various abandoned areas in the Wynaad, Coorg, and Mysore, small consignments of cinchona bark have been forthcoming. It must, however, be fully admitted that the amounts on offer have dropped to such an extent in the past few years that available supplies of mature bark can be deemed to be well nigh exhausted in India.

Assistance from Government to Planters and Work in Assam.

39. When criticism is freely expressed that the State did nothing for the Cinchona Industry, at least let this go on record that between the years 1909 and 1937, bark to the value of 49·7 lakhs of rupees was purchased from private growers in South India by the management of the Government Quinine Factory. Secondly, bark on the Government Plantations at Naduvatam and Dodabetta was treated as reserve bark only to be drawn on if public supplies should fail. Thirdly, a provision of two lakhs of rupees was annually provided in the Budget to purchase cinchona bark as and when it came on offer. Fourthly, every effort has been made throughout the past twenty years to ensure that no cinchona bark should be exported which could be used for the purpose for which the Government Quinine Factory has been built.

40. In North India there was a complete relinquishment of cinchona for tea cultivation in the Darjeeling district, in the post-depression period of the eighties. Thus it was that the Government Cinchona Plantations at Mungpoo have had to rely entirely on their own efforts to maintain production of quinine at the adjacent Government Quinine Factory at Mungpoo. Recently as will be referred to in a later Chapter, there is an awakening interest in cinchona in this district. The significance of the existence of these large plantations in India will be dealt with later when prospects for the future are discussed.

41. In Assam, following the early experimental work referred to at para. 16 there has been no sustained effort to cultivate cinchona. This may arise from the circumstance that organised planting companies have never been attracted to the cultivation for the reason that they were not permitted to acquire land in the hills where alone the cinchona tree will grow. This ban—for such it can be termed—is no doubt due to the instinctive concern of Government to preserve, for the aboriginal people of the hills, the rights they have

so long enjoyed in the land from which they can obtain food for themselves and their families. Minor experiments by the Forest Department have not been pursued to a stage when a final verdict of success or failure can be recorded; as stated elsewhere in the report, cinchona is a tricky plantation crop and not a forest tree.

42. There are records to show that at Kulsi, Kamrup district, cinchona was planted, in the plains, in 1884-1885 but Meiklejohn reports that it was "a complete failure": at Tura, Garo Hills, in the same year an experimental plot was begun but this too was unsuccessful, the situation being entirely unsuitable owing to the selection of too low an elevation combined with a southern exposure. But, let the record proceed, for the immediate concern is with recent work in cinchona planting.

43. In 1925 the administration in Assam decided that the question of providing abundant quinine in the province should be investigated. Accordingly Lt.-Col. Ritchie, I.M.S., and Mr. Meiklejohn, I.F.S., were appointed to report: no student can neglect the document they placed before Government. Among other findings, they recommended that a Cinchona expert should report on the suitability of the Mikir Hills for the experimental cultivation of cinchona. In 1927, Mr. Osborne, Manager of the famous Mungpoo Cinchona Plantation, visited these hills and indicated areas on which operations might commence. Some work was undertaken, but no professional estimate of the results appears to have been obtained.

Brief History of Rise of Quinine and Efforts to encourage Use during past Ten Years.

44. It is not proposed to discuss at any length the quinine situation in India, but it will lead to a clearer idea of things if a rapid summary is made of what is, for the most part, referred to in earlier paragraphs with the addition of more recent happenings. The original object of introducing cinchona has been shown to be the provision of increasing quantities of a cheap febrifuge—a mixture of all the alkaloids—from cinchona bark. There was however a growing medical preference for a white crystallising quinine rather than an earthy drab-like substance—Cinchona febrifuge. Later, when chemists were employed from 1866 to deal with problems of manufacture, quinine and the cultivation of high-grade trees containing quinine, gradually dictated planting policy. At first this was not easy to accomplish on account of the vast areas planted under Cinchona succirubra which is not employed for quinine extraction. In time, however, Bengal followed Java in planting Cinchona Ledgeriana almost exclusively. In the Government Plantations in South India, until the Anamalai plantation was opened a little over ten years ago, there was no land available for this desirable quinine yielding variety, so effort was concentrated on increasing the varieties which grew well and yet contained a reasonable quantity of quinine.

45. The disappearance of the private planter in the eighties and nineties following the catastrophic fall in bark prices, and the gradual emergence of Java, towards the close of last century, caused the question of making India self-sufficient to be treated with less enthusiasm than was formerly the case. As is referred to above at para. 30, a definite effort was, however, decided on to improve the position of stocks in India against an emergency. In 1912

arrangements were made to house 300,000 lbs. of quinine in India and to stimulate planting on the provincial Government plantations. The military requirements of the war caused a great inroad to be made into this stock. From Java in 1919 and again in 1921 fresh quinine was received under contracts entered into. By 1928, the stock of quinine rose to over 360,000 lbs. while the official demand in India fell from 80,000 lbs. of quinine per annum to 60,000 and that although the sale price of quinine had fallen from Rs. 30 to Rs. 18 per lb. An offer to sell quinine to the provinces as low as Rs. 14 to encourage the use of the drug met with such a discouraging reception that when the main recommendation of the Royal Commission on Agriculture was considered, about the same time, it was decided to take no action on it.

46. The recommendation of the Royal Commission on Agriculture was essentially that the Government of India should assume direct control of all the Cinchona work in India, and should gradually build up a state of self-sufficiency in the country by the aid of scientific research (*vide* Appendix II). A later unsuccessful effort to utilise these stocks more actively, by making an offer of quinine at Rs. 12 per lb., for all quantities purchased over and above the average consumption, decided the Government of India that a substantial price reduction is at the very root of the problem of the employment of larger quantities of quinine in India. As the Central Public Health authorities had revised their calculation of the emergency stock necessary to be held in India, to 150,000 lbs. it was decided to make a free gift of 45,000 lbs. of quinine to the provinces of India in 1935-36.

The Desirability of considering again the Suggestions of the Royal Commission on Agriculture.

47. Reviewing the course of events in India during the past 10 years, so far as India is concerned, there must inevitably arise a feeling of regret that so little has been done. The recommendation of the Royal Commission on Agriculture of 1928 was framed in language of such cogency and appeal that a speedy translation into action seemed a foregone conclusion. It appeared to every one interested in public health that if the policy were put into action, then a happier era for India must necessarily follow. But history will show that the recommendation came up for consideration at a time which was most unfortunate. Stocks of quinine had been cheerfully built up and plantations had begun in Burma, in the post-war period, for the express purpose of treating problems of malaria on a comprehensive scale. The planting in Burma was dogged with misfortune in spite of the most valiant efforts to acclimatise the cinchona tree, and, regarding the stocks of quinine, these mounted up without any of that corresponding increase in demand which was both looked for and expected from the Provinces and States in India. Unquestionably these stocks were a source of increasing embarrassment. Added to this the critic was not absent who directed attention to the lock-up of funds involved in these stocks and pressed for measures to be taken to liquidate the situation. In the circumstances, it is not to be wondered at that the advice of the Commission (see Appendix II) could not be acted on. Perhaps matters would have righted themselves within a very short time had the world's crisis of the 1930-35 period not intervened. But this caused a definite "tightening of the belt" on the part of the provincial administrations and thus it was that offers from

these stocks on a most enticing basis met with a seeming apathy. If it is conceivable that any sense of disappointment should linger over the poor response of the provinces to a generous gesture, let it be recalled that times were hard and the need for utilising more quinine had to be weighed and considered against other items of expenditure, making for the public weal

48. It took many years to build up the quinine reserve and its function was to provide for a forward campaign in every province and state in India as well as to be a stand-by in an emergency. It can be inferred from what is written above that these stocks have been reduced to a figure well below what was at one time considered necessary. This proves that every effort has been paid to the request for economy. The estimation of the reserve required by India is properly a duty of the Public Health Commissioner and no one is better able to determine the stock needed by India should a serious epidemic of malaria occur. Provincial stocks have in recent years been curtailed partly because of repercussions of the criticism at the Centre and noteworthy too because of a desire to make greater use of the drug especially in Bengal.

49. Except what is growing on the Government Cinchona Plantations, there is no Cinchona bark of any consequence in India to-day to replace these stocks at the Centre in the event of these being rapidly used up. Unfortunately these plantations cannot be expected to restore this reserve as well as to fulfil the normal work in the provinces. The contracted budgets of the past ten years have necessarily restricted development work on the plantations. The attitude of private enterprise has not unnaturally been one of avoidance of cinchona planting. It is possible that the feeling that cinchona planting and quinine making are functions of the Government may have influenced this.

It can be appreciated then that the state of things outlined has caused considerable anxiety lately. This is reflected in the tone of addresses in the Council of State in March 1937 when a very sympathetic reply was given by the Government. It would seem that a fitting start would be an earnest consideration of the recommendation of the Royal Commission on Agriculture. Whether accepted in whole or in part, the suggestions offered have as great a value to-day as they had when the words were penned over ten years ago.

50. There is a widespread feeling in India that the growing of cinchona bark and the manufacture of quinine is a monopoly of the Government and that no private concerns may embark on these enterprises. This is wholly wrong. Cinchona bark can freely be grown by any one, and, equally so, quinine can be made by any one possessing the requisite knowledge. The misunderstanding may have arisen from the fact that the only quinine factories in India are those belonging to the Government of Bengal and the Government of Madras in places adjoining Cinchona plantations of these respective Governments. The control of production, of prices and of the areas in which official demands for quinine from these factories can be complied with, was expressly vested in the Government of India. Under the new Act of 1935 the Government of India has no longer any control over production in India. The effect of this withdrawal of control is outside the scope of this report. There has however been formed a Central Advisory Board of Health which is largely an association of Ministers of Public Health in the provinces. These Ministers can properly be expected to view questions relating to quinine in a broad and co-ordinating manner and that this Central Board of Health is solicitous of the welfare of

India in the matter of quinine supply, is clear from its action at its inaugural meeting in 1937. It was then decided, as reference to the introduction to this report will show, to press for an investigation regarding the possibility of finding land from which increasing quantities of quinine at a price within their reach can be obtained for and on behalf of the poor sufferers. This then is the purpose of the search for land which will be discussed in greater detail in subsequent pages.

CHAPTER III.

LESSONS FROM THE HISTORY OF CINCHONA IN INDIA—THE SPECIES WHICH IT IS ADVISABLE TO CULTIVATE IS CINCHONA LEDGERIANA.

51. What is to be learned from the history of Cinchona in India regarding future planting?

Variety to be grown.—It will be appreciated from what has been written in the historical introduction that the work of McIvor, the earliest experimenter in India, was largely devoted to Cinchona succirubra. McIvor's experimental stations were on the Nilgiris at 6,000 to 8,000 feet and at too great an elevation for him to master the difficulties in cultivating the finer variety (Cinchona Calisaya) which he accomplished so remarkably with Cinchona succirubra. Seed from his stations was distributed far and wide throughout India and Ceylon. C. succirubra was found relatively easy to grow and in the early days at any rate commanded a good price. Thus the choice seemed a sound one. But medical opinion was veering round towards quinine, in preference to the alkaloids obtainable from this variety (succirubra), and this gradually dictated the demand. Java early followed the medical preference, if such it may be called, as also did Mungpoo. Thus it was that Java and Mungpoo were in a position to experiment successfully with the rich kind of bark (C. Ledgeriana) when seed came on offer. From those early days, the quinine-yielding bark (C. Ledgeriana) has steadily grown in favour in Java to the well nigh complete exclusion of all other varieties. That South India can grow high grade C. Ledgeriana has been shown.

In this investigation it is the land considered suitable for Cinchona Ledgeriana, that has been selected. Cinchona Ledgeriana, when properly cultivated, yields the most profitable return because it contains the maximum quantities of quinine. To recommend any other variety in preference would go against the verdict of history. Up to 4,500 feet therefore Cinchona Ledgeriana is the species to employ in any contemplated scheme of planting.

THE MAINTENANCE OF NURSERIES BY THE STATE IS DESIRABLE.

52. The narration of events may perhaps have laid an undue emphasis on the difficulties of growing cinchona in India. It will however be noted that in the early days of cinchona cultivation in Java the growing of cinchona was regarded "as an expensive hobby of the Governors-General". Success was only won after much untiring labour and followed from the introduction of Cinchona Ledgeriana in 1865. In India, save in Mungpoo, cinchona has not proved the unquestionable success of Java but let it be made clear that the growing of cinchona on balance is far from unprofitable as the accounts of the Cinchona Departments of Bengal and Madras reveal. The work of C. R. T. Congreve and Marsh, in the early days of the War, showed what could be done by persistent work. The failure of Burma can be ascribed to conditions of growing under which conceivably cinchona could never thrive. While the violent alternation of periods of heavy precipitation and drought are characteristic of India also, there is no doubt that a continuance of heavy rain is not nearly the fearsome visitor it was. But it must be treated with the greatest respect.

53. So far as it is possible to generalize about Cinchona growing in India, most of the failures are ascribable to (1) poor nursery stock and (2) lack of plant food owing to the selection of worn out or leached soils. Generally the elevation suitable to cinchona is correctly estimated, the suitable species is selected and the necessity of avoiding clay, to any marked extent in the subsoil, is appreciated. Reference to the soil work will show, as would naturally be guessed, that a minimum nitrogen content is invariably associated with successful results. It is possible to remedy a mere relative poverty of soil so long as the cost is not excessive. But regarding the first cause of failure, there is no remedy. Cinchona is an intractable plant and is peculiarly liable to root diseases. These maladies are often discernible in the early seedling stage but frequently pass unnoticed. Sooner or later however the disease asserts itself and thus occur those discouraging blanks in the cultivation which often baffle all efforts in refilling.

54. Discussion on this tour with potential growers of cinchona reveals this: that in nearly every case trouble has been found in judging correctly the water requirements of the developing seedling. This is the art of the gardener and only by experience can this delicate handling be acquired. The technical work on the nurseries (See Appendix I) of the Government Plantations at Mungpoo is far in advance of the work in South India, although in fairness let it be said that the field nursery on the Anaimalai Plantation was worthy of great praise. Conditions are admittedly different but if the idea of state nurseries—shortly to be referred to—is accepted, then it is to the north of India that the supervising staff should be looked for or at all events to officers trained in the traditional methods of Mungpoo. Nothing in the way of cinchona planting has been seen on this tour which can compare with the even stand of 400 acres of cinchona between two and five years old at Mungpoo. The same high state of efficiency was observed in the nursery. So well is water controlled that this nursery had been in use for seven years continuously. That South India has something comparable has already been noted on the nurseries of Mr. Sladden at Singampatti Group and this excellent work augurs well for the future plantation.

If it were only recalled, that as the nursery is so shall the clearing be, there would be less of that fatal optimism in planting seedlings only fit for the scrap heap.

As it is in the interests of the State that Cinchona should be grown in India on an extended scale, then a fitting contribution of the State to this work should be the formation of nurseries in selected areas. For this work at present, there is not the trained staff which is necessary but that can be obtained in time. If clean healthy plants were put freely on offer at a minimum cost, this would undoubtedly remove the greatest hindrance to a wider employment of land under cinchona.

Need to Organise Research in India modelled on Work in Java must be recognised.

55. Not only is it necessary for disease-free seedlings to be obtainable but there is need for systematic research on the lines followed by Java from the early days of planting. Whatever the cause may be, it is undeniable that so far as the Government Cinchona Plantations in India are concerned,

research has been a subordinate feature. The early records are full of the most dexterous experimenting of McIvor and Gammie but in modern days the concentration on the work in hand in supplying cinchona bark and extracting therefrom the alkaloids, despatching the produce of the factories and collecting the sale proceeds, has proved a heavy enough task for a staff barely sufficient for the work. The policy has been so to work the departments that they entailed no loss on the State, and with this end so prominently in view, it is not surprising that, for scientific research, there has been no staff available. In Bengal, it is noted, there is an appreciation of the dangers in this.

56. The question of what scientific research is called for in cinchona cultivation and in Quinine production might lead this report outside of the permissible boundaries. But the record would be incomplete if the lines, on which the work should be done, are not indicated. Regarding quinine production, this leads the discussion into aspects of chemistry which are not of general interest and beyond the remark that the Quinine Factories should have attached to them a definite research branch, there need be no further mention in this report. Regarding cinchona cultivation, however, the lessons of history are many. Although the Bengal cinchona plantations have grown Ledger bark for nearly fifty years with success, it must be acknowledged that the average quinine content is markedly below that obtained by the Dutch in Java.

57. When one reads in reports from Java for 1938 of cinchona bark on average, working out at 8 per cent. of quinine sulphate, there is a feeling of envy not unmixed with admiration for the achievement. In India we may reconcile ourselves to the possession, on the whole, of soil and rain distribution markedly inferior to Java as conditions of success. But at least there is an obvious job awaiting a properly organised Research Station. With normal progress, such a Research Station can properly be expected to raise the average quinine content of our cinchona bark (as it goes to our quinine factories) from 4 per cent. to at least 7 per cent. within a measurable time. This is no quixotism for Congreve in the Anaimalais grew cinchona bark yielding over 11 per cent. as has been noticed and this can conceivably be repeated. Further the recent work on the Government Plantation in the Anaimalais—an estate in which it was singularly difficult to estimate the reasons for comparative failure till recently—shows that 6 per cent. should be easily obtained in the future so long as cinchona trees are maintained in a healthy condition and are not cut down untimely before the maximum quinine content is reached.

58. In India, at least in the South, Cinchona Ledgeriana does not reach its maximum quinine content till about the tenth year. As soon as bark on standing trees shows a desirable high quinine content, there should be a rapid multiplication of this variety by grafting on to a suitable stock. As a rule it will be found that Cinchona robusta (containing on an average 3½ per cent. quinine sulphate) is just as hardy a stock as Cinchona succirubra (which yields only a little over 1 per cent. of quinine sulphate). Thus if systematic efforts are made to learn the "tricks of the trade" involved in successful grafting, this would be a second desirable line of work. Attempts have been made in India before to graft Cinchona Ledgeriana on to Cinchona succirubra and it must be acknowledged with indifferent success. But when an examination of the cause of the failure is made, it has revealed this: three-quarters of the failure is due to ignorance of the correct technique and the need of perseverance in

order to profit from previous failure, leaving only one quarter to be explained by the narrow limits of time within which grafting conditions are obtainable in India. The most effective method of shortening the period of apprenticeship is to offer a suitable bonus for successful work when the grafts are ready for their permanent home in the field.

59. It might be wondered at why so much attention is given to grafting but after observing the ease with which the trained artisan in Java can make from 200 to 250 grafts a day with an astonishing percentage of success, there is need to insist on this work. First it would be work suitably attached to a Research Station. As the staff is trained, then in the State nurseries suggested above, multiplication of grafts can become a matter of regular routine.

When exceptionally high quality grafts are obtained, these should be grown in 'isolation plots' in the forest, as far removed as possible from the dangers of cross-fertilization with inferior varieties. These grafts in time would become sources of high quality seed and if this work is continued, disparaging comparisons of work in India compared with Java would no longer be heard. It is obvious, however, that mere high quinine percentage in the bark is not the only matter of study. There must also be taken into consideration the robustness of the variety under experiment for it is manifest that the cost of production of quinine in the bark is related to the yield of bark per acre. This can be appreciated from the following. If 2,500 trees are planted in an acre of land and these yield after ten years, on coppicing, 3,500 lbs. of dry bark and give 6 per cent. of quinine, this is on the face of it much more valuable than a similar stand of 2,500 trees, yielding 2,000 lbs. of bark because of a less robust habit, even though the quinine content is 8 per cent. of quinine sulphate, for the respective yields in quinine sulphate are as 210 is to 160.

60. In Java to-day it is probable that most of the area under cinchona is on grafted stock. Even if seedlings of high grade varieties are first planted, on a second replanting, many of the troubles experienced in coaxing cinchona to grow in the same area again can only be overcome by employing grafted plants. For India, too, the fact that succirubra and robusta trees are hardier and better rooted than Ledger, throws open a prospect of the employment in cinchona planting of what may be termed second class land.

Research has other duties ahead such as the collection of reliable statistics over planting distances. So far as experience goes, close planting is preferable to wide planting by which is meant that a better return can be expected from planting at 4×4 or even $3\frac{1}{2} \times 3\frac{1}{2}$ rather than 5×5 or 6×6, although it is admitted that for rich soil a minimum of 5×5 seems desirable. In practice, however close planting ensures at harvesting time that complement of trees per acre which will give the highest economic return.

61. The shrewd Indian *mali* who has multiplied in recent years the many excellent varieties of mango, citrus, and other fruits throughout India, is inferior in no way to the artisans now carrying out the grafting work in Java, if only he is suitably initiated and encouraged. While dealing with the subject of a Research Station, it is obvious that the planting side cannot be divorced from the laboratory. These are given as instances of the experimental work which is lying to hand and are directly related to practical day-to-day work.

If nothing else should ensue from this report, *let the inauguration of an efficiently manned Research Station complete with practical workers on both*

the planting and laboratory aspects of India's problems be considered a recommendation calling for immediate action. In the meantime, however, until this is feasible it may be worth while to attach to existing Cinchona Plantations of Government, a research staff. For the planting side, it would be necessary to have areas definitely set aside for research. But in the main it should be possible, without interfering perhaps too much with plantation routine, to organise experimental work in relation to control work at the laboratory. The details of suitable schemes for experimental work can be discussed with the existing staff on the Government plantations. But so incontestible is it that plantation work is bound up with laboratory control, that a close administrative relationship is desirable at all times.

EVERY NEW AREA HAS ITS PROBLEMS AND TESTING OF LAND IS A PRE-REQUISITE OF SUCCESS.

62. The provision of healthy seedlings and grafted plants will doubtless pave the way in the hands of a skilled planter to make a successful plantation. This however is not enough. If past experience is allowed to guide, it is advisable, nay, imperative, that a test or trial planting should invariably be made before a Cinchona Plantation is initiated. To the experienced planter this may seem unnecessary, but it is notorious how often errors have been made involving large financial loss which this precautionary measure would have helped to prevent. To the new comer in planting many valuable lessons, which will be of immense service later, will be afforded by the experiment. The area required need only be about one acre if a plantation of say 100 acres is contemplated. For acreages up to 500 acres, it is suggested that there should be three or more of these trial plots at different parts of the forest, later to be felled. The purpose of this one acre experimental planting is to test under field conditions the cinchona tree. A suitable method of initiating the experiment is to fell a square area in the forest of 80 yards by 80 yards, and to clear the ground and make a barbed wire fence to protect the plants from jungle animals. The actual planted area would commence 5 yards from the fence on each side. Thus the inner square to be planted would be of 70 yards on all sides which roughly gives one acre. The object of commencing planting 5 yards from the fence is to ensure that the young plants are not destroyed by drip from the surrounding forest trees. For the purpose of the experiment, holes should be dug at a distance of 4 feet by 4 feet. These holes should be about 1½ feet cube as is usual in other plantation crops. Theoretically an acre gives 2,722 holes which will receive a cinchona tree. (Under actual planting conditions where inspection paths are included in the area, it is seldom that more than 2,400 plants can be obtained from an acre of ground, if shaded).

63. Although the trial acre will be protected from wind and sun in a way it would not be as part of a large planted area, the suggestion is that there should be pursued the same method of work as in a large clearing. Now authorities differ regarding the need for shade and very healthy trees were seen in Java without this addition. It is also the practice in Mungpoo to grow cinchona without shade. The recommendation is however that shade should be planted and in the following manner. The shade tree should be planted 20 feet apart. In South India, *Grevillea robusta* would be the first choice for a shade tree and in North India, perhaps, one of the *albizzias*. *Alnus Nepalense*

is not suitable for a shade tree. Thus the plantation is composed of squares of shade trees 20 feet apart and inside each square some 24 or so cinchona trees on an average. The number of squares would be about 109 to an acre. The work involved in laying out the planting is considerably less than the explanation suggests. If the shade is first planted, this will occupy about 100 holes leaving over 2,600 holes or so for the trial proper.

64. Having planted the cinchona trees which have been previously arranged for, little except weeding is necessary for sometime in the trial-acre. After the third year or so, the growth of the canopy will shade more or less the ground, so that the growth of weeds is checked. If this experiment can be made from two years to three years ahead of planting, it will prove the ground for cinchona in a manner as effective as any.

It is suggested that an expert opinion should be obtained before a pronouncement is made on the experiment. After all, the acid test of the experiment is the production of as many lbs. of bark as possible containing as much quinine sulphate as possible. It would take 7 to 10 years properly to carry the experiment to its logical conclusion—the stage when cinchona bark is removed for the entire area—in order to estimate the yield. When the results are conclusive in themselves, no outside opinion is needed. But in the intermediate stage, it has been found that experiments have been closed down before any real tangible result was obtained beyond a satisfaction with the progress so far accruing. For this reason there is need of an expert visit especially if a large planting scheme is being founded on the experiment at a stage prior to what is above termed the logical conclusion. The experimenter can teach himself much during the lifetime of these one acre experimental plots. But it is recommended that on no account should manuring experiments be attempted as this would destroy the fundamental purpose of the experiment which, as shown, is to test the suitability of the land.

65. Obviously to the scientifically minded planter, trial plots embodying (a) an estimation of soil loss, (b) use of specific manures, and (c) of cultural methods generally, if separately and independently carried out, would give results which would have great practical value and should be encouraged. But the primary object of this discussion is to enable an area to be tested as cheaply as possible. This being so, the elaboration to which reference is given above may be considered a work to be tackled by the Research Station. The squares of shade trees—a feature of the planting system advocated—form a useful device in enumeration of (1) the supplies necessary for vacancies, and (2) standing trees; and later when estimates are required regarding the probable yield of bark per acre. If sampling of the bark is done when the trees are reaching a mature age, the results obtained from the chemical analysis will give a clear estimate of the money value of the standing crop.

Full Advantage should be taken of Private Resources of Land and Service in planning the Extension of Cinchona Cultivation.

66. In the history of cinchona, save perhaps in the early days, there was never a time when there was such a genuine interest in Cinchona as there is today among private owners of land.

The great restriction which has been, by legislation, imposed on production of tea and of rubber in India and the continuance of extremely low prices for coffee have caused Indian and European planters, not only in South India and in the Darjeeling Tea District, where there is a tradition of cinchona growing but also, to a lesser extent, in the Dooars and in Assam, to make enquiries regarding the suitability of their land for cinchona. They see themselves faced by a very restricted output and wonder when they can reasonably hope to produce crops up to the full extent of the cultivation. They read harrowing tales of the ravages of malaria in India and note the resolutions passed in the legislatures, calling for action to make India self-supporting regarding quinine. It is not to be wondered at, therefore, that it is the professional planter who is most able to size up the situation and to work out for himself whether cinchona is worth considering. Cinchona, after all, although admittedly more difficult to grow than coffee and tea and rubber, is similar in most respects and the operations are such as the private planter is daily in contact with in his own cultivation. Even on estates which are working at a profit, there is the feeling that a second plantation crop is desirable. It is manifest that when a body of professional men engaged in plant raising, for such the planter can be termed, is willing and ready to experiment with cinchona, this valuable offer should not be rejected without due consideration.

67. There is a considerable acreage of suitable land in India ready to be placed under a scheme of cinchona planting if the State, in return for this service to public health, will enter into some form of economic planning beneficial to both parties. Had restriction of planting not been in operation in tea, it is more than likely that these valuable lands would have been employed in that industry. Cinchona is a crop which will not thrive in worn-out soil, that is, a soil lacking in nitrogen, to name but one ingredient. The happy circumstance that there are substantial blocks of rich forest land still obtainable in India, in easy accessible regions, close to settled districts, and affording in all an expanse of land perhaps not much less than is devoted to cinchona in Java, is one which should be pondered over.

Cottage Industry.—In directing attention to the possibilities of private enterprise shouldering the burden of making India self-sufficient, it is not intended that the small holder should be neglected. Whether a plant which has so far proved difficult to cultivate in India is suited to this purpose, can only be determined by trial. There is little doubt, however, that the peasant with his small resources cannot be expected to embark on the growing of cinchona except under some inducement. For him it will be a "cash crop" as referred to by Sir John Russell and he will naturally wish to know what return he can expect. In discussing this aspect of the question with the minister in Assam, it was represented that the small holder will speedily take to cinchona if it is manifest that it will grow well in the same conditions under which he works. This would suggest then that demonstration planting along with the provision of stout disease-free seedlings in some selected area, is an essential condition in inviting the co-operation of the peasant. If happily it is found that cinchona will grow in the land belonging to small holders, an additional source of cinchona bark would thus be found and, perhaps too, a desirable addition to income in rural districts.

ORGANISED SCHEME OF DISTRIBUTION OF QUININE IS AN ESSENTIAL PART OF ANY FORWARD CAMPAIGN IN PRODUCTION.

68. In a previous paragraph considerable attention was devoted to the difficulties experienced in making use of the quinine stocks which had been obtained for the express purpose of combating malaria. As this is a matter of recent history it is desirable if a similar situation is not to arise again that there should be careful planning to correlate consumption with production. Colonel Russell has shown that 100,000,000 may be taken as the figure representing the persons suffering from malaria in India for whom quinine is needed. If a minimum effective dose of 45 grains were given, this would indicate a consumption in India of 600,000 lbs. annually. Calculations have been given by other authorities showing as high as 1,250,000 lbs. as the desirable consumption in India. For present purposes however it can be assumed that 600,000 lbs. is the upper limit which may be reached or, at all events, need be considered at this stage. In reality however India is consuming only about 210,000 lbs. of which approximately 1/3rd or 70,000 lbs. is produced in India, leaving 140,000 lbs., be the figure more or less, to be supplied by importation.

69. It would seem desirable that, as a first step in development, a scheme to meet the needs of India's population should concern itself with the present position. Thus the 140,000 lbs. of quinine, which is at present obtained elsewhere, should be arranged for by encouraging cinchona planting to this amount. This action would arise from no wish to affect adversely the trade of another friendly country but because of the very natural desire which is animating India to be self-supporting in an essential drug.

Java's present production of quinine is generally believed to be of the order of 1,300,000 pounds and this probably represents only 50 per cent. of the producing capacity of existing plantations there.

70. The results of the search for land will be discussed later but for present purposes, it can be stated that there is enough suitable land in India for the upper limit of 600,000 lbs.

The agency which should be employed in this work is a matter which interests many administrations but a suggestion is that the two local Governments of Madras and Bengal should continue their present plantations on the present scale of output, while private enterprise, (see Appendix IV) under whatever arrangement is agreed on, should be invited to grow in India cinchona bark equal to an annual output of 140,000 lbs. of quinine sulphate.

The ratio between the amount of quinine consumed in India and the amount the Public Health Commissioner considers necessary for real malaria control, roughly 1 to 3, is probably a fair indication of the position in many other tropical countries. The necessity for adequate supplies of quinine has been so strongly emphasised at recent medical and health conferences, and the world has become so much more alive to the need of adequate 'quininisation', that we may look for a greatly increased consumption of quinine in the near future. It is not too much to say that if any one of the great colonial powers were to undertake really active campaigns against malaria, Java's capacity to supply might be taxed to the utmost and India might even experience difficulty in maintaining imports at their present level. Bearing in

mind the fact that cinchona takes seven to fifteen years—according to the species—to come to full bearing, the best considered scheme of developing Indian supplies (by progressive plantings after adequate experiments) would not greatly enhance our supply until about ten years hence. It is clear that time should not be lost in making a beginning. It has been suggested elsewhere in the report that it would be eminently sound policy gradually to plant an area which would provide the amount of quinine at present imported. But it is necessary to visualize another aspect of such development. With the greater consciousness of the human and economic wastage created by malaria it is not too much to hope that there will be a progressive increase in the amount of quinine used in India itself. Such expansion might well absorb the whole of the new Indian production without any reduction of imports.

CHAPTER IV.

Yield and the Cost of Bark.

71. For obvious reasons since there are so many variable factors, it is possible to give figures relating to the planting scheme only approximately. If the basis is accepted that one acre of Cinchona Ledgeriana will yield 2,300 pounds of bark containing an average of 5 per cent. quinine sulphate this will give 115 lbs. of quinine sulphate as the produce of an acre after 7 years when the trees would be coppiced. By the next five years it will ordinarily be found that 1,300 pounds of bark yielding 65 lbs. of quinine sulphate should be obtained, making in all a yield of 3,600 pounds of bark containing 180 lbs. of quinine sulphate over the period. From this it can be calculated that 1,000 acres of cinchona planted annually will give 180.000 lbs. of quinine sulphate and the present import of 140,000 lbs. can therefore be met by planting about 778 acres annually. Similarly if Colonel Russell's figure of 600,000 lbs. is taken as the figure which should be produced in India, then the annual planting to meet this is 3,333 acres.

If India is really in earnest to rid itself of the menace of malaria, then a mere acceptance of the first part of the programme, namely the 140,000 lbs. will not satisfy the requirements of Public Health. Coincidently an expansion programme should be framed so that the real need of India should be in time met. As a corollary of equal importance, a comprehensive working plan should be prepared providing for practical means to ensure that consumption of quinine increases in step with the enhanced production from the plantations.

It would be the duty of the State to regulate the production of cinchona in the interests of the grower so that he would be stimulated to produce, as consumption expanded, the desirable quantities of quinine, so that all sufferers could obtain an effective supply of the drug. At the same time, by maintaining a close liaison with the industry, the State would be in a position to profit, from any experimental work permitting of increasing supplies of quinine, at prices progressively within the means of the poorer classes.

72. A yield of 3,600 pounds of cinchona bark equivalent to 180 lbs. of quinine sulphate at a unit of 5 per cent. is 15 lbs. per acre per annum. This compares very unfavourably with the 40 lbs. per acre per annum commonly believed to be the yield in Java. The purpose of this report is to present figures as near as possible to present yields. It is obvious, however, that a much closer gap will exist in time between the respective yields as experience is gained in India. Much of the land on which cinchona is being cultivated on the Government plantations is in need of a thorough reconditioning arising from the continuous cultivation of cinchona since 1861 in some areas. Thus the figures can, it is hoped, be justly accepted as the minimum which any planter can obtain without a great expenditure of effort. It should be explained that quinine is formed in cinchona bark in small degrees from the seedling stage. Until the fourth year, it is unusual to obtain any harvest, although all bark from thinnings should be carefully preserved as this gives a desirable early return on capital. There are various methods of working a cinchona estate; local soil and other conditions vary so much that it is not possible to state what is the best practice for all areas.

73. Generally it will be found that planting 4′ × 4′ with shade in the square system advocated at para. 62 should be accepted as a standard method. In fresh forest soil, good stout seedlings of about the thickness of a lead pencil and of one to even two feet, will rapidly crowd each other about the fourth year, when bark will be obtained from thinning and from prunings of the branches in shaping the young trees. If there have been no unusual set-backs and if vacancy filling is about average, yields of bark can reasonably be expected as in Table 5. Considering the years first, it will be observed that a period of 12 years in the history of a plantation from the end of the first year's planting is shown. In the next column it will be observed that no bark is ordinarily looked for in the first three years of planting and even in the fourth it only amounts to 20 lbs. per acre. The method of harvesting is that in use in Bengal where Cinchona Ledgeriana reaches a peak of development at the end of the 7th year. The cinchona tree is then sawed down, the cut surface of the stem tarred, and, resumption of growth from the new shoots within a few years yields a return, culminating in a figure of about 1,200 lbs., at the 12th year. At the 7th year the main harvest is obtained and in all 3,600 lbs. can be looked for.

74. In South India no exact system has yet been laid down for Cinchona Ledgeriana because of initial nursery and other difficulties which have caused many methods, such as shaving of bark, thinning and uprootal only of diseased trees, to be tried. Perhaps it will be found that generally in India up to 3,800 feet, coppicing at the end of the 7th year is desirable—and be it noted, the condition of the trees is the best criterion. Between 3,800 feet and 4,800 feet, which latter is the upper limit for Cinchona Ledgeriana in most areas, it may be necessary to extend the coppicing period till the 10th year. As a rule, however, on any manifest sign of arrest of growth, coppicing with the addition of decayed cattle manure, compost or a stimulating artificial manure, will cause a renewal of vigour. It should be borne in mind that coppiced trees do not *all* spring to life again, but it is well not to be impatient. Provision should be arranged for 25 per cent. of the area to be refilled at the end of the 7th year and for this, extra stout plants are needed of one to two years old. Well rooted big "supplies" are especially needed in order that these may hold their own against the more luxuriant shoots from the neighbouring coppiced trees.

TABLE 5.

75. *Yields which may be looked for from Cinchona Ledgeriana from one acre.*

End of year	Pounds of Cinchona Bark (Dry) obtainable	Equivalent in pounds of quinine sulphate
1	...	...
2	...	...
3	...	...
4	20	1
5	80	4
6	200	10
7	2,000	100
8	...	...
9	...	...
10	20	1
11	80	4
12	1,200	60
Total	3,600	180

Bark increment 300 lbs. per acre per annum.
Quinine average 15 lbs. per acre per annum.

At para. 36 will be noted a suggestion, that on the only private plantation of Cinchona Ledgeriana in recent years of which any records are available, the cinchona bark increased in quinine content up to the 10th year. A similar experience has been found in the Government Plantation of the Anaimalais where a poor portion, so far as the number of existing trees was concerned, has given a return in 1938 of 2,83,397 pounds of an average analysis of 5·54 per cent. quinine sulphate for 10 years growth.

Costing.

76. Earlier in this Chapter an attempt was made to forecast the probable yield per acre in the new planting both in terms of bark as well as of quinine sulphate, and it has been shown that a yield of 3,600 lbs. of bark of 5 per cent. quinine sulphate per acre giving 180 lbs. of quinine sulphate is the production of 12 years.

Whatever may be the case in Java, there is no doubt that no exact method of costing exists in India. By costing is meant the cost determined in a scientific manner of a pound of quinine in bark form, to the grower. At para. 10 there is a discussion of the same subject from the point of view of the manufacturer of quinine. For those who are unfamiliar with cinchona bark and the method of accounting in use, a short description is given. In the Bengal Cinchona Plantation no yearly cost of quinine in bark form is published in the accounts. On that Plantation, commercial accounts were not introduced as was the case in Madras about 1923. A figure is employed there which was determined about twenty years ago. The cost of extraction (*vide* para. 11) on the other hand, both in Madras and Bengal, is worked out in a manner which is accurate and takes into account all charges. There are many inherent difficulties in a true costing for quinine in bark form and that is the reason why it is not attempted. Doubtless with modern methods of computing and a fully equipped office on the statistical side, much is possible.

77. In Madras commercial accounts have been in operation as stated for many years now and a fully audited balance sheet and profit and loss account is prepared and published annually. The cost per pound of quinine in bark from the Government Plantation does not form part of the system of accounts as will shortly be explained. Madras Quinine Factory developed out of small experiments on the plantations to find the means of making a drug out of the mixed alkaloids in the cinchona bark. As the method of making quinine was developed, more and more did the local private growers rely on the Government Factory for their market. It is true that the bark on offer was a mere pittance compared with the exports before the slump. As far as possible the policy of the Government was to take up the bark on offer as an encouragement to growers of bark in India and to use bark from the Government estate only to the extent of the deficiency from private offerings. This policy was in operation when the commercial accounts were framed and thus the plantations came to be regarded as reserve plantations. For this reason no determination was arrived at annually of the cost of the plantation bark brought to the Factory stores as distinct from the purchase price of cinchona bark from private planters on contract. The plantation has no profit and loss account, there being but one for the Department. For some years, however, the plantation account up to about 1930 could have given a costing figure for bark had that been necessary. But it would have given a very misleading figure. Indeed if calculations

were to be made from the figures in the accounts, it will be seen that up to 1930 the bark was costing a unit rate above that at which bark could be purchased in the local market. This discrepancy was due solely to the restrained harvesting.

78. About 1930 it was decided to alter the accounting of the plantations so that while admitting the duty of the Government to take up any bark on offer, yet to consider the Factory as buying bark impartially whether from (1) private plantations, or (2) from the Government plantation. Thus the Plantation Account received a credit per pound of bark at the same unit rate as was paid for bark of the private grower. If this result gave a surplus balance, the amount was placed to a Capital Reserve. Adopting the market rate it can be seen that in some years when bark harvest was low, the credit has not been sufficient for the debits and thus the Capital Reserve has been drawn on. There are many difficulties in getting an exact costing system—in some plantations, for example, it is customary to take 2,700 trees as an acre which is clearly too high if paths, drains and so on are included as should be. Again a fruitful cause of difficulty arises from the fact that cinchona is of the nature of a wasting asset, the tree being cut down to yield a harvest. In South India uprootal is the chief method in operation, so the asset then disappears. The difficulty then arises in cost about the exact share of the asset to be written down. It is obvious that 10,000 lbs. of bark can be recovered from a large estate without any apparent difference in the plantation and the surviving trees may thus obtain more space or alternatively the trees may be near their limit of growth so that any removal affects the acreage. In actual practice, even when the work is pursued with a simple eye to a correct account there are often difficulties.

79. The purpose of this report is to use relevant figures in arriving at an estimate of costing. The best contribution which can be made is to consider all the outlay on the first twelve years of the life of an estate and to try and find out what the cost per acre works out at. In this spirit an estimate has been drawn up which it is hoped will be fairly accurate for all the districts where cinchona is likely to grow (*vide* Table 6). In Darjeeling labour is cheaper than in Madras because it is customary to give a grant of land for the cultivation of maize to each household. In Koraput again the daily rate of labour will doubtless be much less. Altogether it is hoped this estimate will be useful in guiding a prospective grower as to what cinchona will cost. If cinchona is grown as a subsidiary crop on an existing garden, then there will be a substantial reduction over many heads in this account. Doubtless too, it will be discovered that there are material omissions.

TABLE 6.

Probable cost of planting one acre of Cinchona, which forms part of a 500 acre plantation, employing a staff on Rs. 850 per mensem in all, providing also for 1 mile of metalled road cut in the hills suitable for lorry and bus traffic. The assumption is too that the average check roll rate for men coolies is about 6½ annas per day and women coolies is about 5 annas per day.

Rates per acre. Planting 4×4.

	1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	8th year	9th year	10th year	11th year	12th year
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
Roads main, metalled at Rs. 6,000 per mile and upkeep.	12	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
Overheads or General Expenses.												
Share of—												
Superintendent and other salaries: 850 × 12 ÷ 500.	20	20	20	20	20	20	20	20	20	20	20	20
Leave, Provident Fund Charges, etc.	5	5	5	5	5	5	5	5	5	5	5	5
Bungalows (15,000 ÷ 500) and upkeep.	30	½	½	½	½	½	½	½	½	½	½	½
Office, Stores (9,000 ÷ 500) and upkeep.	18	½	½	½	½	½	½	½	½	½	½	½
Cooly lines (2/5 cooly per acre: say 40 rooms at Rs. 300 each 12,000 ÷ 500 and upkeep).	24	½	½	½	½	½	½	½	½	½	½	½
Cost of Land	75	...	...	...	...	...	...	...	...	...	...	...

Interest at 5 per cent—												
Working Capital Rs. 320 per acre at 5 per cent=16. Capital Rs. 42,000÷500=84 per acre=4.	20	20	20	20	20	20	20	20	20	20	20	20
Clearing forest (*i.e.*, cutting and burning).	30	...	...	...	...	...	...	...	...	...	...	...
Lining	6	...	...	...	...	...	...	...	...	...	...	...
Pitting	30	10	5	...	...	...	...	10	...	...	...	...
Filling	10	3	1	...	...	...	...	...	...	...	...	...
Draining	10	2	1	1	1	1	1	1	1	1	1	1
Plants (at Rs. 15 per 1,000 plants : 2,750 to an acre).	41	12	7	...	...	...	...	10	...	...	...	...
Planting	10	3	3	...	...	...	...	3	...	...	...	...
Shading, staking and pruning	8	5	5	5	5	5	...	1	...	...	...	...
Roads—Plantation paths	5	½	½	½	½	½	½	½	½	½	½	½
Weeding	18	18	...	...	...	...	...	...	...	...	...	...
Cultivation	...	...	14	14	14	12	5	12	12	12	12	5
Medical and Welfare	3	3	3	3	3	3	3	3	3	3	3	3
Harvesting	...	...	...	...	...	...	100	...	...	...	...	50
Tax on land	2	2	2	2	2	2	2	2	2	2	2	2
	377	106½	89½	73½	73½	71½	150½	90½	66½	66½	66½	109

Total Rs. 1,350.

It will be seen that the schedule of charges is a simple elaboration of expenditure over a twelve years period. No attempt is made to fix a stage at which development may be said to cease when the estate would be on a maintenance basis. The account provides for average conditions and for men labourers at 6½ annas per day and women labourers at 5 annas per day.

80. As readily accessible land is largely taken up by other products, it follows that an area brought under cinchona has to bear the cost of an approach road. In an entirely undeveloped range of hills, this item of approach road may well cost as much as Rs. 15,000 to 18,000 per mile. It is assumed that a more modest outlay would be called for and Rs. 6,000 per mile is provided and that one mile of road will be required. The assumption is that the plantation will amount to 500 acres and thus Rs. 12 per acre is placed against the first year's working and thereafter at the rate of Rs. 1½ per acre for annual upkeep. This is by no means high, for in effect it means an expenditure of Rs. 750 per mile.

Rupees 850 per month is provided for the Superintendent and other salaries including overseers and a writer. The cost of this per acre will be Rs. 20. As provision has to be made for acting arrangements when members of the permanent staff are on leave and also to build up a Provident Fund or a Pension Scheme, an entry of Rs. 5 per acre is made. Rs. 15,000 may appear a small provision for bungalows for a Superintendent, three overseers and a writer. But it would seem reasonable not to raise the capital charges unduly until the prospects of growing cinchona are assured. Therefore the provision is intended for wooden buildings of a size large enough for ordinary domestic needs. A sum of Rs. 9.000 is needed for an office and bark store; the latter would require to be built of stone to a large extent as heating arrangements are necessary in the monsoon period to dry bark obtained from fallen trees, etc.

The estate will need about two-fifths of a cooly per acre and in this respect demonstrates that cinchona does not require the same amount of labour as tea for which one cooly per acre is usual. Substantial lines for the labour can be made for Rs. 300 per room; it is recognised however that, a fifty per cent. increase is necessary if the rooms are to conform to the newer requirements of Ceylon.

81. The cost of land will vary from Rs. 25 per acre to Rs. 100 or over. Accessible land will cost a high figure, while more remote parts will be cheaper. Naturally those lands adjoining settled districts will call for less expenditure on roads than areas in distant and outlying parts. Possibly an average of Rs. 75 will not be found excessive.

The question of interest in the accounts is discussed in a later paragraph. To give a completeness, interest at 5 per cent. has been shown on a Working Capital of Rs. 320 per acre and Capital Works—(made up of Roads Rs. 6,000, Bungalows Rs. 15,000, Office and Store room Rs. 9,000, Cooly Lines Rs. 12,000) amounting to Rs. 42,000, giving a cost per acre charge of Rs. 84.

Thus the charge for interest amounts to Rs. 20 per acre per annum. The ordinary plantation operations are provided for at rates usual in South India—Clearing forest (*i.e.*, cutting and burning) Rs. 30, Lining Rs. 6, Pitting (or making holes of 1¼ foot cube to receive the cinchona plants) Rs. 30, filling holes at Rs. 10, Draining—a very necessary provision to ensure conservation

of the soil especially in districts subject to heavy downpours—Rs. 10. The cost of a nursery is not easy to state, much depending on the extent to which roots from the felled jungle trees are dug out to make beds. This may cost up to Rs. 5,000 per acre. It will be found in practice that a provision of Rs. 15 per 1,000 stout healthy plants of 1½ to 2 feet, ready for their permanent home in the field, is fair.

82. Under the head shading, staking and pruning, money is allowed for the protection given to the young plants by means of fern or shingle shading and the cost of the shade trees according to the method discussed at para. 62. In South India, as has been stated in this report, heavy winds during the monsoon period are usual. Much failure in cinchona can be attributed to the absence of adequate staking. In practice it means the cost of the operation by which the young plants are firmly tied to stakes driven in to the ground. In windy winter, a circular hole forms round the plant if not held secure and distressing stem diseases result from the lodging of water at the collar and the chafing resulting from the wind. Pruning is the expenditure head for shaping the trees, removal of extra branches and in practice, the operation which brings in an early supply of bark.

For adequate inspection and to enable the labour to go quickly to "work spots", a system of paths and roads should be planned. Rs. 5 per acre is allowed for this.

For the first two years a system of selective weeding is advocated. By this deep-rooted grasses and noxious weeds are removed as they appear in a monthly weeding programme but other weeds are left, if not too numerous, to protect the soil against wash during the rainy season. Clean weeding is therefore only performed in the dry season. For one and a half rupees per month the plantation can be maintained in a clean condition for two years. From the third year onwards the plants will increasingly shade the ground and thus weeds will ordinarily cause no trouble. Cultivation is therefore shown as the expenditure head devoted to general cultural operations. The head "Medical and Welfare" is sufficiently clear to call for no explanation and Rs. 3 per acre is assumed. It should be pointed out, however, that this is substantially below that on many tea gardens in India. Harvesting charges will mainly be incurred at the end of the 7 years period by which time approximately 2,300 lbs. of dry bark will be obtained: for this Rs. 100 is provided. Again a renewal of growth will lead to another harvest at the end of the 12th year, when 1,300 lbs. of bark will be taken and for this work Rs. 50 is provided. The provision for harvesting allows for drying bark and other operations. Finally, provision is made for a tax on land at Rs. 2 per acre per annum.

The successive expenditure, from the 1st to the 12th year is as follows: Rs. 377, Rs. 106½, Rs. 89½, Rs. 73¼, Rs. 73¼, Rs. 71¼, Rs. 159¼, Rs. 90½, Rs. 66½, Rs. 66½, Rs. 66½, Rs. 109 making a total of Rs. 1,350 in all.

83. It will be noted that the entire cost per acre of the bungalows Rs. 15,000, office and store room Rs. 9,000 and coolv lines Rs. 12,000, as well as the cost of 1 mile of main metalled road Rs. 6,000 has been debited against the first year's operations *pro rata* per acre. It will doubtless be more accurate to expect these to last 30 years or over, in which case, the first year's expenses debitable to an acre will be reduced by Rs. 65 on those four items, making

for the first year a revised total of Rs. 312 against Rs. 377 as shown. The effect of this is to lower the total expenditure over the period to Rs. 1,285.)

No entry has been therefore necessary for depreciation as the whole expenditure over the period is recovered in the statement of costs now given.

84. The total expenditure is shown to be Rs. 1,350. If an attempt were made to find out the cost of bark the operation consists in dividing Rs. 1,350 by the number of pounds produced.

$$\text{Thus} \quad \frac{\text{Rs.}}{3{,}600} = \frac{\text{annas}}{3{,}600} = 6 \text{ annas per lb.}$$

Now in the bark there are other alkaloids besides quinine. In practice it will be found that these amount to about half the quinine expressed as quinine sulphate. Thus 1 lb. of cinchona bark containing 5 per cent. quinine sulphate usually contains in South India 2 per cent. other alkaloids. Taking these at ½ an anna per unit of combined cinchonine and cinchonidine, the value of these other alkaloids comes to 1 anna per lb.

	Rs.
Thus 3,600 lbs. of bark cost	1,350
Deduct other products at 1 anna per lb. (3,600 × 1 anna)	225
	1,125

1 lb. of bark containing 5% quinine sulphate = 5 annas

Therefore 1 lb. of quinine sulphate in bark = Rs. 6·25.

Cost of quinine sulphate.

1 lb. of quinine sulphate in bark	6·25
Loss in conversion at 10% (If the grower were also the manufacturer, he would have to make an allowance for loss in working)	·625
Cost of Extraction and overheads to factory station . .	5
Distribution charges say (This covers cost of staff, agency charges, repacking charges, etc., at such main issuing centres as Madras and Calcutta and freight from the factory stations to those centres) . .	3
Total .	14·875

Thus the *cost of quinine sulphate* on the data given and on this method is *almost Rs. 15 per lb.*

85. Whilst the above will serve our immediate purpose, there is need for a comprehensive system of costing designed by an expert. It is possible that a reduction in cost would accrue, if work on a big scale were attempted in a factory on (1) the cost of extraction, and (2) the cost of such mixed alkaloidal preparations as Cinchona Febrifuge and Totaquina. But generally it is more likely that the cost of bark will rise, rather than fall, on account of the modern tendency to pay labour at much higher rates than in olden times. Hence, at present, it is in the cost of extraction that reduction can be looked for.

PART II.

CHAPTER V.

CONDITIONS FOR SUCCESSFUL GROWTH.

86. It has been recorded as the verdict of history that Cinchona Ledgeriana is the variety which should be regarded as the aim of all planting schemes in India. Accordingly in the search for land, conditions suitable for the cultivation of Cinchona Ledgeriana have been considered to the practical exclusion of all other varieties. Previously in this report it has been mentioned that Cinchona Ledgeriana to the extent of 94 per cent. occupies the plantations in Java while, even in India today, the proportions have been shown to be Cinchona Ledgeriana 72 per cent., Cinchona robusta 22 per cent., Cinchona officinalis 5 per cent., and Cinchona succirubra 1 per cent. Cinchona robusta and Cinchona officinalis make up together 27 per cent. of the balance in India and these are for the most part only to be found in the Nilgiris.

Before conditions suitable for Cinchona Ledgeriana are considered, it is as well that there should be a remark regarding the special case of the Nilgiris. On the plateau of the Nilgiris, Cinchona Ledgeriana will not grow successfully, but as will be shown later when the Nilgiris comes under detailed consideration, there are some places which were examined on this tour where Cinchona Ledgeriana will prove suitable. It will also be shown that there are areas in the Nilgiris for which Cinchona robusta and Cinchona officinalis might well be tried. The conditions under which Cinchona Ledgeriana will grow have been so exhaustively described by Col. Gage while on a similar search for land in 1917 that a reference to his interesting report on this point will give the conditions in a very succinct manner.

87. "*Temperature.*—Although adult plants of Cinchona Ledgeriana may recover from a temporary slight amount of frost, young plants suffer badly and it is inadvisable to risk exposure to frost at any time. A high dry temperature is almost as injurious as frost. The ideal temperature should be fairly equable, say about 75°F. with a mean minimum about 60°F. and a mean maximum about 85 throughout the year. Such conditions are most likely to obtain in South India.

Rainfall.—According to the character of the soil and of the slopes on which cinchona would be cultivated and the distribution of the rainfall the latter may vary considerably. With a stiff soil, a heavy rainfall, especially if it were concentrated over a few months in the year, would be injurious as tending to water-logging and suffocation of the plants. So on steep slopes, very heavy rainfall would be apt to cause "washouts". On the other hand, with a porous soil, gentle and well-drained slopes, a forcing and equable climate and a good distribution of rainfall, cinchona will probably stand a very considerable precipitation. According to circumstances, the limits may roughly be from 75 to 160 inches per annum and with very favourable soil slopes and distribution probably even up to 200 inches per annum would not be excessive.

Altitude.—The general limits of altitude may be placed from 500 feet to 5,000 feet. The altitude however may be effected not merely by latitude but also by local physiographic conditions.

Soil.—Cinchona Ledgeriana will not flourish on a stiff soil and dies out on a waterlogged or clayey soil. The best results can be obtained only from a rich, porous, well-drained, loamy soil on moderate slopes which have not been impoverished by cultivation. Such soil, at the necessary altitude, can be found only as a substratum of ever-green forests and only in India over volcanic or granitic rock formations."

Substantially the requirements of Colonel Gage are valid today, but it is interesting, so far as soil is concerned, to consider the soil requirements of 1917 against those found necessary in this investigation of 1937 in the section on soil work in present cinchona plantation.

Generally speaking the main difference which exists between the lands which have been examined in the north of India and the south of India consists in this that the north of India areas seem protected, no matter what part was examined, from the fierce winds, which are characteristic of the Nilgiris and indeed all the hilly regions in the Western Ghats where the search for land was mainly concentrated.

88. Before this tour began, a Sub-Committee was appointed by the Imperial Council of Agricultural Research drawn from gentlemen living in widely scattered parts of India in order that as comprehensive and fruitful a search could be made as possible. Every area holding out any promise of growing cinchona came under review by the Sub-Committee and finally it was decided that the search for land should be made in the following localities: (1) Areas in the vicinity of the plantations of Mungpoo and of Munsong of the Government Cinchona Department of Bengal which by long experience with Cinchona Ledgeriana entitles those northern areas to be regarded as offering conditions of success as favourable as any other known in India. (2) Contiguous areas such as Sikkim and, although a visit was not actually paid to the State, the case of Bhutan received notice in discussions with Raja S. T. Dorji, a well-known figure in that State. (3) Assam followed after this where visits were paid to the Khasia Hills and to the Mikir Hills. (4) Thereafter the Nilgiris was visited and beginning from (5) north Mysore a long tour was made throughout the coffee district and in all likely areas in, (6) Coorg. The Anaimalai Hills were next inspected and following this a visit was paid to the extensive tract of country in the (7) High Range owned by the Kanan Devan Hills Produce Co. The foot hills of Travancore were given attention in various places from Pullivasal below Munnar as far south as the southern termination of the Western Ghats near Cape Comorin. On the eastern side proceeding in a northerly direction the (8) Singampatti Group of Estates of the Bombay Burma Trading Company was inspected, as also the (9) lower slopes of the Pulni Hills. About the middle of May, Dr. Mirchandani, the Soil Chemist attached to this investigation, made supplementary visits on the Western Ghats for the collection of soil samples and particularly to examine the (10) High Wavy Mountains at the suggestion of Mr. J. H. Cantlay, Manager of the Madras Tea Estates, Ltd., in Cumbum Valley and (11) the Nelliampathies Hills in Cochin. During this time the writer proceeded to the (12) Andamans to carry out an investigation there regarding the prospects of cinchona growing on those islands. Visits were also made to (13) Orissa where the area round Koraput and Jeypore was investigated. As the writer was unfortunately off duty for two months owing to illness which had prevented the preparation of a planting scheme in Assam, a second visit was paid which has

led to the selection of an area in the Khasia Hills as the starting point for a suggested development in Assam.

So many contradictory results have been met with in cinchona growing that it is considered essential to present first the investigations which were made in the soil aspect of the problem. Although, as has been shown, the soil is only one of many factors, still its importance is such that this enquiry was requested to make special note of soil differences. The general plan of work is explained below.

Soil Work in Present Cinchona Plantations.

89. The object of including a soil survey in the scope of the enquiry into the possibilities of the extension of cinchona plantations in India was—

(*a*) to ascertain the best conditions of soil under which cinchona will grow successfully and to study the soil differences between plantations of good, medium and poor crop growth in order to find out to what extent soil was a limiting factor in the successful establishment of the cinchona tree. This line of work naturally led to the existing cinchona plantations, and

(*b*) to examine the soil in new areas of forest land to judge of the suitability of these for the inauguration of new cinchona plantations.

Instances have been known where cinchona would not grow in an apparently suitable area and where the plants died after showing promise for the first two or three years. Along with soil, there are clearly other physical factors to be considered before deciding upon the suitability of a particular tract. These are (1) elevation, (2) rainfall, periods of drought and frost, (3) aspect, and (4) wind. This section will refer only to these factors in so far as they have a bearing on the soil.

90. The general plan has been to examine the soil in the present Government plantations in Bengal and Madras, with a view to acquire first hand knowledge of the soil requirements of cinchona and to utilise the knowledge in evaluating new areas later to be explored. It was not possible to visit the abandoned cinchona plantation in Burma.

In the cinchona plantations at Mungpoo and Munsong in Bengal, at Dodabetta, Naduvatam and Valparai in Madras, the areas for soil examination have been selected on the basis of the quality of crop growing on them. Thus the successful, the partially successful and the poor blocks have been examined separately in order to ascertain if any soil factor is responsible for the difference in the crop. The field study consisted in the examination of a number of soil profiles in each block and the collection of representative soil samples for analysis in the laboratory.

91. In the new areas, each area has been treated as a unit and as many profiles as possible examined and soil samples collected. Unfortunately, as can be appreciated, it was not possible to traverse the whole area on foot as would have been advisable to determine exactly the nature of the land under examination. This was due to the lack of time and facilities. The soil studies were therefore confined to the portions accessible from the road-side and from the nearest halting point. This part of the report dealing with new areas therefore suffers from the limitation that the conclusions drawn are based upon the

examination of a small portion (sometimes only a fraction) of the total area under consideration, the field examination of soil profiles and as much analytical work as has been completed. Further analytical work is in progress and a supplementary report will be submitted. The soil profiles are described in Appendix V and the analytical data are given in Appendix VI.

92. *Present cinchona plantations.*—As explained in the introduction, a few blocks from each plantation were selected to represent good, medium and poor crop growth. These are set out below:—

*Distribution of blocks according to crop quality.**

Good.	Medium.	Poor.
Mungpoo 1934 . . .	Bichkaman 1919-37 . .	Mungpoo 1934 (Portion only)
Labdah 1930	..	Labdah 1928 (Portion only)
Burmiak 1913 . . .	..	..
Kashyam 1935 . . .	..	Kashyam 1935 (Portion only)
Kashyam 1917 . . .	..	..
Naduvatam 1926 . . .	Moyer 1934 Block XII Plot 1	Devamalai 1934 & 1935.
Dodabetta Plot 7 . . .	Naduvatam Plots 1 and 2	Moyer 1934 Block XII Plot 4
Valparai 1928 (Portion only)	Hooker Extension II . .	Moyer 1928 (Portion only)
Valparai 1927 . . .	Dodabetta 1928. . .	Valparai 1928 (Portion only)
	Valparai 1925 & 1926.	

*The crop quality in this report refers exclusively to the crop growth and has no relation whatsoever to the yield of bark per acre or to the quinine content of the bark.

The examination of the soil profiles in both the plantations has brought out clearly that a good crop of cinchona is invariably associated with soil, at least 2½ to 3 feet deep, loamy in texture, granular, having a friable consistency and well supplied with organic matter, at least in the top foot. Wherever these conditions are not fully satisfied, the crop failed to come to expectations. There are also other factors which come into play in an apparently suitable soil, resulting in a lowering of the crop quality in the whole or a portion of a block. These factors will be referred to while discussing the soil conditions in the areas, carrying indifferent crops.

Bengal.

In order to obtain a correct appreciation of the optimum requirements of cinchona in Bengal, to serve as a standard for comparison for failed and new areas in North India, analysis of soil from four averagely good blocks are discussed first.

These are Mungpoo 1934, Labdah 1930, Burmiak 1913 and Kashyam 1935. The soils are described in profile Nos. 1—4. These blocks show a good uniform soil, at least 2½ feet deep and having loam to clay loam texture. The analysis has brought out the following additional points.

pH.—The range of *p*H appears to be fairly wide. The crop thrives with 5·23 (Kashyam) to 4·58 (Mungpoo) in the top foot and as low as 4·25 in the third foot.

93. *Physical texture of the soil.*—Drainage is perhaps the most important of the physical factors in the cultivation of cinchona as the tree is impatient of any accumulation of free water at its roots. From the results of the four blocks, it is clear that loams and clay loams are quite suitable for cinchona. The highest clay content in these blocks is in the Mungpoo 34 block where as much as 37·7 per cent. clay in the third foot was estimated, yet the crop seems to be doing well. The other blocks show a lower clay content. From the point of view of free drainage, this percentage of clay, *i.e.*, 37·7 per cent. in the lower horizons is rather high but the good slopes in the block would help towards ensuring free movement of water. The high clay content is undoubtedly attended with risk in areas where most of the rainfall is concentrated within three months. On the other hand, the capacity of the soil to hold a desirable quantity of water for the crop is of primary importance and too light a texture can easily disturb the proper moisture relationship in the crop-soil system, resulting in the failure of the crop. The necessity of a proper soil texture therefore must be kept in the forefront while considering new areas.

Organic matter and nitrogen.—The organic matter content of the soil is indicated by measuring the loss on ignition. This figure includes combined water. The direct determination will be done later on in some samples at least.

Generally speaking, the organic matter and nitrogen content of the soils are fairly high. The top foot has a nitrogen of over 0·2 per cent. and the third foot, not less than 0·1 per cent. The nitrogen is so intimately connected with the organic matter of the soil that it (*i.e.*, nitrogen) gives a fair indication of the organic matter level therein. Both the organic matter and the nitrogen of the soil are dependent upon factors such as removal, or digging in, of weeds, amount of shade, leaf fall, frequency of interculture, etc., which vary from block to block. They thus give no direct information regarding the optimum or the minimum requirements of cinchona. They nevertheless do show the general fertility level, where cinchona does well. Further, the organic matter in the soil directly contributes to the nature of the soil body and defines its moisture and nutrient relationships. It can be safely said that if the nitrogen in the top foot keeps in the neighbourhood of 0·2 per cent., the soil should be considered as well supplied with this nutrient for cinchona and that the organic matter would be at a level well suited for the retention of water in the soil.

94. Summarising the position from the data so far available, the conditions best suited for growing cinchona in the Darjeeling District seem to be (1) *p*H range of 5·3 to 4·2, (2) clay content varying from 20—35 per cent., (3) nitrogen content of over 0·2 per cent. in the top foot and not less than 0·1 per cent. in the third foot.

Generally speaking, the Bengal plantation has no "failed" blocks. This is to be attributed to the original selection of the area, the elimination of the

doubtful portions from the planting programme and the high state of efficiency in the nursery work and in the subsequent planting. In spite of this initial care, there were, however, portions in certain blocks where the crop was rather poor. These were in Mungpoo 1934, Kashyam 1935 and Labdah 1928. In each case, the general condition of the crop, except in pockets, was good. These bad pockets are represented by profile Nos. 7, 9, and 8, respectively. Both in Mungpoo 1934 and Kashyam 1935, the explanation of the poor growth is found in the wet sub-soil. These portions flatten out and as the soil in the blocks is clay loam, having 30 per cent. clay and over in the lower horizons, the drainage in such areas is defective. The *p*H and the nitrogen content of the soil in the block and the bad pockets do not fully account for the difference in the crop growth. In Mungpoo 1934, the good area has a *p*H of 4·2 to 4·6 against 4·5 to 4·6 in the bad pocket; similarly nitrogen varies from 0·155 to 0·277 in the good area and 0·126 to 0·235 in the bad pockets. In Kashyam 1935, the resemblance is not so close. The good area has a higher *p*H (5·1 to 5·5) than the bad pocket (4·65 to 4·91) but the crop grows well with *p*H as low as 4·2. The nitrogen in the good area is definitely higher than in the poor pocket, it being 0·105 to 0·327 in the good area and 0·090 to 0·272 in the poor pocket. The nitrogen in the last foot soil being less than 0·1 in the poor pocket would explain partially the lowering of the nutrition level at the root range in the three year crop. The clay content does not show differences sufficiently significant between good and poor portion in either block though in Kashyam 1935, 22 per cent. clay in the good area against 29·6 per cent. in the poor block in the second foot might appear significant at first sight. This is, however, offset by the higher "very fine silt" content of the good area.

In Labdah 1928, the steep slope and aspect, resulting in heavy erosion are the contributory factors for the poor growth of cinchona. The soil profile No. 8, is found to be very shallow, full of stones and in most cases, rock was met at 14 to 18 inches. The area is so steep that it was difficult to go over it for sampling purposes. The rest of the block which was not so steep was well stocked with good cinchona trees.

Bichkaman 1919-37, profile No. 6, also suffers partially on account of steep slope and also from the fact that it is carrying a crop of cinchona continuously since 1919. The crop was only of medium quality.

Madras.

95. In Madras, however, the conditions are entirely different. It is possible to find blocks showing crops of different quality. The good, medium and poor blocks are shown in the preceding table. Naduvatam 1926, Dodabetta Plot 7 and Valparai 1927 give a fair indication of conditions under which cinchona grows well in the Madras Presidency. The soil from these three plots has been analysed and this data, along with the profile study, is examined here and compared with the good blocks in Bengal, described in a previous paragraph.

While in Bengal, both the Mungpoo and Munsong plantations are situated in the same district with approximately the same climatic conditions the plantations in Madras are situated in widely differing conditions of climate, elevation and soil. In the Naduvatam (which includes Hooker and Moyer) plantation, the elevation varies from 3,500 to 6,500 ft. with about 80 inches rainfall. Dodabetta is about 7,500 ft. high and receives only 45 inches rainfall. Both

are in the same district. Valparai, in the Anaimalais, is 3,000—4,000 feet high and gets 150—200 inches rain. The soils in Naduvatam 1926, Dodabetta Plot 7 and Valparai 1927 are described in profile Nos. 10, 17 and 19 respectively.

pH.—The reaction of the soil in these three blocks varies from 5·0 to 5·6, *i.e.*, a less acid reaction than that in Bengal. With the present knowledge of Indian conditions, it looks as though cinchona can tolerate a *p*H from 4·2 to 5·6 but whether it would thrive in Madras at *p*H as low as it does in Bengal, remains to be proved. So far, *p*H 5·0 is the minimum recorded in the good blocks in Madras.

Physical texture of the soil.—The mechanical analysis of the soil from the three blocks shows a much greater variation than that in Bengal. Naduvatam 1926 has a clay content of 30 per cent. in the first two depths, which rises abruptly to 50 per cent. in the third depth. The effect of this high clay content in the third depth is being further investigated. Dodabetta Plot 7 has a clay content of over 46 per cent. all through upto 3 ft. whereas in Valparai 1927, it varies from 8 to 18 per cent. in different depths. That cinchona can stand such a great variety of soil conditions is a point worthy of special mention. This can only be confirmed after further analyses are completed. The clay content of 46 per cent. in Dodabetta (assuming this represents the whole area), would be considered too high but for the fact that Dodabetta gets only about 45 inches rainfall per year. It has, however, to be remembered that the clay determination was made on the International method which, owing to pre-treatment, gives relatively high clay results. A higher rainfall would make such soil unsuitable for cinchona. There is also another point in its favour and that is a high organic matter content in the soil, the presence of which makes the soil less liable to water-logging. Valparai 1927, with 8—18 per cent. clay and the rainfall of 180 inches, drains well but a good deal of soil erosion from the surface and leaching of soluble plant nutrients from lower depths takes place constantly. This shows itself in a low nitrogen figure in lower depths.

Organic matter and nitrogen.—There is abundance of nitrogen and organic matter in Naduvatam 1926 and Dodabetta Plot 7. Even in the third foot the nitrogen content is 0·1300 per cent. in Naduvatam 1926 and 0·2201 per cent. in Dodabetta Plot 7. There is a good deal of shade in these blocks and the high clay content helps to keep nitrogen from being washed away. In Valparai 1927, the leaching effect, due to low clay content, is indicated by a very low nitrogen content—0·0861 per cent. only in the lower depths. This is however, in the fourth foot.

96. Summarising the position from the data so far available, the optimum conditions for growing cinchona are: (1) the *p*H of 4·2 to 5·6 in Bengal and 5·0 to 5·6 in Madras; (2) a nitrogen of over 0·2 per cent. in the top layer and not less than 0·1 per cent. up to three feet in both Bengal and Madras. The clay content up to 35 per cent., on good slopes does not adversely affect the growth of the crop but whether it can stand a higher clay content, either under special conditions such as those prevailing in Dodabetta or otherwise, remains to be established. Similarly, further analytical data would fix the lower limit of clay for good growth.

No further analysis of soils are yet available and the discussion of the poor and the medium blocks is based upon profile study only. Amongst the poor

blocks, Devamalai 1934 and 1935 and Moyer 1934 Block XII Plot 4 may be specially mentioned. These blocks are uniformly poor. Devamalai soil is described in profile No. 11. The soil layer is just about 7—8 inches only and the subsoil conditions are unfavourable for holding moisture, due to the loose and crumbly nature and lack of finer fractions in the soil. Moisture is therefore likely to be a limiting factor in this soil. In spite of the fact that the cinchona trees are growing on land which was recently occupied by virgin forest in 1934, the organic matter content is low. For this the aspect is mainly responsible. The block faces south and is exposed to high winds and the full fury of the monsoon winds, resulting in the washing away of the surface soil and carrying organic matter to the lower valley. The northern face of the same block shows a much better soil texture. The poor crop on this land is mainly due to the lack of a water-retentive capacity and to the general poverty of the soil below seven inches.

97. The Moyer valley presents a different set of conditions and soil in Block XII Plot 4 is described in profile No. 12. The soil is generally clayey after the first 6 to 8 inches and liable to crack on drought. In heavy rains, partial water-logged conditions will prevail in such a soil and in the periods of drought, the soil will assume a hard cake-like consistency with numerous fractures. In light showers, the water will doubtless drain through the cracks and accumulate at some lower depth. The conditions of the crop in this valley depend upon the intensity of the unfavourable conditions. In Block 1934, Plot I, the crop is growing fairly well. The soil is described in profile No. 14. It will be noticed that the soil is less clayey, contains organic matter up to about 20" and the drainage is assured by the presence of stones and pieces of disintegrating rocks in the lower depths. Portions of Moyer 1928 and Valparai 1928 have also poor crops. The soils are described in profile Nos. 13 and 22. The soil in this part of Moyer is less clayey and generally has a good texture with a fair amount of organic matter in the first foot at best. The cause of the poor crop should perhaps be looked for in the chemical analysis of the soil. Valparai 1928, *i.e.*, a portion having poor crops, shows a plastic subsoil, hindering proper drainage. The area flattens out and this makes the position worse from the drainage point of view. It is understood that cinchona failed in this area despite many trials. The analysis of the soil would therefore be of special interest.

Amongst blocks of medium quality crop, mention has already been made of Moyer 1934 Block XII Plot I. Naduvatam Plots 1 and 2 have been carrying a crop of cinchona since 1860. The deterioration in crop quality on such a plot is easily understandable. The soil, described in profile No. 15, has a good texture but is chemically poor. In steep portions of these plots, a good deal of wash is taking place.

The medium quality of crop in Dodabetta 1918 is associated with unsatisfactory soil conditions in the block. The soil is described in profile No. 18. It will be seen that the soil is good only in the first foot, after which it is mixed with plenty of weathered hydrated rock; in fact the third foot is practically all weathered rock.

The explanation for the medium crop in Valparai 1925 and 1926 is not easily obtained from the study of soil profile No. 21. As seen there, the soil is loamy to clay loam, granular and fairly well drained in most parts of these

blocks. The soil may be chemically poor, though why it should be so in this particular block, is not easy to understand. It is possible that an abnormally heavy monsoon in 1931 (100 inches in one month) gave a setback to the crop at a critical stage of its growth. This is a well-established fact for many crops such as sugar cane, wheat and others, that an abnormal set of conditions at a critical stage of its growth brings about their failure. The same would apply with equal force to cinchona.

It is thus seen from the preceding paragraphs that the failure of cinchona to grow well in certain areas can be attributed to a variety of factors such as shallowness of soil, clayey subsoil, lack of body in the lower horizons or the poverty of the plant nutrients. Each one of these, singly or in combination with another, causes a setback to the crop in its early stages. It is well to emphasize that in the newly cleared forest areas, where the fertility level is usually high, the moisture relationship in soil-crop system is of primary importance in the successful establishment of cinchona plantation.

97-A. From the examination of the soil profiles and the analyses of some of the soil samples collected in the cinchona plantations in Bengal and Madras, the conclusion is arrived at that cinchona requires a deep, rich, well-drained soil, acidic in reaction, and well supplied with organic matter. The optimum *p*H range for Bengal and Madras respectively is 4·2 to 5·5 and 5·0 to 5·6. In both Presidencies, a nitrogen level of about 0·2 per cent., in the top foot and not less than 0·1 per cent. in the third foot is necessary for maintaining a good crop of cinchona. It has been shown that in Bengal the crop can stand, on good slopes, as high as 35 per cent. clay which becomes a limiting factor if the land is flat. In Madras, cinchona is seen to thrive on soil with a clay content of 47 per cent. as in Dodabetta but the low rainfall (45 inches only as against 100—120" in other cinchona areas) and the presence of a large amount of organic matter remove the danger of water accumulating within the root range of the crop. The behaviour of the ultimate percentage of clay (as determined by the International method) is so much modified by factors such as the presence of organic matter, iron, lime, etc., that the upper limit for clay content for the good cinchona soil is difficult to fix but generally speaking a loamy soil is to be preferred, unless there are special considerations which make even the heavy soil quite suitable for cinchona.

The shallowness of the soil, clayey subsoil, lack of body in the soil—thus causing erosion—poverty of plant nutrients are the factors which, singly or in combination with one another, cause a partial or a complete failure of the crop. It has been shown that in the Bengal plantations, the bad pockets in the good blocks, Mungpoo 1934 and Kashyam 1935 are due to the wet subsoil, the area being flat and clay content over 35 per cent. in the third foot; the failure of crop in a part of Labdah 1928 can be attributed to the soil erosion brought on by the steepness and the aspect. In the Madras plantations the poor crop in a greater part of the Moyer Valley is due to the clayey subsoil, in Devamalai due to the shallowness of the soil and lack of proper water relationship on account of the nature of the subsoil. The remaining analytical work on soil samples will doubtless bring out further quantitative relationships in these and other areas examined.

Manuring of Cinchona.

98. This aspect of cinchona cultivation has not received as much attention in India as it deserves. There have been a few isolated trials both in

Bengal and Madras but no systematic experiments with adequate controls have yet been attempted. Though the details of manuring cinchona in Java are not available in literature, it is, however, mentioned that at the Government plantations in Java stable manure increased the quinine content of the bark and ammonium sulphate reduced it slightly. No information is available regarding their effect on the yield of the bark per acre.

In general, the information is required in India on the effect of organic and inorganic fertilizers on: (1) Yield of bark per acre, (2) Quinine content in the bark, (3) Thickness of the bark, if this is related to the quinine content. Under item (2), it may also be necessary to study the effect of fertilizers on other alkaloids than quinine.

In the choice of fertilizers, it is well to emphasize that inorganic fertilizers should only be used in combination with organic manures, unless the organic matter content of the soil is already high or is reinforced by cultural methods. The use of inorganic fertilizers alone, even if they give a good immediate response, would lead to soil deterioration later on. The experiments may be directed to determine the effect of nitrogen alone and in combination with phosphoric acid on the growth of the crop and the yield of bark and of potash on the alkaloid content of the bark. The general effect of liming also needs to be studied.

Organic manures.—These can be supplied by: (1) application of compost or stable manure, (2) growing and turning in a green-manuring crop. The leaf fall from the shade trees and forking in the weeds also contribute to the supply of the organic matter. The use of compost, to replace stable manure, has become so well known that it need hardly be specially mentioned beyond saying that the preparation of "compost" is fully standardised and can be carried out efficiently and cheaply at any plantation. In fact, at some tea and coffee plantations "compost" is being manufactured on a large scale and used to very good advantage.

Rotation.—The usual rotation followed in India for cinchona is to put the land under forest for 15—20 years, after the cinchona has been uprooted. Where there is scarcity of land, cinchona follows cinchona. This is obviously unsatisfactory because no land can support the same crop indefinitely without adequate rest or suitable rotation. No information is available regarding the effect of decreasing the period for which the land should be under forest or of the substitution of forest trees by a quick-growing crop. This is a matter for experiment. An extensive green manuring, supplemented by inorganic fertilizers for a few years can bring the land back to a state of fertility required for cinchona. This needs an intensive study of the soil and the crop. The detailed analysis of the soil just before the cinchona is put in and immediately after it is removed, the comparative analysis of the soil after green manuring and after forest and the analysis of the crop would be necessary in the study of this problem. The experiment would need to be properly designed to obtain statistically valid information in as short a time as possible. If it could be proved that a long period under forest is not necessary and can be replaced, it would solve a big problem, namely the total area required for the production of quinine would need to be much smaller than it is now.

CHAPTER VI.

NEW AREAS.

99. The main purpose of this enquiry was to find new areas likely to be suitable for cinchona. The search for new areas as stated has been confined to Bengal, Assam, Sikkim, Madras, Mysore, Coorg, Travancore, Cochin, Orissa and Andamans. All the likely areas were visited and, as far as possible, representative areas were subjected to an inspection. In addition to the forest reserves and other Government land, the lands belonging to planters were included in the scope of the enquiry.

Except for Assam, very little analytical work has yet been done on the soil samples. This part of the report is therefore based mainly upon the profile study and other physical characteristics of the area. This section is divided into several sub-sections, each dealing with one Province or State.

BENGAL.

100. The plantations at Mungpoo and Munsong, which are such a credit to the officers working there, were closely looked into in order that data should be obtained regarding the soil which could be used in estimations of other areas throughout India. This was peculiarly the work of Dr. Mirchandani which has led to an estimation of the conditions of soil associated with (*a*) good growth of cinchona, (*b*) of medium growth and (*c*) of poor growth. It can be appreciated that a work of this sort can only be done properly by the collection of analytical determinations of thousands of samples. It will however be found that some interesting observations have been made on the tour as a result chiefly of what was seen on the existing plantations of Mungpoo and Munsong in comparison with visits which were paid to the Government Cinchona Plantations in the Nilgiris. The plantations at Mungpoo and Munsong have done yeomen service in cinchona and the pity is that in the vicinity there is little or no land offering high promise. In consequence of this for the past few years, there has been under consideration the opening of a third plantation in land available in the Samsing and Rongo area lying to the west side of the Jaidaka River and to the north of Matali Hat. A decision in fact had been arrived at prior to the visit to Bengal indicating Rongo rather than Samsing as more suitable from many considerations. A visit was paid to Rongo, the arrangements for which were kindly made by Mr. W. Meiklejohn, Senior Conservator of Forests, Bengal. Along with Mr. T. V. Dent, I.F.S., A. C. Gupta, I.F.S. and H. Thomas, Manager of the Munsong Cinchona Plantation, a tour was made to Rongo and the opportunity was taken to examine the Samsing area which had been finally pronounced by the Cinchona Department as equally if not more suitable. The soil was examined at intervals until a peak at 2,628 feet called Pokhridanda was reached from which a good view was obtained of the land of the Rongo Block lying to the west and north. The underlying strata are (1) Alluvium, then higher (2) Nahan series giving soft sand stones, and (3) Sikkim gneiss of the lower Tertiary Eocene yielding well-foliated gneiss.

Rainfall.—From available records and enquiries it was ascertained that the rainfall in the lower hills will reach the high total of 210 to as much as 250

inches per year. The records of rainfall were examined in Kumai Tea Estate Busty at a height of 3,500 feet and this gave a rainfall of 206 inches for 1937. During the visit it was noticed that there was a complete absence of water in the streams except of course in the main stream, the Naksal Khola. This is explained by the presence of very permeable mica schist and sandstones in the composition of the underlying strata. This eastern area of Darjeeling district certainly did not appear as the optimum place on which to build a cinchona plantation. The vegetation is that characteristic of the foot hills. Prominent among the trees are *Schima Walichii*, *Castanopsis Tribuloides* and *Indica*, while others noted were *Phoebe Hainesiana*, *Michelia*, *Cinnamomum Cecicodaphne*, *Terminalia myriocarpa* and *Duabanga sonneratioides*.

101. On the second day an examination was made by the party in the middle Rongo area where a search was made to find a possible nursery site as well as to trace out roughly a road for exploiting the area should a plantation be decided on. To the north and west is Khasmahal land running up to 5,500 feet and it was noticed that the forest is thin and the area can be judged to be useless for cinchona. So far as the Murthy is concerned there is no suitable land at all for cinchona in this area. Towards the west, that is on the ridge forming the eastern portion of the East Nar Valley, suitable land appeared but perhaps rather low. The East Nar Block was not examined by the party but records were shown of an examination by Mr. Calder in 1936. After making allowances on a slightly higher scale than at Munsong (where ordinarily one-third of the land is fit for cinchona) it is estimated that only 800 acres suitable for cinchona can be found in the Rongo Block. As the search for land in the Rongo Block has revealed so little, it is suggested that Government should earmark all land lying between 1,500 and 4,500 feet in the East Nar Block also so that a plantation of about 1,400 acres can be obtained from the East Nar and Rongo Block taken together. The area forming the catchment of the Santra Khola of about 500 acres can be excluded because (1) it is now the source of the water-supply for the Samsing Group of tea gardens and (2) it is the northern extension of a useful fuel working circle (Samsing, Chalauni and Engo).

Speaking generally, the soil in the Rongo is markedly inferior to that of Mungpoo or Munsong; so it would be well that no extravagant hopes are entertained from this area. The possibilities of very heavy rain with possible severe and destructive falls at one time seems the most deterrent factor in the choice of this area for cinchona.

102. *General conclusions.*—On the west side hilly land in Bengal suitable for cinchona marches with Nepal and on the east side with Bhutan. The area west of the Teesta was not examined, but competent observers have informed me that as much as 600 acres can be obtained in Latpanchor and areas to the south and south-east of Sittong Hill. This is of course on the exposed face of the Himalayas and heavy rains can be expected but it would seem advisable that a definite test should be made to indicate how much of this 600 acres can profitably be brought under a scheme of cinchona growing. As a general principle, the advice can be tendered that owing to the scarcity of land suitable for cinchona in Bengal now, all areas in the foot hills of the Himalayas within Bengal should be considered as a Cinchona Reserve to be worked as and when required under conditions to be laid down by the local Government. A rough estimate of the land which would thus be obtained for cinchona, even including

likely parts of Noam and Ambiok as well as Mirik, will give a figure not likely to exceed 2,500 acres in all.

A suggestion has been made that cinchona should be grown in forest coupes as a catch crop while slower maturing forest trees are growing. These experiments would be under the charge of the Forest Department and until the method is tried, it would be wrong to pronounce any judgment. Generally, however, the experience in regard to cinchona has been this that unless cultivated under plantation conditions involving regular weeding and the making of extensive drains in localities subject to heavy rain, cinchona has never proved a successful crop.

In view of the disquieting estimate that the yield of bark, reckoned in terms of pounds of quinine sulphate, is falling from a recent figure of 55,000 lbs. to an unexpectedly low level of 40,000 on the Bengal Cinchona Plantation, then it seems imperative that, after due experiment, another Cinchona plantation worked on orthodox plantation lines should be planned. Since the visit was paid, it is understood that the Government of Bengal have sanctioned the opening of an experimental area of 50 acres in the Rongo Block and the results from this, especially in this year of abnormally heavy rains in the Himalayan foot hills, would provide data from which future action can be decided on.

Discussion with the President of the Darjeeling Planters Association and other planters reveals that contrary to the general opinion there is a very keen desire to try cinchona again and perhaps 1,000 acres may be found in the spare land attached to the tea gardens which can profitably be grown under Cinchona. Small packets of a rich variety of Cinchona Ledgeriana were distributed amongst keen experimenters in this district. All told a figure of 3,500 is set against the probable contribution of new land which Bengal can give 2,500 coming as above explained from the foot hills and 1,000 from the spare land of the tea gardens.

Assam.

103. The Forest Department of Assam has shown a keen interest in cinchona over many years and initiated several experiments in cinchona growing, all of which have been abandoned except one at Umsaw in the Khasia and Jaintia Hills at the 37th mile on the Gauhati-Shillong road. This latter was under examination in some detail as well as two of the abandoned ones—one in the Khasia and the other in the Mikir Hills—the latter by Dr. Mirchandani only. The exploration for the new areas was made in the forest lands along the Gauhati-Shillong road in the Khasia-Jaintia Hills, along the Shillong-Sylhet road beyond Pynursla and in the Kaliani reserve of the Mikir Hills.

Experimental plots.—The plot at Umsaw at the 37th mile on Gauhati-Shillong road was opened out in 1934. The trees in the oldest block, planted 5×5 are just meeting. Altogether this experiment is very promising. It shows, as would be expected, a lack of cultivation. If the plants in the adjoining nursery are utilised to fill up the vacant portions, this should give a compact block. The soil in the plot is represented by profile No. 24. It has a good texture, is well compacted but appeared chemically poor. The analytical figures show a low nitrogen in the 2nd and 3rd foot, particularly in the third foot, where it falls below 0·1 per cent. The soil is distinctly acid, having a *p*H 4·48 in the top foot and 4·29 in the third foot. The area is clean weeded

and the provision of drains or soil traps would prevent the soil wash which is taking place in the area.

104. The second experimental plot in the Khasia Hills is situated between the 35th and 36th miles on the Gauhati-Shillong road, about one mile eastwards. There still remain about 150—170 plants in half an acre of land. The soil is represented by profile No. 23 and is of the same type as described in the preceding paragraph except that the top two inches showed more organic matter than that in the previous plot.

The third experimental plot visited is situated at Cheniabinshon in Kula Parbat. This is really outside the forest reserve and forms a part of the series of hills, extending into Kaliani and Mikir reserve forests. There are only about 200 plants, growing in a few soil pockets. Most of the plants are seven feet high and look healthy. The soil is represented by profile No. 29 and is found to be generally shallow. The general soil depth is about 20" but there are a few pockets of deeper soil where cinchona is thriving. The soil texture is good, being loamy and friable. There is practically no organic matter after the first 4 inches or so. The area is generally stony and steep.

Khasia and Jaintia Hills.

The Shillong plateau consists of a great mass of gneiss, which is bare on the northern border but in the central region is covered by transitive or sub-metamorphic rocks. To the south, in contact with gneiss and sub-metamorphic is a great volcanic outburst of trap which is stratified and brought to surface, south of Cheerapunji.

Along the Gauhati-Shillong road, the forest lands examined were those between 39th and 40th miles, at the 37th mile next to the experimental plot and between 28th and 29th miles which is the north-eastern end of the Nongkhyllem reserve. The soil in these areas is represented by profile Nos. 25, 26 and 27. The areas at the 39th and 37th miles may be considered together. The soils are loam to clay loam, containing up to 40 per cent. clay but generally it is less. The top foot contained a fair amount of organic matter and had a nitrogen content of 0·15 to 0·2 per cent. but the nitrogen fell as low as 0·05 per cent. in the third foot in one case but was usually over 0·07 per cent. This indicates a poverty of soil so far as nitrogen is concerned and might show an adverse effect on the crop after a few years. The *p*H value of the soil varies from 4·3 to 4·8. This is within the range of tolerance for cinchona. These areas are worth experimenting on but the crop may need manuring quite early in its life—say after 2-3 years.

The Nongkhyllem reserve as seen at the 29th mile had rather a heavy sub-soil. The soil is represented by profile No. 27. The clay content in the 2nd and the 3rd foot is over 50 per cent. and the very fine silt about 7-10 per cent. Such soil would offer difficulty in drainage when the rain is heavy and concentrated within a few months only. It is richer in organic matter and nitrogen than the areas discussed above, with a nitrogen content of 0·18 per cent. in the top foot and just over 0·1 per cent. in the third foot. Further exploration is necessary in this reserve to ascertain if these conditions at the north-eastern end are representative of the whole area. It may be noted

that the area at the 37th mile, discussed in the previous paragraph, touches the southern end of the Nongkhyllem reserve. The soil conditions in that area are more satisfactory for experimental work.

The forest land, beyond Pynursla, on the Shillong-Sylhet road between 34th and 35th miles was visited. There was no area worth examining at Pynursla. The area between 34th and 35th miles is not a reserve forest. The soil is represented by profile No. 28. The soil is generally shallow and unsatisfactory. There are a few good pockets but usually the soil is only about 12" deep. The area was stony and steep. The soil was loamy and had some organic matter in the top 10 inches, after which it was light red loam and generally poor in plant nutrients. The area is not worth considering.

105. *Mikir Hills.*—These hills, consisting of the Kaliani Reserve Forest and the Mikir Reserve Forest, have been mentioned as likely areas for cinchona. An experimental plot at Cheniabinshon in the Kula Parbat has already been described in a preceding paragraph. The northern hills are composed of gneiss rocks, which towards the south are overlain by sedimentary strata of tertiary origin. These younger rocks consist of soft yellow sandstone, finely laminated grey shales and nodular earthy limestones.

Camping at a Naga village on the southern bank of the River Kaliani, just outside the Kaliani reserve, it was possible to examine the eastern part of the reserve towards Guasin Parbat on the north of the river and towards Barsathung Parbat on the south of the river. The elevation of the portion inspected was 2,000—2,500 ft. The soil is represented by profile Nos. 30 and 31. The area is generally stony and the northern part is particularly dry with hardly any undergrowth. Bamboos predominate on the slopes but the ridges are wooded. The soil was shallow and practically devoid of organic matter. The texture was generally loamy and, with one exception, the clay content never exceeded 37 per cent. Usually it was less. The very fine silt fraction was between 3·5 to 7·6 per cent. The loss on ignition and the nitrogen content showed the soil to be poor. The *p*H varied from 3·9 to 4·6. The lower figure makes the soil too acid. The soil has generally a good physical texture but is not deep enough to be useful. It is also sure to be chemically poor and the very acid conditions would adversely affect the normal micro-biological activity in the soil. This portion of the reserve is not worth considering for cinchona, even though it may be possible to find a few good pockets of soil which can grow cinchona well.

An interesting discussion was entered into on the tour while visiting the Research Station of the Indian Tea Association at Tocklai, Assam. The interest for every planter in Assam and in the Dooars lies in the question whether cinchona can grow in spare land attached to the planted tea areas. The records are against any probability of success, unfortunately, although H. R. Cooper, Chief Scientific Officer, expressed the opinion that a trial would be arranged under ordinary Jorhat conditions. Seed was provided for the experiment. Another point which came up for consideration was the alleged Russian method of growing cinchona as an annual. This is probably no more authentic than the war-time accounts of the Russian troops shipped to roll back the enemy in Flanders.

106. The conclusion which can fairly be drawn from this soil examination along with other conditions necessary for the good growth of cinchona is:—

(a) The area immediately beside the Umsaw experiment appears very hopeful even if perhaps not very rich in organic matter. There are about 500 acres of land at this place—the 37th mile—and this would be a suitable starting place for a controlled experiment. As is mentioned in connection with other areas, experimental blocks of one acre as described should be opened out.

(b) The area near the 29th mile on the Gauhati-Shillong road is obviously too clayey for cinchona. This land has only been withheld from "jhuming" for about twenty years and a quite noticeable improvement is occurring in the soil. If experiments in (a) give satisfactory results from the 500 acres said to be available, then attention should be paid to Nongkhyllem where 500 acres ought easily to be found quite as promising as in (a) above.

It must be understood that these figures of 1,000 acres from Assam are being carried merely as a first contribution of what that province can supply in the general scheme of extending the area of cinchona in India. A more complete soil survey of the Nongkhyllem Reserve Forest of 40,000 acres would, it is felt, produce perhaps as much as 4,000 acres on which cinchona will grow. Countless thousands of acres in the Mikir, North Cachar, Lushai and Garo Hills doubtless hold land which could swell this total. But accessible land is a very desirable matter for controlled experiments and if success follows from a trial planting, it will be a simple matter to determine whether these more distant places can produce cinchona bark at an economic figure.

Orissa.

107. There is a widespread interest in Orissa regarding an experiment to test the suitability of some of the highlands in Orissa Province. So far cinchona has only been successfully grown in the Darjeeling District and in the hills of the Madras Presidency. To find, therefore, a possible suitable area for cinchona more or mid-way between these places, is of great interest to India. As Koraput had been mentioned as the part of Orissa holding out greatest promise for cinchona, that area was visited by arrangement with the Director of Development, Cuttack, and arrangements were made for a tour in the district by the Collector (Mr. Viswanatha Iyer). On account of difficulties of transport due to a succession of very wet days, all the Koraput area could not be examined at first hand. On the way up the hill, at the 16th and 17th mile, good land was seen on either side of the road. The elevation must be nearly 3,500 feet or a little less. The land unfortunately has been heavily jhumed but this is the case in all the hills throughout the Agency tracts unfortunately. Proceeding to the 3,000 feet plateau on which Koraput stands, a red laterite soil was encountered and scarcely a tree was visible throughout miles and miles of this plateau. Certainly, Koraput would be unsuitable from the point of view of growing cinchona for most of the soil has been washed down to the rivers owing to heavy jhuming in past ages. On the slopes from Koraput to Jeypore, there is, however, an outcrop of very good soil which was inspected and from which soil samples were taken. This soil

is unlike the red laterite soil of Koraput, not many miles away, and looked promising. The analysis of the soil samples shows that the soil contains a high percentage of clay, 43 to 45 per cent. in the first two feet which decreases to 36 per cent. in the third foot. The soil is rather poor in nitrogen, even the top foot containing only 0·14 per cent. The *p*H varies from 5·06 to 6·3. Similar land can be traced towards Pudwa on the south and to Kotah Estate Forest on the north. Thus, if cinchona can be established in experimental plots in the forest near the 56th and 57th mile on the Koraput-Jeypore road and can be induced to grow successfully, then 1,000 to 2,000 acres of similar land can be obtained in the vicinity. The soil, however, is, at best, of second class quality and rather lacking in humus. Still the soil is of an open texture and it would not be surprising if cinchona were found to grow well. The rainfall is between 57 and 75 inches, but in a place like this the precipitation varies from hill-range to hill-range.

108. In addition to tours with the Collector, interviews were arranged with the Diwan of Jeypore at Jeypore and discussions were held with the Chief Forest Officer. All are very interested in the new cultivation and in anticipation of orders, arrangements were made for a small seed nursery to be made from some seed which was supplied on the visit. It is regretted that after the visit to Koraput, which was presumed to be the only portion of the Province where there was any hope of growing cinchona, information was received regarding hilly tracts in Ganjam where large areas are believed to lie between 3,000 and 4,000 feet and where the rainfall can be assumed to be about 65 inches. Unless the rainfall is fairly well distributed and showers can be looked for during January, February and March, to supply moisture during the dry season, there is a danger that the cinchona plant will suffer owing to drought and relatively high soil temperature.

Elsewhere in this report is indicated the experimental work which should be undertaken to test cinchona in any area, but, before leaving consideration of Orissa, the following selection of areas can be considered:—

(1) The forests around mile 55 (Biddaghat Estate Forest) and Baridonger at mile 57 of the Koraput-Jeypore road offer immediate hope of being successful

(2) Later the Kotah and Kondamali Estate Forests near Molebatta on the north side, and

(3) At Nandipuram to the south of Koraput and on the Sembligudi-Pudwa road are worth considering. In Kottah-Kondamali Estate Forest perhaps as much as 500 acres may prove suitable out of a total acreage of roughly 3,000. This area lies near to Jeypore, although on the low side so far as altitude is concerned. The forest round Nandipuram is over 3,000 feet and is adjacent to a small town where there is a forest ranger. The town has a thana and the Agriculture Department has a fruit farm and a coffee plantation. There is a fair weather road to Walair through Pudwa.

(4) Near Wandragadda, ten miles south of Pudwa, there is a vast expanse of perhaps 10,000 acres of forest over 3,000 feet. This should be taken into account for future development, should results in

experimental areas more accessible, *e.g.*, Biddaghat at the 55th mile, prove encouraging.

(5) Other areas which can be earmarked as probably suitable lie in Dharmgod described as one of the best forest blocks in the district. The low elevation however may operate to render this area of doubtful use.

(6) On the extreme north of the district there is a forest block near Lakshmipuram at about 3,000 feet elevation and containing perhaps 2,000 acres. This land is on the edge of the plateau. A road, which will be made *pucca*, runs from Koraput to Rayag da and solves the question of an approach road. In fact, so important is the presence of an existing road in reducing costs and ensuring adequate supervision from the commencement of operations, that it would be well to consider accessibility of areas as a prime necessity.

(7) Other areas which can also be taken into account later are Debula Estate Forest near Durgi, Raisili Estate Forest near Narayanpatnam, south of Lakshmipuram (contain perennial water and about 1,500 acres of forest), and there is also an area of perhaps 100 acres at an elevation of 3,500—3,800 close to main road from Salur to Koraput at the 18th mile and about 4½ miles from Pottangi.

Until experimental work warrants a higher figure, the total acreage which will be taken in the records of this enquiry is 500 acres.

Sikkim and Eastern Himalayas.

109. About 11 miles from Gangtok by the cart road there are two places where cinchona may perhaps be established. The first is at the 11th mile at a place called Namle, about a mile to the north-east of the Shamdong Rest House. Officially it is called Namle Reserve Forest and contains about 40 acres. The altitude is about 2,500 to 3,000 ft. It is a piece of natural forest and the prominent species are *Schima Wallichii* and *Castanopsis*.

Another area in the same vicinity about a mile to the north-west of the Shamdong Rest House is a small reserve forest called Doreng Reserve Forest, lying on the boundary, on the west side being Pagla Jhora and on the right side Chuba Basty and on the south Shamdong Basty. This is an original forest and the species are as in Namle, principally *Schima* and *Castanopsis*. It is about a mile from the cart road. These small forest reserves were examined and the soils are described in profile Nos. 80, 81 and 82. The soil in the forest reserves is loamy and granular, with substantial quantities of organic matter, reaching to the third foot. The areas are well wooded and in Namle, *Tephrosia candida*, a legume, grows wild. The clay content of soil in the Namle reserve varies from 14 to 21 per cent.; the nitrogen content is very high (·23 to ·35 per cent.) up to 2 feet and even in the third foot, it is over 0·1 per cent. The *p*H varies from 4·2 to 4·6. Doreng which of course is not so good as Namle is also worth experimenting. The soil texture is good but it would have less organic matter and nitrogen.

The Basty land lying between grows indifferent crops of maize and buck-wheat. The soil is described in profile No. 82. It has all the appearance of being poor in organic matter and in plant nutrient. The soil is light loam and has rather a loose consistency. Considerable wash has occurred in this area. It contains only 5—8 per cent. clay and 0·03 to 0·09 per cent. nitrogen. The soil in its present state is not suitable but would respond to green manuring.

The rainfall in this locality is about 120 inches per year. The total area of the two reserves is about 87 acres and of Basty land about 100 acres. The larger forests, from 1,000—2,500 feet altitude, are under Sal, and the trees being deciduous forests, are unsuitable for cinchona. It was not therefore thought worthwhile to visit any of these areas.

There is an area of perhaps 400 acres on the east of Rangli Bazar at a place called Rigu. This land has been under shifting cultivation but, if necessary, the State can stop this if it so desires. This area contains no extensive forests and is under shrubby trees. What the quality of the soil is, has not been determined but it is of interest to record that this land lies only about 12 miles from Munsong where cinchona is being successfully cultivated and the rainfall will be slightly more than that at Munsong. There is an abundance of labour in the vicinity.

In addition to the above, there are two other places.

Barmek.—This lies west of Singtam Bazar, about 4 miles from Singtam. It lies on the belt of forest along the Teesta River. The forest consists of bamboo, *Schima*, *Terminalia microcarpa* and miscellaneous species

110. The land lies about half mile from the Teesta on a bridle path and there may be about 40 acres suitable for planting. This lies about 20 miles from Gangtok. *Tarku*,—There is an area here of about 30 acres under *Schima*. It is under Gurucharan forest (which means that it is open to cattle grazing). The soil here may prove suitable. This area lies not far from Barmek, probably 2 miles away. Thus it is about 6 miles from Singtam Bazar. It lies on an elevation of 2,000 to 3,000 ft. and is about 22 miles from Gangtok. There are several other small areas which might suitably grow cinchona and, if it were possible to grow cinchona as a cottage industry, many additional acres might be found in the State. The peasants here have achieved considerable success in growing oranges and cardamoms and are quite skilful in this work. If cinchona could be established as a cottage industry, then it seems that these Sikkim peasants are just the sort of people who would make it a success. But it would be necessary, of course, to give them considerable help at the initial stages, because cinchona is a new crop and the difficulties of raising disease-free stock will be considerable. Local arrangements for the supply and distribution of seedlings would seem necessary.

Along the Rangit Valley there is an extensive forest of sal and *Pinus longifolia*. It is quite likely that the rainfall will be low and the soil unsuitable.

Generally speaking, there is not very much land in Sikkim between the limits of 2,000 and 4,000 which is not under very productive crops of oranges and hill paddy or has been taken over for general Basti cultivation. But in the meantime until experiment gives a higher figure, 250 acres are being presumed as suitable.

The Eastern Sub-Himalayas.

111. *Bhutan.*—It is natural that in this search for land suitable for the best quinine *jat* of cinchona, particular attention should be paid to land as similar to Mungpoo as possible. Accordingly the suggestion has been made that all the foothills in Bengal—estimated to give only 2,500 acres—should be earmarked for future cinchona planting. Across the Jaldaka River, to the east lies the mystic land of Bhutan. A visit could not be arranged there but from a discussion with Raja S. T. Dorji of Bhutan, it seems more than probable that excellent land on "unjhumed" territory is to be found to the eastern side of Bhutan. Provisionally 750 acres have been carried. If the results in Sikkim are satisfactory, there is reason to believe that experiments will be made in Bhutan with the object of forming a "Cottage Industry".

112. *Balipara Frontier Tract.*—The enormous stretch of hilly land north of Assam and to the east of Bhutan is termed the Balipara Frontier Tract. The possibilities of the area have been examined very kindly by the well-known traveller, Mr. F. Kingdom Ward, who is at present in that country, and to whom grateful thanks are offered for the information he has given of this little-known area of India. An extract of his remarks is given:—

> "The inner valleys of the Assam Himalaya. Balipara Frontier Tract will be of no use for cinchona unless it is frost-resistant. We get pretty sharp and continuous night frosts here from about the middle of October, on between 5,000 feet and 7,000 feet, *i.e.*, at the bottoms of the lowest valleys. At Rupa, 5,000 feet, it perhaps just does not freeze, normally; it is pure limestone there,—I don't know whether cinchona is definitely calcifuge, some spp. should be tolerant. But Rubiaceae as a whole are not abundant even on mountain limestone such as this. At Rupa however the river valleys are mostly gorges, and the slopes very steep. There is very little real jhuming in the Balipara Frontier Tract inner valleys. Cultivation is almost all permanent,—barley, maize, buckwheat and a little rice. But all slopes facing south are burnt over annually, to give better grazing. The result is a fire climax association of *Pinus excelsa—Quercus Griffithii*, dominants (latter deciduous), with Pieris and *Rhododendron arboreum* sub-dominant, undergrowth bracken, tufted grasses, Cyperaceae and *Gaultheria* Spp. as the main constituents. Soil—where there is any—light and sandy, easily worked. Average slope of the mountain 40°—50° but frequently scarped, particularly at the lower altitudes (5,000'—7,000') and in the limestone belt. In the valleys, cultivation is mainly confined to river terraces; and comparatively gentle slopes.
>
> In the limestone belt, the same fire climax, but *Q. lanuginosa* (evergreen) largely replaces *Q. Griffithii* and the woodland is even more open, due to steeper slopes and porous limestone. The rainfall at Dirang Dzong (5,000' *plus*) is perhaps 50-60 in., the same at Shergaon, and possibly Rupa—the three most likely centres for your purpose. Average maximum temperature for four summer months 70°—85°F. At Dirang Dzong the average relative humidity may be so low

as 60—70 per cent. in summer, possibly lower in winter. Dirang Dzong, though little over 5,000' altitude, is very cold in winter, and almost certainly has night frost.

I must leave you to draw your own conclusions! My own impression is that where suitable land can be found, as at Shergaon, it is either too cold or too dry or both, for the commercially suitable species.

Let me know if there is any further information I can give."

It is likely that frost would exclude this vast country from consideration as a source of cinchona bark but in the lower hills, perhaps an experiment can be arranged, if and when the Mikir and other hills are under examination at some future date.

MADRAS.

113. (a) *Thiashola reserve forest.*—This is an extensive reserve in the Nilgiris at an elevation of 6,200—7,000 feet. The forest is evergreen, having huge trees and undergrowth, with a good deal of Eupatorium—a prevalent weed in the Nilgiris. Cinchona was grown in a part of this area about 70 years ago. The area suffers from high winds and there is likelihood of frost in greater portions of the reserve. The soil was examined at a few points on both sides of the road from Thiashola Tea Estate to Carrington. The soil is described in profile Nos. 35, 36 and 37. The top 12-13 inches soil is rich in organic matter, loamy in texture and appears fertile. In the lower layers it is inclined to clayeyness but is neither sticky nor plastic. On a good slope, the drainage conditions would be normal. The soil is deep, about 5 feet; the rock, in varying stages of weathering, is encountered after 5 feet depth. The lower part of the road appears rather wet. It has plenty of ferns and palms in many places, presumably due to heavy shade. There is no doubt that this part would improve considerably, if it is opened out. The slopes are generally satisfactory. If frost does not operate to exclude the area for cinchona, the area from soil and other physical factors is worthy of detailed exploration. It receives both monsoons, the total rainfall being about 100 inches. There are thousands of acres of good forest in this reserve.

114. (b) *Dodabetta reserve forest.*—This is a small reserve situated along both sides of the Ootacamund-Kotagiri road. The area is undulating with alternate ridges and sholas. The sholas are well wooded. The part of the reserve examined lies between 4 miles 2 furlong to 6 miles 1 furlong from Ootacamund. The soil in the sholas and the ridges is described in profile Nos. 38 and 39 respectively. The soil in the sholas is deep, rich in organic matter and has good texture and consistency. The soil is well drained. The soil on the ridges is poor as may be expected. It is mainly grass land with a few shrubs. Though the top 6-8" contain some organic matter, the lower layers are gravelly and poor. Omitting the ridges, the area in the sholas would not exceed 100 acres. It has, however, the advantage of being near the present Dodabetta Government plantation and can be worked from there.

(c) *Anaimalai Cinchona reserve.*—This is an extensive piece of reserve forest, situated on both sides of the River Kallar, adjoining the Government Cinchona Plantation. The area is over 20,000 acres and has been reserved by the Government of Madras for the future extension of cinchona cultivation. The soil

in the reserve closely resembles that in the plantation and is described in profile Nos. 32, 33, 33A and 34. On the southern side of the river, the soil in the forest reserve is at least 3 feet deep, with top 7 inches well supplied with organic matter. The weathered rock is encountered from one foot downwards but only in small quantities with soil predominating up to 3 feet. The soil is loamy in texture and well drained. Except in parts where the soil is rather shallow due to exposure and high winds, the general nature of the soil is almost the same as that in the plantation. The loamy soil extends to 8-10 inches and the weathered rock is encountered from about 1½ feet. In certain parts, quartz grains are seen after 2½ feet. The soil can not be considered as first class but would no doubt grow a good crop of cinchona as the Government plantation is doing.

115. (d) *Ouchterlony Valley.*—This area belongs to Messrs. Peirce Leslie and Co., Ltd., and has a total acreage of about 14,000 acres. The valley stretches from the Naduvatam village near the Government Quinine Factory down towards Malabar. The elevation varies from 3,000 to 6,000 feet but the areas examined are between 3,000 to 4,500 feet. There will be about 3,000—4,000 acres within the above elevations available for planting. The valley receives a rainfall of 80 to 120 inches, with showers in December and February, and some rain (2-4" each month) during March, April and May. Many years back, cinchona was extensively grown in this valley and some trees were observed in the Glenvans estate and one or two trees in Guynd estate. They were all of Cinchona succirubra. Five areas were examined (a) abandoned coffee estate in Lauriston group between Suffolk 5 and 6 and Lauriston No. 1 and 2, (b) an abandoned estate known as old Cinchona Estate on the top of Guynd and a big virgin forest next to this estate, (c) an abandoned coffee estate known as Helen, (d) Jungle land known as Sandy Hill and (e) Jungle land rolling away westwards by the side of the road from the Valley to Gudalur. The soil in these areas is represented by the profile Nos. 40, 41, 42, 43, 44 and 45. Of all these, the area on the top of Guynd (abandoned estate as well as the forest next to it) is decidedly the best. It has a good fertile soil (profile Nos. 41 and 42) with a fair amount of organic matter in the top foot. The soil is about 3 feet deep and the lower layers were well drained. There was however only a small amount of organic matter beyond one foot, even in the virgin forest. The clay content in this area does not exceed 25 per cent. up to 3 feet and rises to 33 per cent. in the fourth foot. The nitrogen level is high in the 1st foot (0·416 per cent.) and does not fall below 0·1 per cent. in the third foot. The *p*H varies from 4·6 to 6·0. The area would be about 300 acres and has satisfactory conditions for experiment.

The jungle land by the side of the road to Gudalur is another area worth considering though it is not so good as the one on the top of Guynd. The soil is described in profile No. 45. It is covered with lantana, secondary jungle and some bamboos. The soil is granular, loamy but rather shallow. The disintegrating rock predominates after about 2½ feet. The soil contains very little organic matter after 9". The land will drain well. There are several hundreds of acres of this land between 3,000 to 3,500 feet. This would need be further explored. Sandy Hill area, represented by profile No. 44, is not particularly good whereas Helen estate (profile No. 43) and estate in Lauriston group (profile No. 40) are definitely unsuitable. In Sandy Hill, the soil texture is good

but has no depth. Helen is very greatly 'washed' and has hardly four inches of workable soil. It is covered with grass with some shrubs. The abandoned estate in the Lauriston group, though not so bad as Helen is found to have shallow soil. The soil has a good texture and would be chemically poor beyond the first foot or so.

There are several hundred acres of land at 4,700 feet and upwards below Wapshare Peak. This area could not be examined but from all accounts appears to be suitable for further exploration. It looks very well wooded and has good slopes.

116. (*e*) *High Wavy Mountains* (*Cumbum*).—This vast tract of virgin forest belongs to the Madras Tea Estates, Ltd., and is in charge of Mr. J. H. Cantlay. It is situated in Madura district and can be reached from Madura (distance 75 miles plains road and 10 miles Ghat Road) or from Cumbum (18 miles). The whole estate has an acreage of about 10,000 out of which only 500-600 acres are at present under tea. The general elevation is 4,000 to 5,000 feet with a well regulated rainfall of 90 to 150 inches per year in both monsoons. There are no extremes of heat or cold in this area.

Two blocks, Manalar and Megamali, were examined. Manalar is an extensive block of about 2,000 acres, well wooded with big trees and has plenty of undergrowth. The soil is described in profile Nos. 46 and 47. The soil is 2 to 3 feet deep, loam to clay loam and has a fair amount of organic matter. The valley soil has a clay content of 20 to 34 per cent., a large amount of nitrogen (·24 to ·58 per cent.) and a *p*H of 4·8 to 5·1. The land will drain well as it has very good slopes. The area is worthy of experimentation and possessses an additional advantage that it can be worked from the Manalar division of the same estate. The ridges in the block are not so good and may have to be omitted.

Megamali block has an equally good soil texture but is poorer in organic matter. Occasionally the weathered rock is encountered at one foot depth but usually it is much deeper. The area is well wooded and would be about 800 acres.

117. The prospects for Cinchona in (a) Thiashola and (b) Dodabetta are undoubtedly excellent so far as soil is concerned. Thiashola Reserve Forest is subject to wind owing to its location in relation to the South-west monsoon breezes. But if care were taken not to uncover the forest from the ridges and to select sheltered pieces doubtless cinchona would do well. One must recall however that wind as one of the contributory, if not the main factor, caused the abandonment of a Government Cinchona plantation in this immediate neighbourhood about 1872.

(b) Dodabetta Reserve Forest is an old selection of the writers and the 100 or so acres available will be useful to add to the acreage under cinchona on the adjoining old plantation of Dodabetta.

It should be noted however that only Cinchona officinalis will grow on the latter, while Cinchona robusta would be the selected species for (a). On neither area will the species, which is selected for this enquiry, thrive at all. For the records a contribution of 500 acres is assumed.

A suggested course of action is that the Dodabetta Reserve and the Thiashola Reserve should be considered by Government as areas reserved for cinchona.

Dodabetta should be handed over at once for Cinchona under following conditions:—

(1) all ridges should be left under forest trees, and

(2) the streams should be protected so that the water which flows to the lower Badaga villages will not be diminished.

118. (c) *The Anaimalai Cinchona Reserve.*—So far only 1,000 acres or so have been utilised out of 10,000 acres which may prove suitable for cinchona. The plantation which occupies the western end of the reserve has given in very recent years much cause for anxiety. As has been noted elsewhere however, there has been a decided improvement so that, if work on the same standard continues, there need be no fear that later clearings will repeat the melancholy story. The quinine percentage is, as noted, much better than elsewhere, and the undeniable vigour of growth of the 1927 and 1928 clearings showed the suitability of the land for high grade cinchona. If all seedlings showing the merest trace of root disease in the tips are summarily burnt and a policy of employing plants of not less than a pencil thickness is pursued, then, with adequate staking, many of the past difficulties need not recur. The possibility of this reserve proving a valuable experimental station where grafting and seed selection work can be done, should not be forgotten. Generally its suitability as the location of a Research Station is worthy of notice for it is near an extensive planted area and privately-owned forest-land ready to be planted under cinchona, if suitable terms can be arranged by the State. The estimate of the private forest which might find employment under cinchona is 2,000 acres—a conservative figure.

If cinchona planting in the future should meet with a desirable measure of success both private and Government, the case for opening an up to date Quinine Factory here to deal with the outturn of bark seems incontestible

Until the cinchona position is clear, it is suggested that the entire area be preserved as a cinchona reserve. In the meantime, 4,000 acres of this reserve are being accounted as available for planting under any conditions which Madras Government may decide.

All together then the area suitable for cinchona from the Anaimalai Hills can be expressed as follows:—

(1) Existing Cinchona—1,000 acres,

(2) Cinchona Reserve—4,000 acres,

(3) Private Estates Reserve—2,000 acres, or 7,000 acres in all.

119. (d) *Ouchterlony Valley.*—It has been estimated that there are from 3,000 to 4,000 acres suitable for cinchona. The richness of the soil is apparent and this certainly appears a promising area. This famous valley in which cinchona formerly was grown on an extensive scale is so near to the Government Quinine Factory that an experimental planting with *Cinchona Ledgeriana* (in place of Cinchona succirubra of the old days) would on the face of things, seem called for.

(e) For the purpose of estimating the acreage which Cumbum can furnish for cinchona, only 2,000 acres are assumed. This may be a definite under-estimate, but the main bulk of the land seems to lie at or near the upper limit

for *Cinchona Ledgeriana*. At the same time the mildness of the climate in this valley even at the higher altitudes is specially noteworthy.

(f) There are two other areas in the Nilgiris which came under examination (i) an area of about 400 acres of spare land at Kolakumby, Craigmore estate, of which Mr. Charles Greig is the General Manager. The soil sample has unfortunately not been completed in time for this report. Whether Cinchona Ledgeriana would grow at the elevation is not certain. On the Nilgiris 4,500 feet appears the upper limit. A trial with a good robusta as well as Cinchona Ledgeriana would soon settle the point on the lines of the experimental work suggested at Chapter 16. Nearby there is some very promising land, belonging to Mr. Reilly, which would certainly suit Cinchona Ledgeriana. There are from 100 to 200 acres in this estate which the owner would like to plant with Cinchona. The soil is open and friable, and contains much organic matter. The above estates are near Kullikumby about 20 miles south of Ootacamund and at about 4,300 to 5,000 feet.

120. (g) *Singampatti Group of Estates.*—In para. 37, Part I, the occasion was taken to commend Mr. Sladden for the remarkable success he has obtained with his nursery in this area. The concession is owned by the Bombay Burma Trading Company and the restriction on new planting of tea—as in the case at Cumbum, the High Range and on the Anaimalais Hills, to name the more important places—has left thousands of acres of suitable land for Cinchona Ledgeriana idle and consequently, unremunerative. The forest land in Cumbum, High Range and Anaimalais and Singampatti is excellent. It is a happy circumstance therefore that this land is now available to the State to assist in supplying India's needs of quinine. There should therefore, it is submitted, be no delay to arranging to make use of the land now so freely offered. Should fortune again smile on the tea industry, any unnecessary delay in coming to arrangements about supplies of Cinchona bark or even of quinine itself will undoubtedly cause these lands to be turned over to tea.

If help is required from private growers, this group of estates at Manjolai, 50 miles or so from Cape Comorin, will be in the van. A scheme of planting 50 acres a year until a comprehensive policy of development is made, has begun and judging by the results so far accruing, there need be no hesitation regarding the future success. Mr. Eric Johnson, the General Manager, has shown faith in cinchona as a worthy occupation for planting companies for some years and small trials of cinchona are being made in other estates of the Company. But Manjolai area (for soil samples *see* Appendix III) undoubtedly offers the fairest prospect for cinchona that the writer is aware of, particularly in the higher and newer areas where commendable success has followed in the nurseries also. The area which can be opened for cinchona growing would from the Company's point of view depend on any contract which the State would enter into but in the meantime the figure of 3,000 acres is taken.

MYSORE.

121. The Government of Mysore have a small experiment with cinchona on a 5 acre plot at Kemmangundi, not far from His Highness the Maharaja's summer camp. The crop was not looking cheerful but this is mainly due to the lack of attention. The clean weeding to the extent done in this area is leading

to a good deal of soil erosion. There are also some good plants growing from cuttings.

The areas visited in Mysore were Henya, Devagange, Malandur Gudda and Bababudan forest. The Bababudans include Kemmangundi and Atigundi. A few abandoned coffee estates near Atigundi and Chikmagalur as well as small pieces of forest land near Chikmagalur were also inspected.

The profiles of all the areas examined are described. The examination of these indicates that the Henya, Devagange and Malandur Gudda reserve forest, profile Nos. 66, 67, and 68, are all unsuitable for cinchona. The soil is shallow, practically devoid of organic matter and where the soil is deeper as in Devagange, the lower layers are inclined to be clayey. The rainfall of Henya and Devagange is about 80—100 inches and the soil contains plenty of ferrogenous rock pieces. The Malandur Gudda gets only 60—80 inches rainfall and the land is flat in many parts. The soil has a tendency to clayeyness and would also in all probability be found to be poor chemically. The forest area near Chikmagalur, described in profile No. 75, can also be ruled out. The area has a rainfall of 60—80 inches only, the soil is shallow, disintegrating rock being visible very near the surface and the slope is rather steep. The soil would also be poor in plant nutrients.

Bababudan forest reserve and some abandoned coffee estates offer suitable areas for cinchona. The soil conditions and the rainfall are suitable but there is a danger from heavy winds in the Bababudans. A provision of wind belts would be necessary for the plantations in this area. Four typical areas in the Bababudans are described in profile Nos. 69, 70, 71, 72 and 73. The Shola, which contains the experimental plot and where also a new one acre clearing has been made for extending the cinchona experiment, has soil of good depth, rich in organic matter and of good texture and consistency all through. Profile Nos. 69 and 70 illustrate this.

122. Another very good piece of forest land in the Bababudans is along the inner road at 23rd mile on the Chikmagalur-Kemangundi road. The land is very well-wooded and has a good soil. The organic matter is present in sufficient quantity and though the land looks stony in parts, even next to the stones, good deep soil is available. The soil is clay loam but not heavy enough to impede drainage. The presence of small stones would also facilitate the movement of water. The area is described in profile No. 72. The analysis of the soil from this area, Nos. 1106, 1107 and 1108, shows the percentage of clay to be from 26 to 49, nitrogen over 0·12 per cent. in the third foot and a *p*H of about 6·0.

A small area at the 24th mile described in profile No. 71 is not so good as that at 23rd mile, but is worth considering for experiment. The area at the 22nd mile along the same road is not very promising. The soil is liable to crack and except in certain parts, the disintegrating rock is met very near the surface. The soil is described in profile No. 73.

The abandoned coffee estates near Atigundi have generally good soil as shown by profile No. 74. These are isolated areas and the total area would not be much.

In the Mysore State, the Bababudan forest offers suitable soil conditions for cinchona. The whole reserve extends to about 4,000 acres and would need explo-

ration to ascertain the extent of the suitable area. The Shola where the present experiment is being conducted and the one at 23rd mile would be the safe starting point.

Whether the high iron content of the Kemmangundi land has affected the plants is hard to say. Most of the plants seen in the experimental ground were of Nilgiri hybrid (Cinchona robusta). The experiment may have been on a mere "care and maintenance" basis, for it looked less promising than it actually is. There are approximately 1,000 acres of first class land in the west side of the hills and, if not too high, there is a prospect of a remunerative crop of cinchona being obtained here, for the forest is of excellent growth. Care should be taken in an exposed area such as this to arrange for shelter belts on all western ridges. Many of these old coffee areas which are mentioned in the previous paragraph vary from part to part and only an experimental planting will prove their suitability. An area in Mysore which suggests itself as admirably suited for Cinchona Ledgeriana is to be found at Mr. Brown's estate, some fifteen miles north of Balehonnur. At Kadamane there has been some experimenting with Cinchona robusta and the growth of the ten-year old trees is surprising especially when it is recalled that the rainfall cannot be much short of 280 inches. Indeed on this estate was seen an old Cinchona succirbura tree which measured 72 inches round the base, the largest ever seen by the writer. It would be interesting to try Cinchona Ledgeriana at Manjanahalle (part of Kadamane estate) either on its own roofs or grafted on to Cinchona succirubra which thrives so well there.

To explore all the possible land for cinchona would have taken a much longer time than could be devoted to this work. In the meantime, it is assumed that Government Forests in the Bababudans can furnish 1,000 acres and a similar 1,000 acres can be obtained from abandoned coffee estates which have lapsed into jungle, making 2,000 acres in all.

Coorg.

123. In Coorg, there are thousands of acres of Government forest land as well as old abandoned coffee estates which have reverted to jungle or lantana. This land is at present under the Revenue Department. The Government are anxious that this Paisari land should be examined for its suitability for Cinchona. A few forest areas were also included in the inspection.

The general impression of Coorg is that there are vast expanses well worthy of serious consideration for an experiment with cinchona. The climate and altitude are favourable and the soil as will be shown later, is also suitable in many parts of the province. Cinchona was grown in Coorg on an extensive scale, but the falling prices of the eighties proved ruinous to many growers. Cinchona succirubra is a feature of Coorg both in the Government land as well as on private estates; there is a small block of about 5 acres of Cinchona at Haggalle in the south-west of Virajpet, belonging to Mrs. Urathia. It was coppiced a few years ago and one can count as many as 22 coppices on certain trees. The trees stand about 7 feet high and are of Cinchona succirubra variety. The soil was satisfactory and representative of the Haggalle village, described later. Though the variety of cinchona is not good, this demonstrates that cinchona will grow in Coorg, if properly cared for.

The areas examined in Coorg were:—

(a) reserve forest compartments Nos. 1, 4 and 5 and Paisari land, all within 3 mile radius of Mercara,

(b) Paisari land along the road on way to Igoor and the Igoor reserve forest,

(c) Paisari land on way to Virajpet, particularly near Ammeti,

(d) Paisari land along cart road to Haggalle village, branching off from the Virajpet-Cannanore Road,

(e) Paisari land on way to Sampaji,

(f) Paisari and forest land on way to Bhagmandla as far as Kargunda.

From amongst the forest compartments 1, 4, and 5, No. 1 is particularly good. The soil is described in profile No. 49. It has a good loamy friable soil, rich in organic matter. The lower horizons are clay loam with some organic matter, with plenty of roots and small stones. It is generally a well drained soil. The area is well-wooded with big trees and plenty of undergrowth. Compartments 4 and 5 have also a good well-drained soil but the organic matter is much less. These are however also worth experimenting with.

124. The Paisari land, mainly the abandoned coffee estates, within three miles of Mercara, appear rather poor chemically. The soil is leached. It is represented by profile No. 50 and is rather shallow with much gravel near the surface and a good deal of weathered rock after a foot and a half down. In certain areas, the lower layers were sandy. Generally the physical texture of the soil is satisfactory, being loam up to 1½ feet after which the soil was mixed with weathered rock. The soils will drain well and might be experimented with after green manuring.

On the way to Igoor, on the Mercara-Somwerpet Road, Paisari land at the 6th, 7th and 11th mile was examined. The soil is represented by profile Nos. 51, 52 and 53. The soil is deep rich in organic matter and has a good texture and consistency. Lantana has taken possession of these lands, though there are also some forest trees to be found. The slopes are rather gentle but the land would drain well. The soil does not have much clay, right up to 4 feet. There would be about 800—1,000 acres at the three points mentioned. At the 19th mile towards Dibidi estate, exploration showed no suitable accessible land. The forest in that area is mainly deciduous and the area rather stony and soil poor. Further away westwards, some well wooded slopes could be seen, but these are not accessible. The Igoor reserve forest situated at the 19th mile and about half a mile eastwards is also not promising. The vegetation is partly deciduous. There were also rosewood lantana and bamboo.

125. The two typical areas described in profile Nos. 64 and 65 are situated along the road from Mercara to Virajpet. The soil in these areas is not particularly good, being clay loam and not very rich. A good deal of wash appears to have taken place in these areas, before they reverted to jungle. The area at the tenth mile from Mercara may be experimented with as it is superior to that at the 21st mile.

126. The soil in the Paisari land along the road to Haggalle is represented by profile No. 63. The soil is very suitable. It is a loamy soil with varying amounts of organic matter up to 2 feet. The lower layers are lighter in texture and the land is sure to drain well. The land had good slopes. The analysis confirms the loamy nature of the soil up to 2 feet 16-17 per cent. clay, with plenty of nitrogen. The 3rd and 4th foot soil is lighter, 7 per cent. clay, and has only 0·07 per cent. nitrogen. The *p*H varies from 5·2 to 5·7. There are at least 500 acres of this land and much more on the other side of Haggalle block which was not examined.

Paisari land at several points along the road to Sampaji up to mile 11 only was examined as any area westwards would have a very heavy rainfall, exceeding 200 inches, and a low elevation. The areas at the 3rd and 6th mile, represented by profiles Nos. 54 and 55, are worth considering, but these at the 9th and 11th mile, represented by profile Nos. 56 and 57, are not. The first two have a good loamy soil, inclined to clay loam in some parts only, but are well supplied with organic matter in the top. Although the soil is only 2 to 3 feet in depth, it is worth experimenting with. The acreage available in these areas would be about 300—400 acres.

The areas at the 9th and the 11th mile were not so promising. The soil is greatly washed, despite the heavy cover. The rainfall of over 170 inches would explain the shallowness of the soil. There is hardly a foot of real good soil and it would be mere waste of time and energy to experiment in such areas.

Branching from Bhagmandla on the Mercara-Mangalore road, there are several pieces of Paisari and forest land which were examined as far as Kargunda. Areas beyond that would have too great a rainfall. There is one big piece of land extending from the 2 mile 4 furlongs milestone to 3 mile 2 furlongs which is especially good. The soil is represented by Profile Nos. 58 and 59. The soil is loamy, well-drained, well supplied with organic matter up to about 1½ to 2 feet. The lower layers are loose and crumbly. There are also small areas of useful land at the third furlong and at 4th and 7th mile along the road. These are represented by Profile Nos. 60 and 61. They also have a good loamy soil up to about 3 feet. All these would yield about 600—700 acres of land worth experimenting with.

127. There is another a long piece of Paisari land at 12 mile 2 furlongs which does not appear satisfactory, if generally the soil is as represented by Profile No. 62. It is shallow, presumably due to erosion on account of heavy rain. The top layer of soil is very well supplied with organic matter.

The soil conditions in general in the Paisari land in Coorg are satisfactory for experiment with cinchona. It may however be noted that certain land, especially that which has recently reverted to jungle, would require manuring with a green crop or other organic manures such as cattle manure or compost.

Coorg was associated with cinchona from the early days of the introduction of the seed from South America. In 1861 two independent persons protested against Naduvatam being selected for the early cinchona experiments and represented that on the Mangalore road, 4 miles from Mercara, there were possibilities of growing the quinine-yielding variety—Cinchona Calisaya. Instead Cinchona succirubra, which can be found all over Coorg in neglected places, was planted.

It is possible that the blunder of these far off days can be rectified by a carefully conducted series of experiments with Cinchona Ledgeriana. There are large Cinchona succirubra trees to be found in so many places from Elk Hill Estate (Mr. G. Scotland) in the Pollibetta district, where the rainfall is about 60 inches to an Indian owned estate near Mercara where the rainfall is 150 inches or more, so soil conditions rather rainfall appear to govern the suitability of Coorg for cinchona.

128. If a nursery were opened in a suitable locality offering disease-free plants at a minimum cost, there are vast possibilities for the future of cinchona in Coorg. Local conditions would naturally decide where the starting point of operations should be. Care should be taken in the location of the nursery site for it is desirable that there should be made a thorough testing of cinchona in the immediate neighbourhood. Thus there will be, on view, a demonstration of what steps lead to success.

For the purpose of making an estimation of the acreage which might usefully be placed under a scheme of cinchona planting in Coorg, 1,500 acres have been assumed to come from Government Forests and 1,500 from Paisari land, making 3,000 acres in all.

Travancore.

129. On the High Range of Travancore there is a considerable area of forest land at elevations running from 3,500 to perhaps 5,000 feet lying roughly to the west of Munnar, belonging to the Kanan Devan Hills Produce Company. Portions of this would doubtless be suitable for the cultivation of Cinchona Ledgeriana but it must be noted that the incidence of rain in this region would be high and if accompanied by strong winds, as is more than probable, considerable care would be necessary in the selection of areas, were cinchona cultivation to be attempted there. There is, however, a remarkable absence of soil wash throughout the cultivated parts of the upper plateau. Cinchona robusta was formerly grown on an extensive scale on these hills much of which was consigned to the Government quinine factory at Naduvatam. There is still a small area of this variety but no planting proposals for the extension of cinchona cultivation generally are being considered, owing to the uncertainty of the future of the crop.

The Government of Travancore have thousands of acres of evergreen forest on the western slopes from Pullivasal extending south towards Peermade. Much of this land, it is understood, is being given away for cultivation of other crops but its suitability for cinchona appears clear. The rainfall in this area varies very much at short distances 120—150 inches may be considered a fair average for the area examined which is part of the forest referred to above. This lies between the 6th to the 19th mile from Munnar on the Munnar-Alwaye Road. The area beyond the 19th mile is perhaps too low for cinchona, being about 1,500 feet high only. The soil was examined inside the forest on both sides of the road at the 6th, 7th, 14th, 18th and 19th mile. The soil is described in two typical profiles Nos. 76 and 76A. The top soil is generally clay loam with a reddish sub-soil. The underlying rock is ferrogeneous with disintegrating laterite. The soils have a fair amount of organic matter and are usually deep, the rock being found only after 3½ feet. A typical analysis of soil from an

area at 7th mile shows that the soil contains over 40 per cent. clay in the first two feet which decreases to 30 per cent. at five feet. The soil appears well-drained in spite of the clay content in the top two feet. The soil is rich in nitrogen right up to five feet and the *p*H varies from 4·5 to 5·0. A further exploration would doubtless reveal abundance of land of a similar character on those slopes.

The Government have a small reserve, called Kuttikanam, of 316 acres near the Peermade Travellers' Bungalow. This was not examined in great detail but it is significant that the lower layers are more clayey than in corresponding areas at Pullivasal. The planters at Peermade have a fair amount of spare land which they are willing to put under cinchona under certain conditions regarding price of bark. The Rani Reserve is inaccessible. Pullivasal appears to be a suitable starting point for experimental work in this State.

Considering Travancore, it is expected that a total of 10,000 acres of cinchona could be inaugurated being, Pullivasal 500 acres, Peer-made 500 acres, Poonmudi and Kallar vicinity 500 acres, other areas (not specified) 500 acres.

Cochin.

130. The Nelliampathies Hills can be reached from Trichur *via* Nemmara. The areas examined were the virgin forest on the south of the Beatrice Estate and two abandoned coffee estates—Puliampara and East Pullala Estates. The general elevation of the area is 3,000—4,000 feet and the rainfall varies from 120 to 140 inches in both monsoons. Cinchona used to be grown in these estates many years back and a few trees are still standing in abandoned land. They are of Cinchona succirubra. The prevailing geological formation is gneiss which westwards merges into laterite, underlain by gneiss and becomes sandy on the sea board.

The soil of the two abandoned coffee estates is represented by profile Nos. 77 and 78 and that of the forest land by profile No. 79. The soil generally is not deep. In all cases, disintegrating rock is reached soon after 18 inches. But the soils are well-drained and have a good texture and consistency. It was surprising to encounter rock at 18 inches in the virgin forest especially when the rainfall is not very high and is distributed. The soil in the abandoned estates had a fair amount of organic matter after 1½ feet. The same subsoil conditions prevailed even in the virgin forest, though the top layer was richer in organic matter than that of the estates. The analysis of the soil from Puliampara Estate reveals that the soil after the top 4½ inches contains 16 to 29 per cent. clay up to 2½ feet and only 7·4 per cent. in the next 9 inches; the soil would thus drain well and up to 2½ feet is quite rich in nitrogen. The *p*H varies from 5·4 to 5·9. These conditions are comparable with Valparai soil which has been described above. The very low clay content in the lowest horizon (30—39 inches) and very low nitrogen are due to the fact that this layer is almost entirely weathered rock. In spite of the shallowness of the soil, the area is worth experimenting with cinchona and the forest land would no doubt be found richer in plant nutrients than the abandoned coffee estates.

The Nelliampathies plateau is about 3,000 feet above sea level, well-served with transport lines, accessible by a good motor road from Nemmara. The soil is well-drained and as the land which can be brought into a planting scheme is

in the midst of a planting district, these favourable factors make the future of cinchona a hopeful one. The area is reported to be very large but in the meantime, pending trial plantings to assist in estimating, an acreage of 2,000 acres is assumed for the records of this Enquiry.

ANDAMAN ISLANDS.

131. This land of mighty timber trees has been favourably regarded as a possible area in which to introduce the cinchona tree from 1880. The Central Government authorised an investigation and Major Wimberley in time reported that Saddle Peak, the most prominent peak in North Island, might provide suitable land but in his opinion there was little prospect of a profitable return owing to the acclimatization of cinchona into so many tropical lands. There the matter lay till the subject cropped up again in Colonel Gage's Report for 1918. "The Andaman Islands . . . . compare unfavourably with some of the sites on the mainland. The general altitude of the Andamans is low, the highest peaks ranging only from 1,000 to 2,400 feet. The most likely locality, if circumstances should ever render it necessary to consider the Andaman Islands as a choice for cinchona cultivation, would probably be on the slopes of Saddle Peak, 2,400 feet, in North Andaman. Mr. C. G. Rogers, I.F.S., Chief Conservator of Forests, Burma, who was at one time Deputy Conservator of Forests in the Andamans informed me that Saddle Peak was of volcanic origin and that probably about 100 square miles of evergreen forest existed on and around the Peak. The remoteness of the area, its general low altitude and its small extent are disadvantages which would make it come a long way after other areas on the mainland for choice of a site and I did not consider it necessary at this stage to visit the Andaman Islands".

In 1938, while this search for land was proceeding elsewhere in India, it was suggested by Col. Gage that the question of the suitability of the Andamans might be explored as there was no longer a need for large compact blocks of land as was the case in 1917. Accordingly a visit was authorised and was made in May 1938. So little is known about the Andaman Islands that reference has been made to the Working Plan of the Andaman Forests and other literature to furnish a brief description. The Andaman Islands are composed of some two hundred and four islands in all, lying about 750 miles equidistant from the mouth of the River Hoogly and from the harbour of Madras.

132. The principal islands in the main chain are North Andaman, Middle Andaman, South Andaman, Baratang and Rutland, with Interview on the west coast of Middle Island and several smaller islands on the east coast. These islands are separated by narrow channels all of which are navigable and sheltered at all seasons. The principal islands of Ritchie's Archipelago are called after Generals famous during the Mutiny. All these are similarly separated by navigable and sheltered channels.

Configuration of the ground.—The ground for the most part is hilly, the higher ridges being on the eastern side of the island.

Geology—Rock and soil.—"As a southern continuation of the longitudinal mountain ranges of western Burma, and separated from them by the Preparis Channel, the Andamans occur as the peaks of the northern part of a prominent

oceanic mountain, extending in the Bay of Bengal from 10°-30′ north latitude as far south as 6°-45′ north latitude.

133. *North Andaman.*—This is hilly, the highest point, Saddle Hill, being 2,402 feet above sea level. The underlying rocks consist of sandstones and conglomerates, the latter predominating, except in the higher portions where the rocks are intrusive and consist of serpentine. The former produce a coarse, rubbly sandy loam as a soil while the latter produces a dark red loam. The former soil is very permeable while the latter is impermeable, the result being a lack of water where the intrusive rock occurs."

Granted that experimental work establishes the suitability of the Andamans for growing Cinchona it would seem that success can first be looked for in the highest range available, *viz.*, that round Saddle Hill rising to 2,402 feet. In the Middle Andamans it is of course possible that cinchona may be induced to grow successfully. The Middle Andaman consists of Eocene sedimentaries with serpentine series of intrusive rocks occupying most of the hills and ridges of the central and eastern part of the Island. The sedimentaries consist of sandstones grading into conglomerates. A rough geological description of the main islands of the Andamans would be that in the north you find stratified rocks consisting mainly of conglomerates while in South Andamans, the sandstones are associated increasingly with clay and occasional outcrops of igneous rocks of the serpentine series common to the two other islands of the north.

Vegetation.—"By the decomposition of the serpentines there has arisen a very thick covering of fertile soil capable of holding large quantities of water, which they give up very gradually, so that we find dense evergreen jungles of the Gurjan type (*Dipterocarpus*) with thick undergrowth of cane and bamboo throughout the year. The sedimentary areas are also well-wooded and in them the semi-deciduous padauk (*Pterocarpus dalbergioides*) is most prominent. The change from one area where the serpentine rocks prevail to another where the porous sedimentaries are predominant, is very striking. Where the more impervious clays occur among the sedimentary strata, the forests are more dense and resemble those of the serpentine areas.

134. *Climate.*—The climate is damp for the most part of the year. The rainfall on Ross Island averages 117 inches with 175 rainy days. Five miles to the north, the rainfall is 169 and on Mount Harriet the rainfall may be as high as 108 inches. The rainy season of the south-west monsoon begins in May and ends in October. The north-east monsoon sets in in November and continues till December. January, February and March are generally fine but rain, as a rule, falls every month in the year. The average temperature of Ross for the last 10 years is as follows:—

	Maximum.	Minimum.
January	81	73
April	91	74

Water is plentiful throughout the year where the underlying rock and soil is of the igneous nature, which, as stated above, produces a luxurious undergrowth of evergreen forests, in which the soil is impermeable. On the other hand soils of the sedimentary rocks producing deciduous forests hold very little water and in them water is scarce during the dry season."

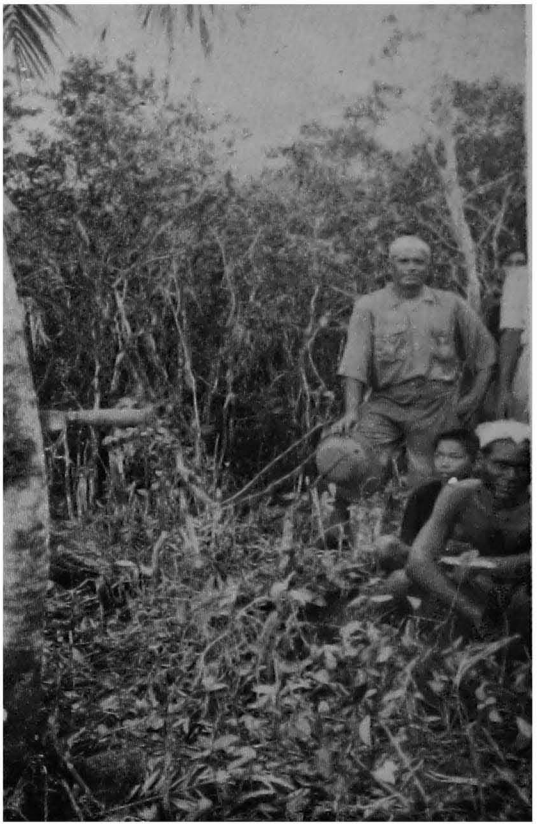
Mr. C. F. Waterfall, C.S.I., C.I.E., Chief Commissioner of the Andaman Islands was exceedingly helpful in this mission to find suitable land. Of readily accessible land at the heights usually associated with Cinchona Ledgeriana, there is none. As a start, Mr. Waterfall indicated Mount Harriet, a hill of 1,200 feet close to Port Blair as worthy of examination. The soil samples reveal a surprisingly small clay content from 11 to 16 per cent. and very fine silt from 3 to 9 per cent. This clay content would be considered admirable but for the fact that the soil appears to contain a fair amount of iron. The soil on drying forms a very hard mass which cannot easily be broken. In the circumstances, if the soil samples are allowed to guide, the prospects are not good for cinchona, especially as it is also poor in natural nitrogen; even the top foot of the soil does not exceed 0·13 per cent. The *p*H varies from 4·8 to 5·8. It was decided by arrangement with Mr. Waterfall that a small experiment in cinchona growing should be begun immediately and 50 cinchona plants were kindly provided by the Cinchona Department of Madras for this purpose, half of Cinchona Ledgeriana and half of Cinchona robusta. The plants were placed in the ground early in June and the progress can be judged from information to hand on 8th September by telegram—

> "48 seedlings planted out Mount Harriet June, 21 died due probably to heavy rain and waterlogging. Of remaining 27 plants, 5 are leafless but stems show young buds coming into flush and appear hopeful; others doing quite well except that of 8 of them show signs of insect attacks on leaves presumably by small bettle but not actually seen."

Saddle Peak area is in North Andaman and a visit was not possible to arrange to this rather remote place. Information has lately been received that the Chief Commissioner hopes to go by air over this area in October and later in the month will investigate the possibilities for cinchona by an actual inspection in company with the Chief Forest Officer. A suitable road is now being prepared and a small camp is being erected. Thus every effort is being made to test the most likely part of the Andamans for cinchona. This has been an unusually wet monsoon period and a small experiment in the raising of cinchona seedlings has been unsuccessful at Port Blair. But there is a request for a further 200 cinchona plants to be placed in the ground in December—a more favourable time than June.

135. Saddle Peak area was explored by Mr. M. S. Balasubramanyam of the Forest Department in April 1937 and a statement has been kindly given by him for this Report:—

> "The path to the top of the peak follows the stream flowing into Lamia Bay for about a mile (elevation about 150′); then it rises up steep up to an elevation of about 1,300′, and then gradually up to 2,400′.
>
> Soil:—The soil along the banks of the stream flowing into the Lamia Bay is clayey loam. From about 250′ to 1,000′ the soil is reddish (disintegration of serpentine), and then it changes again into clay. The soil appeared to be very poor from about 1,200′ to 2,400′.
>
> Types of forest:—A rich dense evergreen forest is found along the banks of the stream flowing into Lamia Bay. From about 200′—800′



ANDAMAN ISLANDS—VEGETATION AT 1500 FEET ON SADDLE HILL, NORTH ANDAMAN (M. S. BALASUBRAMANYAM).

the forest is deciduous, the white and black 'chuglams' predominating. There is practically little or no padouk. The forest canopy is about 120′—140′ high. After about 800′ we get *Dipterocarpus costatus*. From about 800′—1,300′ the forest canopy (topmost) is definitely lower and is about 90′—100′. This may be called the second zone, and in this second zone the forest is evergreen consisting of *Podocarpus nerifolia*, garcinias, calophyllums, etc. From about 1,300′ onwards the height growth dwindles down rapidly and varies between 40′ to 20′. Even *D. costatus* which was about 100′—120′ in the lower zone is not more than 25—30 in the third zone. The undergrowth in three zones mentioned above varies from light to fairly dense, and consists of bamboos.

It seems to me that the poor height of growth in the third zone is due to the poverty of the soil."

A photograph showing the vegetation on Saddle Hill at 1,500 to 1,600 feet shows that shrub jungle only is visible. Altogether the prospects do not seem reassuring.

AREAS OFFERING FAIREST PROSPECT OF SUCCESS FOR CINCHONA PLANTING SCHEMES—CLASS I AND CLASS II AREAS.

136. When the forests in different parts of India are considered, hopeful places for growing cinchona can be divided into two classes.

Class I includes all the areas favourably reported on in the foregoing pages against which an estimate of the acreage suitable for cinchona is made. *Class I areas represent those areas in India which under present conditions offer the fairest prospect of making India independent in the question of quinine.* It will be seen from Table 9 that these areas can be divided up into—

	Acres.
(i) Existing Plantations of Government	6,000
(ii) Government Forests	14,500
(iii) Privately owned Forests	17,500

On a distribution basis the classification is—

British India.

	Acres.
Bengal	7,500
Assam	1,000
Orissa	500
Madras	19,000
Coorg	3,000
	31,000

Indian States.

	Acres.
Sikkim	250
Bhutan	750
Mysore	2,000
Cochin	2,000
Travancore	2,000
	7,000

In naming these acreages in Class I above, it is recognised that the yield per acre of cinchona in India is very small compared with the reputed production of Java. It is in such a matter that the Imperial Council of Agricultural Research can render great service to India in bringing the resources of science to bear on the problems of production.

TABLE

Progressive annual yield of

Totals are shown giving equivalent in quinine sulphate and also the returns from in terms of both cinchona bark and quinine sulphate. The diagram pro-

Age of blocks in years		1	2	3	4	5	6	7
1st Block		0	0	0	20	80	200	2,000
2nd Block			0	0	0	20	80	200
3rd Block				0	0	0	20	80
4th Block					0	0	0	20
5th Block						0	0	0
6th Block							0	0
7th Block								0
8th Block								
9th Block								
10th Block								
11th Block								
12th Block								
Totals for one acre	Cinchona Bark in lbs.	0	0	0	20	100	300	2,300
	Quinine Sulphate in lbs.	0	0	0	1	5	15	115
Totals for 778 acres	Cinchona Bark in lbs.	0	0	0	15,560	77,800	233,400	1,789,400
	Quinine Sulphate in lbs.	0	0	0	778	3,890	11,670	89,470
Totals for 3,333 acres	Cinchona Bark in lbs.	0	0	0	66,660	333,300	999,900	7,665,900
	Quinine Sulphate in lbs.	0	0	0	3,333	16,665	49,995	383,295

7.

cinchona bark for one acre.

an annual Planting Scheme of (1) 778 acres, and (2) 3.333 acres expressed vides for first 12 blocks.

8	9	10	11	12	13	14
0	0	20	80	1,200		
2,000	0	0	20	80	1,200	
200	2,000	0	0	20	80	1,200
80	200	2,000	0	0	20	80
20	80	200	2,000	0	0	20
0	20	80	200	2,000	0	0
0	0	20	80	200	2,000	
0	0	0	20	80	200	2,000
	0	0	0	20	80	200
		0	0	0	20	80
			0	0	0	20
				0	0	0
2,300	2,300	2,320	2,400	3,600	3,600	3,600
115	115	116	120	180	180	180
1,789,400	1,789,400	1,804,960	1,867,200	2,800,800	2,800,800	2,800,800
89,470	89,470	90,248	93,360	140,040	140,040	140,040
7,665,900	7,665,900	7,732,520	7,999,200	11,998,800	11,998,800	11,998,800
383,295	383,295	386,626	399,960	599,940	599,940	599,940

TABLE

Progressive annual yield of cinchona bark (expressed in terms of quinine followed by (2) 778 acres thereafter annually—(in diagram position up to the

Age of blocks in years	1	2	3	4	5	6	7	8	9	10
1st Block of 1,000 acres.	0	0	0	1,000	4,000	10,000	100,000	0	0	1,000
2nd Block of 1,000 acres.		0	0	0	1,000	4,000	10,000	100,000	0	0
3rd Block of 1,000 acres.			0	0	0	1,000	4,000	10,000	100,000	0
4th Block of 1,000 acres.				0	0	0	1,000	4,000	10,000	100,000
5th Block of 1,000 acres.					0	0	0	1,000	4,000	10,000
6th Block of 1,000 acres.						0	0	0	1,000	4,000
7th Block of 778 acres							0	0	0	778
8th Block of 778 acres.								0	0	0
9th Block of 778 acres									0	0
10th Block of 778 acres										0
11th Block of 778 acres										
12th Block of 778 acres										
13th Block of 778 acres										
14th Block of 778 acres										
15th Block of 778 acres										
Total .	0	0	0	1,000	5,000	15,000	115,000	115,000	115,000	115,778

S.

sulphate) for a planting scheme of (1) 1,000 acres per annum for 6 years 19th year is shown).

11	12	13	14	15	16	17	18	19
4,000	60,000							
1,000	4,000	60,000						
0	1,000	4,000	60,000					
0	0	1,000	4,000	60,000				
100,000	0	0	1,000	4,000	60,000			
10,000	100,000	0	0	1,000	4,000	60,000		
3,112	7,780	77,800	0	0	778	3,112	46,680	
778	3,112	7,780	77,800	0	0	778	3,112	46,680
0	778	3,112	7,780	77,800	0	0	778	3,112
0	0	778	3,112	7,780	77,800	0	0	778
0	0	0	778	3,112	7,780	77,800	0	0
	0	0	0	778	3,112	7,780	77,800	0
		0	0	0	778	3,112	7,780	77,800
			0	0	0	778	3,112	778
				0	0	0	778	3,112
118,890	176,670	154,470	154,470	154,470	154,248	153,360	140,040	139,262

137. Taking the useful life of a cinchona tree as 12 years.

1. *An annual planting scheme of 778 acres per annum will provide at the time the amount of quinine, taken as 140,000 lbs., which is at present imported.*

2. *An annual planting scheme of 3,333 acres will meet the needs of public health in India in providing a minimum effective dose for every malaria sufferer assuming that 600,000 lbs. will achieve this purpose.*

But to wait 12 years in order to be in a position to replace the present imported quinine by an indigenous product is a long time. There are therefore submitted calculations showing how the period of waiting can be curtailed by altering the planting programme.

3. *An annual planting scheme of 1,000 acres for 6 years and thereafter at the rate of 778 acres per annum will yield 115,000 lbs. after 7 years.*

These figures are shown in detail in Tables 7 and 8. The figures given in Table 7 may first be discussed. It will be seen that it shows the progressive annual yield of cinchona bark from successive plantings of one acre—how for the first three years there is no harvest but that afterwards the production rapidly rises to the 8th year when coppicing would be done; that in a similar manner the yield increases from the shoots till the tree is 12 years of age by which time 3,600 lbs. have been obtained. From this it is possible to compute the cinchona bark with its equivalent in quinine sulphate for 778 acres which will yield 778 lbs. of quinine in the 4th year, 89,470 lbs. by the 8th year and the summit of 140,040 lbs. by 12 years—the presumed imported quantity.

138. In the case of the planting scheme of 3,333 acres per annum, it is noted that if development at this rate is initiated, there is a sharp rise to 383,295 lbs. at the 8th year until the desirable limit of 600,000 lbs. of quinine as needed by Public Health can be assumed after 12 years.

In Table 8 are given the details of the scheme mentioned in No. 3 above for shortening the waiting period from 12 years in No. 1 to about 7 years. As this may suggest itself as one to which assent should be accorded, the details are set out in full. After the initial planting of 1,000 acres per annum for 6 years, an annual planting of 778 will be sufficient so long as 140,000 lbs. is the upper limit.

It must be made clear however, that such a planting scheme as 3,333 acres per annum calls for an efficient organisation and that as a result all the areas assessed as being suitable would soon be used up. 38,000 acres does not provide that safety margin which is needed, even granted that there is a considerable increase in the yields per acre over those tabulated above. Under these circumstances, India will have more than enough to do in husbanding the land for the people of India so that any idea of stimulating an export trade—even if that were possible—is out of the question. It is suggested therefore that if this big development scheme is officially supported, there must at the same time be a consideration of the merits of some of the Class II areas in order that their value can be proved. This would mean experimental planting to be completed before the actual need arises.

TABLE 9.

Areas which have come under notice in this enquiry and which are considered suitable for Cinchona Ledgeriana (*save in the Nilgiris where* Cinchona officinalis *or* robusta *are substituted*).

Province or State	Locality	Existing Cinchona Plantation	Government land	Other land	Total acreage	Remarks
Bengal	Mungpoo (Darjeeling)	2,000	...	...	2,000	
	Munsong (Darjeeling)	2,000	...	...	2,000	
	Foothills (Nepal to Bhutan) (Darjeeling District).	...	2,500	...	2,500	
	Tea Plantations (Darjeeling)	...	...	1,000	1,000	
Assam	Nongkhyllem Reserve Forest (Khasia Hills).	...	500	...	500	
	Shillong-Gauhati Road, Mile 37-38.	...	500	...	500	
Orissa	Koraput District	...	...	500	500	
Sikkim	.....	...	250	...	250	
Bhutan	.....	...	750	...	750	
Andaman Islands	.....	...	...	...	...	
Madras	Naduvatam and Dodabetta (Nilgiris).	1,000	...	...	1,000	
	Anamalais (Coimbatore)	1,000	5,000	3,000	9,000	
	Ouchterlony Valley (Nilgiris)	...	...	2,000	2,000	
	Kundahs and other areas in Nilgiris and Wynaad.	...	500	1,500	2,000	
	Singampatti (Tinnevelly District).	...	...	3,000	3,000	
	Cumbum Valley (Madura)	...	...	2,000	2,000	
Mysore	Bababudan Hills	...	1,000	...	1,000	
	Coffee District	...	...	1,000	1,000	
Coorg	.....	...	1,500	1,500	3,000	
Cochin	.....	...	2,000	...	2,000	
Travancore	Poonmudi	...	...	500	500	
	Peermade	...	...	500	500	
	Pulivasal	...	...	500	500	
	Other areas	...	...	500	500	
	Total	6,000	14,500	17,500	38,000	acres.

Of the new land, viz., 32,000 acres, the distribution can be—

	Acres.
Cinchona Ledgeriana	31,600
Cinchona officinalis or robusta	400
Total	32,000

139. In the interests of India it seems most important that as privately owned land contributes such a large percentage of the new land, steps should be taken to ensure the co-operation of the owners of these lands, in production schemes. This arises from the fact that 38,000 acres is as explained far from providing that reserve of land which the magnitude of the problems makes absolutely necessary. From the national health point of view it would be a calamity if a revival in plantation industries should lead to the utilisation of these lands in other crops, although in fairness let it be repeated that, in all or nearly every case, the cultivation of tea was the objective in acquiring these lands in the first instance.

So far as it is possible to generalise at this stage, the interest for India in the results of this Enquiry must lie in the prospect of substantial quantities of Indian-grown quinine rather than an expectation of a cheap and still cheaper drug.

140. Class II comprises areas which should only be considered after the claims of Class I areas are disposed of. Here the selection is made with less assurance than in Class I areas. These Class II areas include the Mikir Hills, parts of the Garo Hills, the north Cachar Hills and parts of the Naga Hills, as well as other hill tracts in Assam containing vast areas of land. In many cases, no doubt, extensive areas can be obtained in this class just as suitable as in the areas of Class I. These, however, give rise to special problems:

(*a*) for the most part they lie in remote parts, away from modern communications—roads, bridges and railways;

(*b*) these elevated lands are occupied for the most part by tribesmen of the hills whose right to jhum land is recognised by the Government and thus satisfactory arrangements will have to be made to safeguard the interests of the local people before any planting scheme could be considered;

(*c*) selection of potential cinchona plantations would have to be very carefully made because cinchona will only grow satisfactorily in land where jhuming has not impoverished the soil unduly.

141. These outlying parts, therefore, call for a considerable capital outlay if they are to be linked up by means of modern communications with towns and villages in the plains. It is thus especially necessary that these Class II areas should be subjected to a most carefully thought out series of experiments thoroughly to test the suitability of promising land. Class II areas are not confined to Assam. There is, for example, Khasmahal land in Kalimpong Sub-Division of Darjeeling District, which might prove suitable for cinchona. The area which gives rise to the suggestion is at Nimbong, where cinchona was at one time grown by Government, but abandoned, it is understood, because of lack of communication.

In South India there are thousands of acres of abandoned coffee land now largely overgrown by lantana. The eradication of this pest would be a costly business but there is no doubt that it would prove profitable to bring parts of this large area into cultivation as long as prices are not unduly depressed. For the most part, these lands went out of cultivation because of a long continuance of low coffee prices, or through the visits of plant and insect pests and perhaps too from a relatively poor soil A visit to these

abandoned coffee areas makes one appreciate the keenness of the local Administration to bring those valuable areas of land under such a crop as cinchona and thus improve the economic life of the locality.

142. In the Orissa Highlands where *jhuming*, as in Assam, has been practised for untold ages, there are thousands of acres which could be rejuvenated to a marked degree by the prohibition of this practice of *jhuming* for say 20 to 30 years. There are, in the hills round Koraput, many areas which are visibly improving in soil texture and organic matter since forest trees were allowed to grow on them. Doubtless the same is the case in the Ganjam hills further north. It would be a great boon to institute experimental work near such a place as Koraput for there is the assurance that, if success attends the work there, many thousands of acres would either be immediately serviceable or rendered so by controlled re-afforestation. Labour is plentiful and cost of production would, in all probability, be relatively low.

It is too early to say if the Andaman Islands should be included even in Class II but experimental work is worth carrying on for a series of years. The soil samples have not, it is true, revealed that richness which is suggested by the magnificence of timber trees but an unexpectedly low clay content is a welcome feature for cinchona, in a country subject to very heavy downpours.

CHAPTER VII.

SUMMARY AND RECOMMENDATIONS.

143. 1. The history of cinchona in India shows that, within a short period of thirty years, the plantation industry had been abandoned by private enterprise by 1890, following overproduction and a catastrophic drop in prices.

2. All that remained in India were the Cinchona Plantations belonging to the Governments of Madras and Bengal. These were the pioneers in the work of establishing the plant in India from seed obtained from South America.

3. The early planters could only utilize what seed was on offer in India and this was mainly Cinchona succirubra or Red Bark, a worthless variety so far as quinine is concerned but enjoying a remunerative market in the early days of cinchona growing in India on account of its other alkaloids—cinchonidine, cinchonine and so on.

4. Ceylon followed India in growing Cinchona succirubra but Java, after an uncertain start when failure seemed more evident than success, took to the quinine-yielding family generally termed Calisaya. When therefore seed of the rich Ledgeriana variety of Cinchona Calisaya was on offer in 1865, it was Java which recognised its possibilities and later Bengal. Java, by unremitting scientific work and the possession of optimum conditions for growing cinchona, gradually obtained a complete command of the world's quinine market and now dominates it to the extent of 97 per cent. or so.

5. Java's success is fully recognised as its due but, with so much forest land in India offering prospects for cinchona, there has lately arisen a feeling that this industry should be re-established once again.

6. Accordingly this report has been prepared, to tell the history of the early happenings in India leading to an appraisement of the position today. The lessons of history have been shown to be briefly these:—

(i) That the cultivation of Cinchona Ledgeriana on land suitable for this variety should be India's goal;

(ii) That as Public Health is so concerned with the certainty of indigenous supplies, the State should assist this renaissance by freely placing disease-free seedlings on offer and at the same time should equip a Research Station under the Imperial Council of Agricultural Research for the isolation of strains of high quinine content, the examination of the problems of cultivation and manufacture as well as for the collecting of necessary statistical data;

(iii) That planting schemes, no matter what agency is employed, should be framed on the results obtained from trial or experimental plantings in each locality;

(iv) That it is advisable to consider the employment of private enterprise in cinchona whether this be by contract with private planters (See Appendix IV) or by a State aided Cottage Industry, should this latter be feasible;

(v) That a close liaison should at all times be maintained between the State and the cinchona grower so that, as far as is humanly possible, schemes of distribution leading to adequate consumption should be framed in a timely manner adequate to deal with all the production of bark of the new planting. Only by this can the possibilities of another catastrophe be avoided.

7. India contains enough first class land for an early resumption of cinchona growing, there being available some 38,000 acres distributed in Bengal, Assam, Orissa, Bhutan, Sikkim, Madras, Travancore, Cochin, Mysore and Coorg.

8. India's need is about 210,000 lbs. of quinine today of which roughly 70,000 lbs. are made in the country and the balance or 140,000 comes from factories using Dutch East India bark.

9. The real need of India is provision for 100,000,000 sufferers for whom 45 grains should at least be provided. This will use up some 600,000 lbs. of quinine sulphate annually.

10. Even if Java can supply this quantity by extending its production, an enlightened public health policy regarding malaria in other lands in which the disease prevails, might well leave India with uncertain or inadequate supplies.

11. It is suggested therefore that India should be up and grow its own requirements of quinine by building up an organisation for development to the extent necessary to meet the real needs of India or 600,000 lbs. of quinine annually.

12. A scheme of planting 778 acres annually will under an estimated yield of 180 lbs. of quinine sulphate per acre, by 12 years, provide 140,000 lbs. annually.

13. But this is a long time to wait. A modified scheme providing for 1,000 acres a year for 6 years and thereafter 778 a year will hasten the production and in 7 years production not far short of the present imports of quinine could be looked for in this country.

14. For the real needs of India, calculation indicates an annual planting of 3,333 acres as being necessary to give an annual outturn, under present conditions of 600,000 lbs. by 12 years. For this there is barely enough land.

15. There should be no delay in assessing the value of much of the hill land in the Mikir, Naga, Khasia and other hill ranges in Assam. It will be to Assam that India will look if and when the 38,000 acres are used up.

16. The cinchona tree requires a deep, rich, well-drained soil, acidic in reaction, and well supplied with organic matter. The *p*H range extends from 4·2 to 5·6. A nitrogen level of about 0·2 per cent. in the top foot and not less than 0·1 per cent. in the third foot is necessary for successful growth. In Bengal the tree can tolerate on good slopes as high as 35 per cent. (by the International method of soil analysis) which becomes a limiting factor if the land is flat.

17. Research is urgently required in the following directions:—

(i) The isolation of strains of cinchona with higher quinine content,

(ii) The improvement of cultivation methods, and

(iii) The reduction of the cost of extraction and distribution.

18. An essential feature of any scheme of planting up new areas should be the provision of nurseries for the supply of vigorous disease-free seedlings from the outset and seedlings and grafts of high quinine strains later on.

19. There is need for a comprehensive system of costing laid down by an expert. Tentatively the following costs are given. Granting a bark yield of 3,600 lbs. of 12 years and containing 5 per cent. quinine sulphate and 2 per cent. other alkaloids,—

(*a*) the cost of producing 1 lb. of cinchona bark is 6 annas in all;

(*b*) the cost of 1 lb. of such cinchona bark to the factory, after allowing for the value of other alkaloids, is 5 annas per lb.;

(*c*) the cost of 1 lb. of quinine sulphate in bark form is Rs. 6-4-0 per lb.;

(*d*) the total cost of quinine sulphate at present will probably be Rs. 15 in Madras and Rs. 13 in Bengal;

(*e*) Research would assist in reducing the cost of extraction and distribution as well as the cost of bark.

20. In the meantime, pending the arrival of more workers in the cinchona field, it would be correct to say that the interest for India lies in the hope of plentiful supplies of quinine rather than the prospect of increasing supplies at mass production rates.

APPENDIX I.

Cinchona Seed and Nursery Management.

An ounce of Cinchona seed will yield about 7,000 plants with ordinary care.

Cinchona Ledgeriana is the best variety and is suitable for land up to 5,000 feet or so. Unfortunately it is the most liable to disease. Cinchona robusta—of hybrid origin—will grow well at higher elevations and does best at about 6,000 feet.

Cinchona Ledgeriana is relatively short-lived and should be coppiced about the 8th year at the latest, while the other varieties mentioned will continue to grow for as many as 30 years.

2. *Making nurseries.*—In preparing the nursery, all roots and stones should be removed and as many stumps taken out as possible, the ground should then be dug over and beds formed twelve feet long and four feet wide; trenches should be cut eighteen inches wide and deep and earth should be thrown on the beds on either side thus forming a low platform. It is a good plan to make the bed so that the centre is six inches higher than the sides. A layer of vegetable mould, mixed, with an equal quantity of clean sand, should be spread over the top to the depth of two to three inches. The top should be carefully pressed by hand so that the bed will be of uniform firmness all over but pressure should be carefully applied.

3. The seed should then be scattered pretty thickly over the surface and a sprinkling of fine sand put over it; this is merely to keep the seed in position and bring it into close contact with the soil. Finally the whole surface of the bed should be gently pressed with a board.

4. As it is in the nursery that diseases so common in cinchona have their beginning, it is necessary to call attention to the watering. Watering should be done very carefully and excess avoided. It should be applied in the early part of the day by means of a finely bored can—the ordinary watering can is not suitable (Suttons, Calcutta, supply a suitable can and doubtless other seedsmen).

5. *Shade for seed-beds.*—It is always necessary to provide shade for seed beds, an ordinary thatched roof with hip ends over each bed being the simplest form. The object of the shade is to admit light and air and yet screen the tender plants from sun and rain. It is important that the rays of the sun should not reach the seed bed.

6. In three to six weeks, according to climate, the seeds will germinate when particular care of the watering should be given otherwise the seedlings will die off in patches. When this occurs there is no sure remedy but by sprinkling lime on the patches, the danger of spreading is lessened. Over-watering is the chief cause of these patches and this cannot be too often emphasised. On the Nilgiris it has been found in practice that the edges of the pandal or thatching should be covered with gunny or hessian cloth as cinchona seed germinates better in a darkened environment. When the seedlings are about 1 inch in height and with two pairs of leaves they are ready for transplanting into nursery beds. The pricking out should be done carefully with a sharp stick and only plants ready for transplanting should be taken out. The smaller seedlings should be transplanted later when ready. In transplanting care should be taken to damage the young rootlets as little as possible. In removing the seedling in replanting it, it is of the utmost importance that the *malies* do not touch the rootlets; *malies* should be taught to hold the seedlings by the leaves only. The seedlings so taken out should be transplanted to nursery beds, formed in the same way as the seed beds (described above) but with a thicker layer of vegetable mould and sand. The plants should be put in from four to five inches apart depending on the kind of cinchona.

7. Before removing the plants from the seed-bed, it should be well watered so that as much earth may adhere to the roots as possible and the nursery beds should also be well watered before the transplanting occurs. The best way to put the seedlings in with regularity is to mark the bed with a string at intervals of 3 to 4 inches. When being put into the holes—which the *malies* should make of the right size with their index finger and not with sticks—particular care should be taken that the hole is adequate and that the root is not doubled up. The soil round the seedlings should be pressed down so that water cannot lodge below the roots. For purposes of transport it is often advantageous to transplant the seedlings into shallow boxes filled with earth or in baskets covered with a layer of moss and on no account should the sun be allowed on the rootlets. A cooly can put in up to

2,000 seedlings a day but 1,000 is a fair figure till experience is gained. Women coolies are preferable to men in this work.

8. *Shade for nursery beds.*—Shade is also necessary for the nursery beds by means of a thatch covering although it is possible to make satisfactory nursery beds with stout fern shading between the seedlings, where the rainfall is not more than 80 inches. When thatched coverings are placed over the nursery beds, these should rise from near the level of the bed on the south side in a simple slope to the north. This will carry off the rain, keep out most rays of the sun and at the same time give northern light. The side thus left open should be protected with mats where it affords access to the sun or rain. Thus the beds will lie east and west. From the sowing to the final planting will take about 12 to 14 months depending on elevations. During the whole of this time judicious watering should be carried out whenever the beds are dry, but in the latter months it is recommended that no water whatever is given. The best time for sowing seed is from February to April but if big plants which the writer personally recommends are preferred, a start should be made as early in February as possible.

9. *Planting time.*—From the nursery bed to the plantation is the last stage and it is advisable to plant out, if possible, before the heavy rain of the monsoon occurs. For practical purposes as early in June as is feasible (for South India at any rate) is best. The plants should be accustomed to the sun by a gradual removal of a portion at least of the thatch. This will give stronger and hardier plants. Where fern shading in open beds is adopted a portion of the fern shading should be removed during April. In Assam, Coorg and Mysore the low-growing palm (Phoenix), so common there, will form a satisfactory substitute for fern in shading.

10. One last observation is that on no account should horse or cattle manure be incorporated in either the soil of the seed bed or the nursery bed. By attention to this point and by increasing the thickness of the sand, if necessary, in the compost and careful control of watering, much of the difficulty in raising cinchona seedlings will be lessened. In some areas where the soil is full of eggs and the larvae of insects it may even be desirable to heat the top layer of soil prior to spreading on the bed.

11. When the plants are ready for their permanent position in the plantation, the usual operations as in a tea or coffee estate should previously have been carried out—that is felling and clearing the forest, weeding the area to be planted, lining, holing and filling. The distance apart of each plant varies according to the richness of the soil, the elevation and species of cinchona but a safe distance is four feet by four feet, which will yield about 2,400 trees per acre. Where there is any considerable amount of wind, it is advisable to shade the young plant and to stake it when large enough. The omission to stake young cinchona plants while anchoring themselves in the ground, is the cause of much failure in cinchona planting, especially if the plant collar (*i.e.*, the portion between the root and the stem) has been buried in the soil at planting time. After the cinchona plants are put out in the plantation, it is the practice on the Government plantations in South India to interplant *Grevillea robusta* (Silver oak) and a suitable system is described at para. 63. Cinchona, in South India at any rate, is benefited by shade especially during the dry months (January to April).

APPENDIX II.

EXTRACT FROM THE REPORT OF THE ROYAL COMMISSION OF AGRICULTURE IN INDIA.

411. Not the least of Government's responsibilities in the matter is connected with its policy in regard to the manufacture of quinine and cinchona febrifuge—the principal propylactic in the treatment of malaria. Both for the prevention and for the treatment of malaria, a much wider distribution of quinine is necessary. At present, the high price of quinine militates against this. The total annual consumption of quinine in India is estimated at 1,60,000 lbs. of which only 42,000 lbs. are manufactured in the country. In these circumstances, the Indian price is determined by the world price and this, as is well known, is a monopoly price owing to the fact that ninety per cent. of the world's surplus of quinine comes from Java. To reduce the internal price to a level at which the Government of India would be able to embark on an intensive anti-malaria campaign, it would be necessary that India should produce all its own requirements of quinine and thus be able to reduce the monopoly price.

With the exception of those which were started in 1923, in the Mergui district in Burma, all the cinchona plantations and the factories for the manufacture of quinine are owned by the governments of Bengal and Madras. Under the Devolution Rules, nowever, the Government of India have full powers to regulate the planting programme of the Local Governments, to fix the issue price of quinine on a uniform basis and to prohibit the purchase and sale of quinine by Local Governments. They thus exercise a controlling authority over the industry.

If India is to embark on any large campaign for fighting malaria, we are convinced that it will first be necessary to reduce considerably the price of quinine within India and this can only be effected if India is self-supporting in production. To achieve this self-sufficiency, a considerable extension of the present area under cinchona will be required. Investigations into the possibility of extending the area, and into the problems of development and manufacture, are, in our opinion, matters for the Government of India and not for provincial governments. Quinine is required throughout India, but the cinchona tree can be successfully cultivated only in certain provinces. Some of these provinces have not the resources to enable them to embark on this specialised branch of industry and the Government of India, owing to their larger resources, are in a better position than any provincial government to undertake experiments and to develop any areas capable of yielding quinine for the benefit of the country as a whole. If the question of malaria is to be seriously tackled, we are strongly of opinion that the development of cinchona cultivation in all provinces which contain areas suitable for its growth, the manufacture of quinine and the control of its distribution so far as price within India is concerned, should be taken over by the Government of India. In view of the all-India importance of the question, it is not one which should be left to Local Governments, however efficiently they may in the past have carried out their obligations in the matter.

412. We have been informed that, as a result of the selection of seed, the percentage of quinine yielded by trees in Bengal has been doubled in the past twenty years. This consequence of scientific study is an illustration of what might be looked for, if other problems hindering the progress of cinchona cultivation were systematically attacked, and we are of opinion that a research institute for the investigation of cultural difficulties met with in the growing of cinchona is desirable.

(ii) The need for increased scientific investigation.

A good deal of general information respecting the soils and climates suited for cinchona has been collected but these subjects appear to have received little detailed study and the lack of precise information which can only be gained by scientific investigation has already led to costly failure in cinchona plantations. If scientific staff were assembled for the study of cinchona questions from the point of view of the chemist, the plant breeder and the meteorologist, and if this staff were enabled to carry out carefully planned experiments in localities in which it was proposed to start new plantations, it is unlikely that large scale failures would be repeated.

The possibility of extending the area under cinchona cultivation and of cheapening quinine affords others reasons for scientific study. The cinchonas are exotics which have not taken kindly to Indian conditions, and, as a group, they remain difficult to satisfy. Efforts to find soil and conditions suitable for their cultivation have meantime brought some 4,000 acres only under consideration. This position raises for plant breeders the question of the possibility of altering the character of the tree so as better to adapt it to the Indian

climate, and for chemists the possibility of effecting soil improvement at a cost which would be found economical by the cinchona planter.

We have been informed in evidence that the cultivation of *Cinchona Ledgeriana*, the most valuable species, is restricted by the fact that it can stand neither frost nor high temperatures. But the plant hybridises readily and promising natural hybrids have been found. Cross-fertilisation has been resorted to, but the conditions in which it has been carried on have been unfavourable. In a case of this kind, it is hardly open to doubt that, if plant breeders took up the work in suitable conditions, varieties could be produced more tolerant of the Indian climate than the existing cultivated species. There is also the possibility of increasing the yield of quinine; selection has already provided a crop much more valuable than the original type, and there is no reason to suppose that finality has been reached. Continued selection, with or without hybridisation as the circumstances may require, would almost certainly be rewarded.

Again, we have been informed that this valuable yellow bark cinchona is the species on which the Java industry depends, and that there it thrives on deep soils of volcanic origin; but that it has not done well in Madras plantations, where the underlying rock is different in character. The Madras soil may be unsuitable for different reasons, some remediable, others not. In view of the difficulty of finding soils suited to cinchona, we think that the possibilities of soil improvement should be carefully examined.

As we have had no opportunity of visiting cinchona plantations or of seeing the experimental work now in progress, we make no recommendation respecting the size of laboratory and laboratory staff necessary, or on the extent of the facilities for field experimental studies that are desirable. We are, however, satisfied that in view of the great importance of extending cinchona cultivation and cheapening quinine, much more scientific investigation is called for than has been undertaken in the past.

APPENDIX III.

Results of analysis of eight samples of soils, received from the Bombay Burma Trading Corporation Ltd., Kallidaikurichi with their letter dated the 9th September 1936.

(Results expressed on oven-dry basis)—Singampatti group of estates.

Laboratory number—1936-37 and head of analysis	544 Soil "A" block	545 Soil "B" block Western area from surface to 4' depth	546 Soil "C" block Western area from surface to 4' depth	547 Soil "D" block Western area from surface to 4' depth	548 Soil "E" block Western area from surface to 4'depth	549 Soil "F" block Western area from surface to 4' depth	550 Soil "G" block Western area from surface to 4' depth	551 Soil "H" block Western area from surface to 4' depth	For comparison 1930 clearing soil sample 22nd September 1932
Chemical analysis	%	%	%	%	%	%	%	%	
1. Moisture	2·70	3·56	2·72	2·13	2·76	2·27	2·89	2·97	2·12
2. Organic matter	8·82	10·50	10·88	11·46	10·10	9·47	11·44	11·12	8·02
3. Insolubles	67·89	63·43	65·15	56·32	65·64	63·24	61·72	63·33	75·80
4. Iron	6·74	5·32	7·38	11·19	8·21	8·76	8·87	7·22	5·02
5. Alumina	15·70	19·96	16·25	20·37	15·41	17·99	17·74	17·70	10·04
6. Lime	0·060	0·074	0·072	0·071	0·040	0·048	0·051	0·055	0·22
7. Magnesia	0·085	0·093	0·065	0·083	0·093	0·059	0·116	0·108	0·25
8. Potash	0·158	0·222	0·308	0·136	0·338	0·212	0·243	0·308	0·26
9. Soda	0·901	0·065	0·179	0·045	0·029	0·051	0·017	0·029	0·69
10. Carbonic acid	0·041	0·030	0·040	0·056	0·053	0·051	0·050	0·045	0·12
11. Phosphoric acid (Total)	0·014	0·140	0·061	0·089	0·072	0·005	trace	0·046	0·079
12. Sulphuric acid	0·078	0·102	0·135	0·093	0·143	0·175	0·153	0·145	0·089
Total	99·717	99·936	100·020	99·918	100·128	100·051	100·400	100·016	
13. Nitrogen	0·093	0·105	0·119	0·084	0·127	0·059	0·103	0·134	·178
14. Available potash	0·018	0·0091	0·011	0·0098	0·0085	0·0064	0·0088	0·0054	·013
15. Available phosphoric acid	0·001	0·0011	0·0013	trace	0·003	*Nil.*	*Nil.*	0·008	·0042
Mechanical analysis									
1. Clay	32·01	35·10	36·54	26·31	31·93	41·49	35·27	33·26	18·0
2. Silt	7·96	9·06	10·83	10·22	6·78	5·63	9·26	9·36	12·7
3. Fine sand	6·14	5·02	8·21	11·03	8·38	11·44	11·15	5·42	13·1
4. Coarse sand	52·11	48·42	43·59	49·05	50·03	39·37	45·09	50·41	55·7
Total	98·22	97·60	99·17	96·61	97·12	97·53	100·77	98·45	
5. *p*H	4·71	4·77	4·94	4·91	4·91	4·91	4·92	4·92	

(Sd.) RAMASUBRAMANIAH,
for *Government Agricultural Chemist.*

The 17th December 1936.

APPENDIX IV.

*CONDITIONS UNDER WHICH THE PLANTERS OF SOUTH INDIA ARE PREPARED TO CULTIVATE CINCHONA IN 1938.

"Many years ago a large quantity of cinchona was grown but, owing to the continued refusal of Government to guarantee a fixed minimum price, almost the whole of the cinchona previously in existence has been up-rooted and the land planted with other products.

There is no doubt that a certain number of Planting Concerns in South India have reserve lands which they would like to plant with cinchona provided a fair commercial profit can be expected. This is especially the case in regard to the reserve land of tea plantations as, under the Indian Tea Control Act, the planting of fresh areas of tea has been prohibited for the last five years and is prohibited for the next five years with a possibility of even a longer period of prohibition.

The only possibility of Planter in South India taking up the growing of cinchona again, is with the certainty that Government will be prepared to guarantee them a minimum price for their bark. Hence, if Government wish planters to grow cinchona so as to make the supply of bark for the Government Quinine Factories ample and certain, the Government must be prepared to encourage them to do so and give them a definite guarantee for the future on the following lines :—

1. A guarantee to absorb the production from estates cultivating cinchona provided the bark is of good quality.
2. A guarantee to pay planters the market rate, subject to a fixed minimum price should the market rate fall below that price.
3. Remission or partial remission of assessment on lands newly planted with cinchona for a period to be mutually arranged as between Government and planters.
4. The Planters on their part to give a guarantee that they will not sell their bark to anybody else except Government.
5. Government to have the right to limit the area to be planted with cinchona for which they will give the guarantees suggested above, so as to prevent the overproduction of cinchona under that guarantee and, in consequence, the overloading of the Government Quinine Factories with bark.

This matter of giving Planters a guarantee for a minimum price has been a subject of repeated representations to the Government of Madras from the year 1895 and, at intervals, continuously up to 1915. Finally in the year 1925, as Government had consistently refused to give this minimum guarantee, the Association agreed to the Government itself opening up lands in the Anaimalai Hills for cinchona cultivation to supply the Government Quinine Factories."

*Extract from a letter from the Secretary, United Planters Association of Southern India addressed to the Secretary to Government, Development Department, Madras, dated the 26th April 1938, a copy of which was forwarded under date 27th August 1938, to the Special Officer preparing this Report.

APPENDIX V.

Analytical data (Cinchona Soils).

Sample No.	Description	Depth	Stones	Moisture	pH	Loss on ignition	Nitrogen	Clay	V. Fine silt	Silt	V. Fine sand	Coarse fraction and Loss on solution
		Ft. in.	%	%		%	%	%	%	%	%	%
1	Mungpoo 1934. Good area. (Darjeeling District).	0 12	4·40	5·24	4·58	9·65	0·2270	31·62	12·60	17·20	15·61	22·97
2	Ditto . . .	12 24	16·67	4·21	4·46	8·25	0·1597	33·76	13·12	18·41	14·81	19·90
3	Ditto . . .	24 36	13·33	4·13	4·25	7·95	0·1545	37·70	13·37	13·37	14·57	15·99
4	Mungpoo 1934. Poor pocket. (Darjeeling District).	0 12	12·50	3·64	4·55	9·55	0·2358	30·96	12·99	15·89	11·84	28·32
5	Ditto . . .	12 24	2·80	3·48	4·52	4·33	0·1632	32·53	12·86	19·12	12·63	22·36
6	Ditto . . .	24 36	7·10	3·43	4·60	7·21	0·1263	37·81	7·15	23·06	13·56	18·42
7	Ditto . . .	0 12	8·0	3·77		7·82		35·02	11·69	22·46	8·56	22·27
8	Ditto . . .	12 24	8·0	3·35		6·40		34·36	11·30	24·67	10·95	18·62
9	Ditto . . .	24 36	6·0	3·06		6·37		36·99	12·22	25·29	13·58	11·92
10	Bichkaman 1937. (Darjeeling District).	0 12	20·0	2·85		5·77		20·29	6·76	13·22	9·13	50·60
11	Ditto . . .	12 24	18·25	2·91		5·42		22·25	6·44	12·57	6·21	52·53
12	Ditto . . .	24 36	22·5	2·07		5·50		19·93	5·66	10·93	8·47	55·01
13	Labdah 1934. (Darjeeling District).	0 12	43·0	2·35				18·20	4·00	15·42	13·27	49·11
14	Ditto . . .	12 24	50·0	2·08				15·21	3·77	12·86	13·28	54·88
15	Ditto . . .	24 36	49·0	1·72				17·05	4·39	14·12	14·86	49·58
16	Labdah 1928. Bad pocket. (Darjeeling District).	0 12	50·0	2·49				9·81	4·91	10·49	11·86	62·93
17	Ditto . .	12 24	50·0	2·44				9·60	3·69	11·18	14·19	61·34
18	Ditto . . .	24 36	50·0	1·43				8·33	3·25	10·50	16·17	61·72
19	Ditto . . .	0 12	28·0	2·89	4·98	8·93	0·2449	16·12	2·97	16·45	12·11	52·35

Analytical data (Cinchona Soils).

Sample No.	Description	Depth	Stones	Moisture	pH	Loss on ignition	Nitrogen	Clay	V. Fine silt	Silt	V. Fine sand	Coarse fraction and Loss on solution
		Ft. in.	%	%		%	%	%	%	%	%	%
20	Labdah 1928. Bad pocket (Darjeeling District).	12 24	28·0	2·77	4·98	7·50	0·2106	14·50	5·35	16·86	13·06	50·23
21	Ditto . .	24 36	56·0	1·91	5·10	5·13	0·1088	13·25	4·49	14·48	18·44	49·34
22	Labdah 1930. (Darjeeling District).	0 12	33·4	3·08	5·21	7·54	0·2064	19·69	4·04	14·71	11·52	50·04
23	Ditto . . .	12 24	24·0	3·32	4·43	7·37	0·1913	21·15	6·88	12·73	13·34	35·90
24	Ditto . . .	24 36	26·0	3·36	4·89	6·04	0·1857	18·17	4·90	12·01	13·37	53·55
35	Burmiak 1913. (Munsong, Darjeeling District).	0 12	22·3	5·23	4·65	10·41	0·3782	26·70	7·58	24·89	14·44	26·39
36	Ditto . . .	12 24	22·7	4·98	4·59	7·60	0·2359	22·67	8·95	29·42	17·16	27·80
37	Ditto . . .	24 36	35·0	4·87	4·72	7·05	0·2089	20·32	7·91	32·31	18·77	20·69
38	Kashyem 1935. Poor pocket. (Munsong, Darjeeling District).	0 12	22·2	4·74	4·65	7·83	0·2719	33·53	8·30	22·48	14·49	21·20
39	Ditto . . .	12 24	33·3	4·12	4·75	6·34	0·1402	29·56	8·01	26·23	16·99	19·21
40	Ditto . . .	24 36	29·0	3·27	4·91	5·51	0·0897	28·71	7·51	22·55	18·18	23·05
41	Kashyem 1935. Good pocket. (Munsong, Darjeeling District).	0 12	39·0	4·64	5·23	9·18	0·3274	34·70	8·39	11·85	11·33	33·73
42	Ditto . . .	12 24	25·0	4·34	5·51	5·28	0·1551	21·95	15·05	29·68	15·77	15·77
43	Ditto . . .	24 36	30·0	3·54	5·11	3·91	0·1045	31·41	11·61	29·12	15·06	12·80
53	Burmiak Forest. (Munsong, Darjeeling District).	Top larger.	34·0	6·14	4·74	14·40	0·6622	23·95	8·30	17·88	12·22	37·65
54	Ditto . . .	0 6	16·0	5·21	4·96	8·91	0·3796	24·81	7·93	20·28	16·59	30·39
55	Ditto . . .	6 12	16·0	4·72	4·91	7·51	0·2057	24·60	7·96	22·23	17·80	27·41
56	Ditto . . .	12 24	11·1	4·86	4·73	5·56	0·1413	17·82	6·44	21·54	20·75	33·45
57	Ditto . . .	24 36	19·7	3·90	4·84	4·63	0·1035	24·18	6·14	19·67	17·18	32·83
67	Chhuha Basty land (Sikkim) .	0 12	62·5	0·80	5·09	2·96	0·0975	8·27	2·21	28·02	25·60	35·90

68	Ditto . . .	12 24	66·6	0·53	4·76	1·80	0·0591	6·23	4·11	28·05	17·80	43·81
69	Ditto . . .	24 36	55·0	0·47	4·77	0·98	0·0324	4·48	5·69	30·98	25·82	33·03
73	Namle Reserve 10th Mile. (Sikkim).	0 12	32·0	3·80	4·19	11·08	0·3594	21·66	7·60	28·36	14·09	28·29
74	Ditto . . .	12 24	40·0	3·48	4·36	8·00	0·2364	20·51	10·16	31·17	12·96	25·20
75	Ditto . . .	24 36	50·0	2·11	4·38	6·08	0·1345	20·53	8·99	31·57	15·51	23·40
79	Namle Reserve 11th Mile. (Sikkim).	0 12	41·0	2·80	4·58	8·69	0·2967	16·15	8·02	13·68	13·58	48·57
80	Ditto . . .	12 24	40·0	2·46	4·26	6·42	0·1952	15·17	9·53	13·34	16·19	45·77
81	Ditto . . .	24 36	42·0	1·57	4·54	4·39	0·1124	13·82	6·09	14·94	19·30	45·85
85	Umsaw Plantation No. I. (Khasia Hills)—Assam.	0 12	12·5	2·56	4·48	9·06	0·1987	41·51	5·61	10·60	6·03	37·75
86	Ditto . . .	12 24	16·3	2·58	4·37	7·94	0·1063	44·37	11·71	10·83	6·17	26·92
87	Ditto . .	24 36	16·3	2·45	4·29	7·82	0·0875	45·63	8·68	12·25	6·66	26·78
101	Area at 37th Mile Gauhati-Shillong Road. (Khasia Hills)—Assam.	0 12	28·0	3·11	4·89	7·87	0·1923	31·62	4·68	11·05	9·16	43·49
102	Ditto . . .	12 24	20·4	3·11	4·47	6·86	0·1098	40·69	8·18	10·83	6·68	33·62
103	Ditto . . .	24 36	20·0	3·01	4·59	6·57	0·0982	42·48	4·38	11·26	7·87	34·01
104	Ditto . . .	0 12	19·0	3·42	4·49	8·86	0·1638	31·68	6·11	11·29	5·45	45·47
105	Ditto . . .	12 24	19·0	2·89	4·30	8·03	0·1081	33·98	5·87	13·69	5·46	40·90
106	Ditto . . .	24 36	10·0	2·90	4·41	7·36	0·0865	38·90	4·13	15·85	5·57	36·55
113	40th Mile. Gauhati-Shillong Road. (Khasia Hills)—Assam.	0 12	21·5	2·30	4·77	7·70	0·1476	28·96	4·51	12·0	8·15	51·38
114	Ditto . . .	12 24	40·0	2·39	4·41	6·06	0·0888	36·12	5·02	11·37	5·11	42·38
115	Ditto . . .	24 36	30·0	2·22	4·40	6·18	0·0594	37·22	4·09	11·04	5·73	41·92
119	Ditto . . .	0 12	29·0	2·36	4·74	8·45	0·1980	30·70	4·75	11·24	6·87	46·42
120	Ditto . . .	12 24	33·0	2·21	4·39	7·75	0·0957	39·88	6·44	8·90	7·56	37·22
121	Ditto . . .	24 36	30·0	2·03	4·37	6·67	0·0672	34·40	3·46	10·83	5·06	46·25
134	Forest land on way to Barsathung Parbat 2,000 ft. (Mikir Hills)—Assam.	0 12	30·0	1·23	4·57	4·60	0·1375	25·41	4·36	13·76	9·93	46·54
135	Ditto . . .	12 24	55·6	1·32	4·31	5·76	0·0914	37·19	5·58	10·12	8·63	38·48
136	Ditto . . .	24 36	32·0	2·35	4·00	9·05	0·2697	46·28	7·59	13·78	7·77	19·63

Analytical data (Cinchona Soils).

Sample No.	Description	Depth	Stones	Moisture	pH	Loss on ignition	Nitrogen	Clay	V. Fine silt	Silt	V. Fine sand	Coarse fraction and Loss on solution
		Ft. in.	%	%		%	%	%	%	%	%	%
137	Forest land on way to Barsathung Parbat 2,500 ft. (Mikir Hills)—Assam.	0 12	30·0	0·79	4·34	5·57	0·1397	19·45	4·34	9·98	7·97	58·26
138	Ditto . . .	12 24	30·0	0·89	4·22	5·80	0·0749	29·97	6·66	10·08	9·00	43·39
139	Ditto . . .	24 36	35·0	0·96	4·40	6·29	0·1512	32·21	6·56	9·79	8·69	42·75
141	On way to Gausin Parbat 2,000 ft. (Mikir Hills)—Assam.	0 12	55·0	1·07	4·25	7·23	0·0807	35·47	12·74	11·94	12·13	27·72
142	Ditto . . .	12 24	37·0	1·60	3·88	8·80	0·1508	26·00	5·81	8·34	6·29	53·56
143	Ditto . . .	24 36	36·0	1·68	3·87	8·90	0·1281	27·26	1·81	14·64	7·23	49·56
144	Nongkhyllem Reserve (Khasia Hills)—Assam.	0 12	1	2·37	4·65	13·24	0·2236	55·94	5·93	11·88	8·81	17·44
145	Ditto . . .	12 24	1·5	2·58	4·60	10·56	0·1484	60·55	7·40	3·29	6·15	22·61
146	Ditto . . .	24 36	2·0	2·49	4·66	10·72	0·1198	49·64	3·69	4·11	9·64	32·92
147	Nongkhyllem Reserve. 29th Gauhati-Shillong Road. (Khasia Hills)—Assam.	0 12	54·0	4·00	4·52	10·72	0·1779	43·03	10·88	14·33	5·36	28·40
148	Ditto . . .	12 24	58·9	3·60	4·32	10·83	0·1452	49·00	10·72	6·81	11·58	21·89
149	Ditto . . .	24 36	52·0	2·89	4·40	10·37	0·1048	50·70	9·80	13·96	3·56	21·98
1011	Naduvattam 1926. (Nilgiri Hills)—South India.	0 6	12·0	6·88	5·27	16·42	0·4792	33·30	6·01	8·15	6·24	46·3
1012	Ditto . . .	6 21	13·3	5·49	5·33	11·89	0·2397	30·48	6·77	10·17	14·38	38·2
1013	Ditto . . .	21 36	6·25	5·93	5·60	8·61	0·1300	50·40	14·25	9·14	6·58	19·63
1027	Dodabatta plot 7. (Nilgiri Hills)—South India.	0 12	4·0	6·39	5·00	12·38	0·4411	47·64	8·46	8·42	7·91	27·57
1028	Ditto . . .	12 24	13·0	7·23	5·33	10·46	0·2982	46·13	9·49	12·08	4·10	28·20
1029	Ditto . . .	24 36	2·0	7·76	4·99	10·55	0·2201	47·06	9·09	11·07	7·15	25·63
1057	Valparai 1927. (Annamalai Hills)—South India.	0 9	25·0	4·33	5·45	12·13	0·2601	12·13	0·41	2·31	8·14	77·01
1058	Ditto . . .	9 39	18·0	4·27	5·47	11·11	0·1452	18·60	2·60	2·00	6·16	70·64
1059	Ditto . . .	39 54	7·0	3·13	5·25	10·49	0·0861	7·95	2·58	7·02	10·65	71·80

1106	Bababudan Hills. (Mysore State).	0 4	25·0	4·56	6·18	18·59	0·6204	49·11	7·05	13·84	7·13	22.87
1107	Ditto . . .	4 11	9·0	4·24	5·92	10·87	0·2830	26·31	5·86	12·11	9·60	46·12
1108	Ditto . . .	11 30	13·0	4·12	6·06	8·40	0·1261	46·09	15·23	13·36	6·24	14·08
1118	Coorg (Haggalle) . .	0 7	12·0	2·58	5·70	9·07	0·1883	17·45	2·87	3·83	11·09	59·76
1119	Ditto . . .	7 24	14·5	2·94	5·76	8·39	0·1303	16·07	3·09	6·80	7·21	66·83
1120	Ditto . . .	24 48	21·4	2·64	5·23	6·54	0·0700	6·78	0·41	2·47	9·05	81·29
1142	Ouchterloney Valley. (Nilgiri Hills), South India.	0 3	7·8	6·55	5·99	17·09	0·5074	8·13	1·93	3·21	5·01	81·72
1143	Ditto . . .	3 14	12·0	8·02	4·74	15·53	0·4156	4·78	1·09	4·13	4·79	85·21
1144	Ditto . . .	14 34	15·0	6·09	4·63	8·45	0·1110	25·13	3·63	4·04	3·84	63·36
1145	Ditto . . .	34 48	20·0	3·54	5·31	10·34	0·0692	33·16	4·78	4·94	4·77	52·32
1156	Manalar (Cumbum), Madura District, South India.	0 12	64·3	7·54	5·13	15·01	0·5802	20·76	5·41	12·97	8·23	52·63
1157	Ditto . . .	12 24	50·0	6·99	4·96	10·98	0·3931	32·04	2·79	9·47	8·39	47·31
1158	Ditto . . .	24 36	32·0	7·16	4·82	11·84	0·2411	34·69	3·83	4·73	5·18	41·52
1162	Pullivasal. (Travancore) .	0 8	16·6	4·15	4·64	11·99	0·3437	43·81	9·82	4·37	6·90	35·10
1163	Ditto . . .	8 23	26·0	4·49	4·51	10·75	0·1805	42·31	5·44	6·49	3·98	41·78
1164	Ditto . . .	23 60	20·0	5·24	5·09	11·00	0·1496	30·40	6·12	13·09	2·10	48·29
1165	Ditto . . .	Disintegrated rock.	36·0	2·43	4·78	12·22	0·0527	31·36	2·87	9·85	9·22	46·70
1170	Nelliampathies (Cochin State)	0 4½	43·8	4·11	5·91	13·36	0·8232	40·25	4·80	0·41	4·38	50·16
1171	Ditto . . .	4½ 17	9·0	4·76	5·76	10·69	0·2393	28·98	3·99	7·99	5·44	53·60
1172	Ditto . . .	17 30	7·5	4·50	5·35	8·27	0·1441	16·75	1·05	6·07	2·83	73·30
1173	Ditto . . .	30 39	12·0	3·22	5·37	5·52	0·0517	7·44	2·48	4·34	5·78	79·96
	Koraput 55th Mile 2nd pocket, (Orissa).	0 12	Negligible.	4·56	5·04	8·86	0·1413	43·17	8·39	16·75	5·04	26·65
	Ditto . . .	12 24	„	4·19	5·82	9·17	0·1161	45·30	8·35	15·24	10·43	20·68
	Ditto . . .	24 36	„	4·67	6·33	9·57	0·0758	36·51	8·18	16·15	7·35	31·81
	Mount Harriet No. 4. (Andaman Islands).	0 12	1·8	2·19	5·82	4·37	0·1336	11·45	4·30	10·40	11·26	62·57
	Mount Harriet No. 5. (Andaman Islands).	12 24	2·0	2·66	4·80	3·59	0·0785	16·44	2·88	11·70	9·66	59·32
	Mount Harriet No. 6. (Andaman Islands).	24 36	2·0	2·43	4·84	2·97	0·0769	13·94	9·42	1·86	14·35	60·43

APPENDIX VI.

Province or State.—BENGAL.

PROFILE No. 1.

Location.—Mungpoo, Darjeeling District.
Type of land.—Cinchona Plantation, Block 1934.
Elevation.—About 3,800 ft.
Aspect.—
Climate.—Rainfall 80—100".
Vegetation.—Cinchona in healthy and vigorous condition.
Topography.—Good slope.
Soil.—0—12" Loam to clay loam, friable, granular. Horizon not defined.
12—33" Loamy soil with some small stones, brownish in colour, coarse granular, compact.
33"—Struck rock.
Remarks.—

PROFILE No. 2.

Location.—Labdah (Mungpoo), Darjeeling District.
Type of land.—Cinchona Plantation, 1930.
Elevation.—3,000—3,200 ft.
Aspect.—
Climate.—Rainfall about 100".
Vegetation.—Cinchona, Excellent crop, Hybrid 2.
Topography.—Good slopes.
Soil.—0—12" Loamy soil with some organic matter, granular, friable.
12—36" Loamy friable, granular soil with practically no stones. Met rock after 3 ft.

PROFILE No. 3.

Location.—Burmiak (Munsong), Darjeeling District.
Type of land.—Cinchona Plantation, 1913.
Elevation.—About 4,000 ft.
Aspect.—
Climate.—100—120" Rainfall.
Vegetation.—Cinchona, average crop, once coppiced.
Topography.—Gradual slopes.
Soil.—0—12" Light loamy, friable soil with only a little organic matter. Horizon not defined.
12—24" Some type of soil but with some small slopes.
24—34" More stones, otherwise no change in soil texture or consistency. Rock afterwards.

BENGAL—*contd.*

PROFILE No. 4.

Location.—Kashyem (Munsong), Darjeeling District.
Type of land.—Cinchona Plantation, 1935 Block.
Elevation.—About 4,000 ft.
Aspect.—
Climate.—100—120" Rainfall.
Vegetation.—Cinchona, good crop.
Topography.—Gradual slopes.
Soil.—0—12" Brown loamy soil, friable. Consistency, horizon not defined.
12—24" Same as above.
24—36" Same colour and consistency but a bit clayey.

PROFILE No. 5.

Location.—Kashyem (Munsong), Darjeeling District.
Type of land.—Cinchona Plantation, 1917 Block.
Elevation.—About 4,000 ft.
Aspect.—North.
Climate.—100—120" Rainfall.
Vegetation.—Cinchona, Good healthy crop.
Topography.—Gradual slopes.
Soil.—0—12" Light dark soil, loamy and friable. Horizon not marked.
12—36" Same type of soil. Did not strike rock even at 3 ft.

PROFILE No. 6.

Location.—Bickkaman, Mungpoo, Darjeeling District.
Type of land.—Cinchona Plantation, Block 1919—37.
Elevation.—About 3,800 ft.
Aspect.—North.
Climate.—100—120" Rainfall.
Vegetation.—Cinchona Medium crop.
Topography.—Steep Stony.
Soil.—0—12" Light loamy soil, practically no organic matter, horizon not defined.
12—24" Struck rock or big boulders at about 20" but soil was dry and loose wherever sampling was possible.
24—36" Same as above.

PROFILE No. 7.

Location.—Mungpoo, Darjeeling District.
Type of land.—Cinchona Plantation, Block 1934, Pocket of 1/10 acre.
Elevation.—About 3,800 ft.
Aspect.—North.
Climate—100—120" Rainfall.
Vegetation.—Cinchona, poor growth.

BENGAL—*concld.*

PROFILE No. 7—*contd.*

Topography.—Flat portion.

Soil.—0—12″ Clay loam, a granular, horizon not marked.

12—24″ Clayey loam, heavier than above, a bit moist, soft grain.

24—34″ Clayey and moist with some stones.

34″ Rock.

PROFILE No. 8.

Location.—Labdah, Mungpoo, Darjeeling District.

Type of land.—Cinchona Plantation, 1928, (portion only).

Elevation.—About 3,100 feet.

Aspect.—South.

Climate.—100″ Rainfall.

Vegetation.—Cinchona, poor crop.

Topography.—Very steep, stony.

Soil.—0—12″ Loamy soil, dry and practically devoid of organic matter. No horizon.

12—24″ Struck rock at 14—18″ but wherever sampling was possible, the soil is loose and dry. Appeared to be very poor.

PROFILE No. 9.

Location.—Kashyem (Munsong), Darjeeling District.

Type of land.—Cinchona Plantation, 1935, Block Focket

Elevation.—About 4,000 feet.

Aspect.—North.

Climate.—100—120″ Rainfall.

Vegetation.—Cinchona, poor crop.

Topography.—Flat at the point of sampling.

Soil.—0—13″ Brown loamy soil, granular. Horizon not defined.

13—30″ Brown soil, clayey, stiff, bad drainage conditions.

30″ Rock.

Province or State.—MADRAS.

PROFILE No. 10.

Location.—Naduvatam (Nilgiris).

Type of land.—Cinchona Plantation, 1926 Block.

Elevation.—About 6,500 feet.

Aspect.—West and South West.

Climate.—80″ Rainfall.

Vegetation.—Cinchona, good crop.

Topography.—Good slope.

Soil.—0—6″ Loamy soil with some organic matter, friable, granular, with horizon not well-defined.

6—18″ Loamy soil with a little infiltered organic matter, friable soil, coarse grain, reddish in colour.

18—36″ Same type as above but having no organic matter.

MADRAS—*contd.*

PROFILE No. 11.

Location.—Devamalai, Naduvatam, Nilgiris.

Type of land.—Cinchona Plantation, 1934-35, Block.

Elevation.—About 6,500 feet.

Aspect.—South.

Climate.—Rainfall about 80" (Same conditions as Naduvatam).

Vegetation.—Cinchona, poor crop.

Topography.—Good slopes.

Soil.—0—7" Darkish soil, not very rich in organic matter, loamy, crumby.

7—36" Light brown soil, loose, crumby, appeared poor. Similar type of soil extends to 6 feet.

North face which was being cleared for this Year's planting showed the following profile :

0—3" Very light dark, granular soil, loamy.

3—8" Very light brown, crumby.

8—26" Darkish layer, very loose texture, very little finer fractions : therefore will not hold water.

26—42" Same as above but mixed with small stones.

Note.—At one place, we came across stiff brown layer at 7½ ft. but this was rock.

PROFILE No. 12.

Location.—Moyer, Naduvatam, Nilgiris.

Type of land.—Cinchona Plantation, 1934, Block XII, Plot 4.

Elevation.—3,500 feet.

Aspect.—

Climate.—60—80" Rainfall.

Vegetation.—Cinchona, poor crop.

Topography.—Good slope.

Soil.—0—8" Darkish soil, loamy texture but rather loose. Horizon not defined.

6—18" Hard soil, with plenty of rock pieces, reddish in colour, impervious, liable to crack on drought. Clodular structure.

18—26" Usually struck rock at 16—20" but certain pockets, deeper sampling possible, the type of soil same as above.

PROFILE No. 13.

Location.—Moyer, Naduvatam, Nilgiris.

Type of land.—Cinchona Plantation, 1928 Block, part only : Cinchona after Cinchona without rest.

Elevation.—3,000—3,500 feet.

Aspect.—North East face.

Climate.—60—80" Rainfall.

Vegetation.—Cinchona, poor crop.

Topography.—Good slope, steep in parts.

Soil.—0—11" Loamy soil, with a fair amount of organic matter, coarse grain. Horizon not defined.

11—30" Slightly reddish soil, clayey but generally good texture, a bit plastic, with a few stones.

30" More stones but otherwise same as above.

MADRAS—*contd.*

PROFILE No. 14.

Location.—Moyer, Naduvatam, Nilgiris.

Type of land.—Cinchona Plantation, 1934, Block XII, Plot 1.

Elevation.—3,000—3,500 feet.

Aspect.—

Climate.—60—80" Rainfall.

Vegetation.—Cinchona, medium crop.

Topography.—Good slope.

Soil.—0—10" Loamy soil, with a fair amount of organic matter, friable. Horizon not defined.

10—20" Clayey loam, friable, with less organic matter. Not much cracking of soil at this depth.

20" Same type of soil with plenty of stones and disintegrating rock.

PROFILE No. 15.

Location.—Naduvatam, Nilgiris.

Type of land.—Cinchona Plantation, Plots 1 and 2.

Elevation.—About 6,500 feet.

Aspect.—North-West.

Climate.—Same as Naduvatam. No. 10.

Vegetation.—Cinchona, medium crop.

Topography.—Rather steep slopes.

Soil.—0—3" Loamy soil with leaf and root mould. Horizon not clearly marked.

3—18" Brownish soil, with practically no organic matter, light, granular.

18—42" Reddish soil, lateritic type.

PROFILE No. 16.

Location.—Hooker, Naduvatam (Nilgiris).

Type of land.—Cinchona Plantation, Hooker Extension II.

Elevation.—

Aspect.—

Climate.—No data.

Vegetation.—Cinchona, medium crop.

Topography.—Good slopes, stony, big stones on the surface.

Soil.—0—6" Loamy soil, not well supplied with organic matter, single grain.

6—17" Reddish soil, with practically no organic matter, struck plenty of big stones, irregular prismatic structure.

17—34" Plenty of stones and disintegrating rock, mixed with some soil.

MADRAS—*contd.*

PROFILE No. 17.

Location.—Dodabetta (Nilgiris).
Type of land.—Cinchona Plantation, Block 2, Plot 7.
Elevation.—About 7,500 feet.
Aspect.—
Climate.—50—55″ Rainfall.
Vegetation.—Cinchona, good crop. 19 years old.
Topography.—Good slopes, gradual in parts.
Soil.—0—12″ Darkish loamy soil, fine grain and friable. Horizon not defined.
12—24″ Same type of fine granular soil with lesser amount of organic matter.
24—36″ Same type of soil as the less depth above.

PROFILE No. 18.

Location.—Dodabetta, Nilgiris.
Type of land.—Cinchona Plantation, 1928 Block.
Elevation.—About 7,500 feet.
Aspect.—
Climate.—Rainfall 50—60″.
Vegetation.—Cinchona, medium crop.
Topography.—Good slopes.
Soil.—0—12″ Loamy soil with fair amount of organic matter, granular, horizon not defined.
12—24″ Same soil as above but with plenty of weathered hydrated rock.
24″ Mainly weathered rock. Very little soil.

PROFILE No. 19.

Location.—Valparai, Anamalais.
Type of land.—Cinchona plantation, 1927 Block, part only.
Elevation.—About 3,000 feet.
Aspect.—
Climate.—150—200″ Rainfall.
Vegetation.—Cinchona, good crop.
Topography.—Good slopes.
Soil.—0—5″ Loamy soil, rich in organic matter, granular, horizon not defined.
5—11″ Same type of soil but less organic matter. Horizon defined.
11—42″ Yellowish brown soil, clay loam, granular, well compacted. No rock till 3½ feet.

PROFILE No. 20.

Location.—Valparai, Anamalais.
Type of land.—Cinchona Plantation, 1928, Block part only.
Elevation.—About 3,400 feet.
Aspect.—
Climate.—150—200″ Rainfall.

MADRAS—*contd.*

Vegetation.—Cinchona, good crop.

Topography.—Good slopes, generally, with flat parts.

Soil.—0—12″ Soil with fair amount of organic matter, loamy, coarse grain, horizon not defined.

12—36″ Yellowish brown soil with only a little organic matter, clay loam, not stones, with a little disintegrating rock after 2½ feet.

PROFILE No. 21.

Location.—Valparai, Anamalais.

Type of land. } —Cinchona Plantation, 1926, Block, about 3,400 ft.
Elevation. }

Aspect.—South West.

Climate.—150—200″ rainfall.

Vegetation.—Cinchona, medium crop.

Topography.—Slope good.

Soil.—0—5″ Yellowish soil, with some organic matter. Loamy, friable, horizon defined.

5—17″ Yellowish brown soil, clay loam, coarse granular, with some gravel.

17—30″ Same type of soil but with more gravel which increases as we go deeper.

PROFILE No. 22.

Location.—Valparai, Anamalais.

Type of land.—Cinchona plantation, 1928, portion only.

Elevation.—About 3,400 feet.

Aspect.— ...

Climate.—150—200″ rainfall.

Vegetation.—Cinchona, poor crop.

Topography.—Flat at the place of sampling.

Soil.—0—6″ Darkish, loamy soil, with plenty of grass roots, a little hard. Horizon marked.

6—20″ Brown soil, a little sticky, coarse grain. Clodular.

20″ Disintegrating rock, whitish in colour.

Province or State.—ASSAM.

PROFILE No. 23.

Location.—Between 35th-36th mile on Gauhati-Shillong road, one mile inwards, Khasia and Jaintia Hills.

Type of land.—Experimental Cinchona plot.

Elevation.—About 2,500 feet.

Aspect.—North.

Climate.—No data.

Vegetation.—Eugenia Jambolana, Garuga pinnata, Stereospermum chelonoides, Lagerstoremia parviflora.

Topography.—Good slope.

ASSAM—*contd.*

Soil.—0—2″ Darkish soil, loamy with only a small quantity of organic matter, friable, with horizon well defined.

2—12″ Reddish loam, irregular clod, not very hard, very little organic matter, horizon not defined.

12—24″ Same type of soil as above.

24—36″ Reddish loam, well compacted, with nodular to irregular clods structure.

PROFILE No. 24.

Location.—At 37th mile on Gauhati-Shillong road, Khasia and Jaintia Hills.

Type of land.—Experimental Cinchona plot (Umsaw).

Elevation.—About 2,000 feet.

Aspect.—Mainly south.

Climate.—No data.

Vegetation.—As described in next profile.

Topography.—Sloping with flat portions.

Soil.—0—12″ Loamy, well compacted soil, with very little or no organic matter, reddish in colour and horizon not defined.

12—24″ Loamy, coarse grain reddish well compacted.

24—36″ Loamy to clay loam with some small pieces of disintegrating rock, reddish, irregular nodular.

PROFILE No. 25.

Location.—At 37th mile, on Gauhati-Shillong road, extending a mile inwards, Khasia and Jaintia Hills. Next to the experimental plot.

Type of land.—Forest land—Not reserved but Jhuming stopped by executive order.

Elevation.—2,000—3,500 feet.

Aspect.—Mainly north—particularly west.

Climate.—No data.

Vegetation.—Schima Castanopsis, Stereospermum sp., Vitex peduncularis.

Topography.—Sloping with some steep portions.

Soil.—0—12″ Darkish coloured loam, coarse granular, loose with horizon not well defined.

12—24″ Red loam, well compacted, columnar, with only a little organic matter, plenty of roots.

24—36″ Mixture of clay and sand, compact, coarse grain, with practically no organic matter. Will drain well.

PROFILE No. 26.

Location.—Between 39th-40th mile on Gauhati-Shillong road.

Type of land.—Forest land.

Elevation.—2,000—3,000 feet.

Aspect.—Mainly north.

Climate.—No data.

Vegetation.—Eugenia Jambolana, Garuga pinnata, Vitex peduncularis.

Topography.—Good slope.

ASSAM—*contd.*

Soil.—0—8″ Darkish coloured loamy soil, granular, friable with horizon not well defined.
8—21″ Light reddish loamy soil, crumbly, friable, plenty of roots.
21—36″ Reddish soil, crumbly, fairly compact and porous.

PROFILE No. 27.

Location.—28th-29th mile on Gauhati-Shillong road.

Type of land.—Forest land—Nongkhyllem Reserve.

Elevation.—2,000—2,500 feet.

Aspect.—Mainly south.

Climate.— ...

Vegetation.—Trees mainly Stereospermum, Vitex, Eugenia, Grass Pollinia, Eupatorium and some bamboo. Not well wooded. Some trees appear to have been removed from Wood.

Topography.—Good slopes with many flat portions.

Soil.—0—12″ Darkish soil with a fair amount of organic matter, horizon not defined, loamy, friable.
12—24″ Reddish soil, a bit clayey, granular, soft clods. Not many roots.
24—36″ Reddish soil, clayey, well compacted.

PROFILE No. 28.

Location.—34th to 35th mile on Shillong-Sylhet Road, beyond Pynursla.

Type of land.—Forest land, not reserved.

Elevation.—4,000—4,200 feet.

Aspect.—Mainly south.

Climate.—No data.

Vegetation.—Eugenia, Michelia.

Topography.—Rather steep with some good slopes.

Soil.—0—10″ Darkish soil, loamy with horizon not marked. Small stones.
10—20″ Red loam with more stones and disintegrated rock, loose, irregular clod to nodular.
20″ Struck rock.

Notes.—Usually we struck rock at about 12″ but rarely we were able to go upto 2½ ft.

PROFILE No. 29.

Location.—Cheniabinshon, Kula Parbat, Mikir Hills.

Type of land.—Cinchona Experimental plot 1934.

Elevation.—2,000 ft.

Aspect.—Mainly north.

Climate.—80″ Rainfall.

Vegetation.—Plenty of palms and bananas just round the plantation.

Topography.—Rather steep. Area is stony, plenty of stones, big and small on the surface. Some good pockets.

ASSAM—*contd.*

Soil.—0—4" Darkish soil, loamy, friable. Horizon very faintly marked.

4—24" Reddish soil with practically no organic matter, some stones, loam to clayey loam, well compacted. Horizon not defined.

24—36" Same type as above but appeared poorer.

Note.—This represents soils in the pockets. Usually we struck rock at 1½ ft. or thereabouts.

PROFILE No. 30.

Location.—Kaliani Reserve, south of Kaliani River, on way to Bar Sathung Parbat.

Type of land.—Forest land.

Elevation.—1,500—2,500 ft.

Aspect.—Mainly north.

Climate.—Rainfall about 80".

Vegetation.—Bamboo, some palms, some big and small trees.

Topography.—Slopes rather steep. Plenty of stones on the surface.

Soil.—0—12" Greyish soil with a small amount of organic matter, loamy in texture, coarse granular and loose. Horizon not defined.

12—24" Reddish soil with small stones, irregular nodular. No horizon.

24—36" Same as above. Appeared poorer and drier. The soil is likely to be chemically poor, in addition to being shallow in many places.

PROFILE No. 31.

Location.—Kaliani Reserve, North of Kaliani River, on way to Gussin Parbat.

Type of land.—Forest land

Elevation.—1,500—2,000 ft.

Aspect.—South.

Climate.—80" rainfall.

Vegetation.—No undergrowth in the forest, plenty of dry leaves, bamboo on slopes and some trees on ridges.

Topography.—Sloping. The area is all stony with some pockets.

Soil.—0—12" Reddish soil with very little organic matter, loamy, granular. Horizon not defined.

12—24" Same type of soil but drier and with practically no organic matter.

24—36" Same type but poorer and with irregular columnar structure.

Note.—This represents the soil in pockets where sampling was possible upto 3 ft. This was more an exception than the rule. We never could go beyond 12—15 inches in most borings.

Province or State.—MADRAS.

PROFILE No. 32.

Location.—Cinchona Reserve on south of Kallar River, opposite Blocks 27 and 30.
Type of land.—Forest land.
Elevation.—3,400 ft.
Aspect.—North.
Climate.—Same as Valparai Government Plantation—about 180" rainfall.
Vegetation.—Evergreen forest, big trees and plenty of undergrowth.
Topography.—Good slopes.
Soil.—0—7" Loamy soil containing a large amount of organic matter. Top 1" practically all leaf mould, friable. Horizon not defined.

7—36" Yellowish brown soil with a small amount of organic matter, loamy to clay loam, rather moist, coarse granular. Plenty of roots. Weathering rock seen in the last few inches in some sections but usually after 3 ft.

PROFILE No. 33.

Location.—Valparai, Eastern part of the forest, north of Kallar River.
Type of land.—Cinchona Reserve forest.
Elevation.—3,600 ft.
Aspect.—South and south west.
Climate.—Same as Valparai Government plantation.
Vegetation.—Trees and evergreen undergrowth.
Topography.—Good slopes.
Soil.—0—2" Loamy soil with some organic matter, horizon not well defined.

2—36" Clay loam, with varying degrees of organic matter, yellowish red, clodular, compact, some roots.

36" Weathered rock.

PROFILE No. 33-A.

Location.—Near Poar depot.
Type of land.—Forest land.
Elevation.—3,400 ft.
Aspect.—Mainly south.
Climate.— ...
Vegetation.—Trees and evergreen undergrowth.
Topography.—Good slopes with many steep parts.
Soil.—0—3" Soil with plenty of organic matter, loamy in texture, granular, horizon not well defined.

3—12" Soil with a certain amount of organic matter, loam to clay loam, friable.

12—24" Brownish soil, with stray gravel bits, clay loam, irregular clodular, not very moist.

MADRAS—*contd.*

PROFILE No. 34.

Location.—Western end of the Estear Tea Estate, right bank of Kallar.

Type of land.—Forest land.

Elevation.—3,300 ft.

Aspect.—Partially south.

Climate.— ...

Vegetation.—Trees and evergreen undergrowth.

Topography.—Good slopes.

Soil.—0—3" Loamy soil with organic matter, friable, granular, horizon not well defined.

3—30" Yellowish brown soil, with very little organic matter, clay loam, slightly moist and plastic.

PROFILE No. 35.

Location.—Thiashola.

Type of land.—Forest land.

Elevation.—6,500 ft.

Aspect.—Mostly north.

Climate.—About 100" rainfall.

Vegetation.—Huge trees and undergrowth, plenty of Eupatorium.

Topography.—Good slopes.

Soil.—0—10" Dark soil with a great deal of leaf mould, loamy soil

10—25" Soil rich in organic matter, loamy and friable.

25—31" Red soil with some organic matter infitted, clay loam, coarse grain.

31—67" Same as above but very little organic matter.

67" Weathering rock.

PROFILE No. 36.

Location.—Thiashola, lower part of the Road.

Type of land.—Forest land.

Elevation.—6,500 ft.

Aspect.—Mainly north.

Climate.—About 100" rainfall, possibility of frost.

Vegetation.—Big trees and undergrowth evergreen. Some ferns and plans in certain areas.

Topography.—Good slopes.

Soil.—0—4" Loamy soil, with plenty of leaf mould, moist.

4—13" Loamy soil, with a good deal of organic matter, friable, granular, plenty roots.

13—30" Reddish soil, rather loose, fine grain, clay loamy, irregular colump

MADRAS—*contd.*

PROFILE No. 37.

Location.—Thiashola.—Upper part of the road.
Type of land.—Forest land, Reserve.
Elevation.—About 6,500 ft.
Aspect.— ...
Climate.—About 100″ rainfall.
Vegetation.—Big trees and plenty of evergreen.
Topography.—Good slopes with steep bits.
Soil.—0—14″ Dark soil with plenty of organic matter, loamy, moist.
14—30″ Reddish soil, a bit clayey, irregular clodular, very little organic matter.
30—72″ Red soil, clay loam with varying degrees of weathered rock.

PROFILE No. 38.

Location.—Dodabetta Reserve 5M.—7F. on Ooty-Kotagiri road.

Type of land.—Forest land, sholas.

Elevation.—About 7,800 ft.

Aspect.—North.

Climate.—Rainfall about 60″.

Vegetation.—Evergreen undergrowth, and big trees.

Topography.—Undulating.

Soil.—0—8″ Dark soil with plenty of leaf mould, Loamy, friable, horizon not well marked.

8—20″ Loamy soil with plenty of organic matter, granular.

20—Reddish soil, rather loose, fine grain.

PROFILE No. 39.

Location.—Dodabetta Reserve, same as previous profile at 5M—7F.

Type of land.—Forest land, ridges.

Elevation.—7,800 ft.

Aspect.—North.
Vegetation.—Mainly grass and shrubby.
Climate.—Rainfall about 60″.

Topography.—Slopes gradual to steep.

Soil.—0—7″ Darkish soil, loamy, rather loose, horizon not marked.

7—17″ Soil with some gravel in it, practically no organic matter, nodular.

11″ Reddish soil, irregular clod, compact.

MADRAS—*contd.*

Profile No. 40.

Location.—Ouchterlony Valley.

Type of land.—Abandoned Coffee Estate.

Elevation.—3,000—5,000 ft.

Aspect.—South face.

Climate.—80—120″ Rainfall.

Vegetation.—Chiefly Lantana.

Topography.—Gradual slopes.

Soil.—0—5″ Loamy soil with a little organic matter, granular, horizon not well-defined.
5—20″ Loamy soil, with very little organic matter, mixed with some disintegrating rock. Nodular, plenty of roots.
20—32″ Reddish soil, Nodular, compact.

Profile No. 41.

Location.—Ouchterlony Valley, Top of Gyund.

Type of land.—Abandoned estate (Cinchona?).

Elevation.—3,500—3,700 ft.

Aspect.—North west.

Climate.—80—120″ Rainfall.

Vegetation.—Mainly Eupatorium.

Topography.—Good slopes.

Soil.—0—3″ Loamy with plenty of humus, friable, horizon not well-defined.
3—14″ Same type of soil with less of organic matter and plenty of roots.
14—34″ Yellowish brown soil, loamy, coarse granular, compact.
34″ Disintegrating rock.

Profile No. 42.

Location.—Ouchterlony Valley, Top. Guynd.

Type of land.—Forest land, next to abandoned estate.

Elevation.—3,500—3,700 ft.

Aspect.—North West.

Climate.—80—120″ Rainfall.

Vegetation.—

Topography.—Sloping, steep in parts.

Soil.—0—10″ Loamy soil with plenty of organic matter, friable and granular.
10—30″ Yellowish brown soil, friable. Loamy with very little organic matter, well-drained.

Profile No. 43.

Location.—Ouchterlony Valley.

Type of land.—Abandoned Coffee Estate (Helen).

Elevation.—About 3,700 ft.

Aspect.—North mainly.

Climate.—80—120″ Rainfall.

Vegetation.—Grass with some shrubs.

Topography.—Gradual slopes.

Soil.—0—4″ Loamy soil, rather hard with very little organic matter, greatly washed.
4—30″ Clayey loam, reddish soil with plenty of disintegrating rock, poor.

MADRAS—*contd.*

PROFILE No. 44.

Location.—Ouchterloney Valley.

Type of land.—Jungle—Sandy Hill.

Elevation.—About 4,000 ft.

Aspect.—

Climate.—80—120″ Rainfall.

Vegetation.—A few trees and mainly jungle including lantana.

Topography.—Good slopes.

Soil.—0—9″ Loamy soil with plenty of organic matter, friable, horizon not very sharp.

9—24″ Same type of soil but less organic matter, struck rock at this level, irregular columnar structure.

PROFILE No. 45.

Location.—Ouchterloney Valley, on way to Gudalur.

Type of land.—Jungle land.

Elevation.—3,000—3,500 ft.

Aspect.—West.

Climate.—80—120″ Rainfall.

Vegetation.—Lantana, some bamboo and secondary jungle.

Topography.—Good slopes.

Soil.—0—9″ Loamy soil with some organic matter, coarse granular, friable. Horizon not marked.

9—28″ Reddish soil, loamy texture and very little organic matter. coarse grain, compact.

28—42″ Disintegrating rock predominates.

PROFILE No. 46.

Location.—High Wavys Estate, Madura District.

Type of land.—Forest land, Manalar, Valley conditions

Elevation.—4,500—5,000 ft.

Aspect.—South West and North.

Climate.—80—100″ rainfall, both monsoons.

Vegetation.—Evergreen Forest.

Topography.—Good slopes, steep in parts.

Soil.—0—12″ Loamy soil with plenty of organic matter, granular, friable. No horizon.

12—24″ Same as above and plenty of roots.

24—35″ Same type of soil with less organic matter. Some small stones, partially decomposed, crumby.

MADRAS—*contd.*

PROFILE No. 47.

Location.—High Wavys Estate, Madura District.
Type of land.—Forest land, Manalar, Ridges.
Elevation.—4,000—5,000 ft.
Aspect.—South West and North.
Climate.—80—100" rainfall, both monsoons.
Vegetation.—Same as the previous profile.
Topography.—Good slope.
Soil.—0—2½" Soil with some organic matter, loamy, rather loose. Horizon defined.

2½—12" Loamy loose soil with very little organic matter, coarse granular.
12—36" Brown soil with small stones, clodular, compact.

PROFILE No. 48.

Location.—High Wavys Estate, Madura District.
Type of land.—Forest land, Megamali.
Elevation.—4,000—5,000 ft.
Aspect.—South.
Climate.—80—100" rainfall, both monsoons.
Vegetation.—Evergreen forest.
Topography.—Good slopes.
Soil.—0—2" Soil with some organic matter, loamy and friable. Horizon not distinct.

2—17" Loamy soil with plenty of small stones and disintegrated rock. Plenty of roots.
17—30" Brownish soil, crumbly, rather loose consistency, with plenty of disintegrated rocks.

Province or State.—COORG.

PROFILE No. 49.

Location.—1½ mile from Mercara.
Type of land.—Forest land compartment No. 1.
Elevation.—Same as Mercara.
Aspect.—Mainly south.
Climate.—Same as Mercara.
Vegetation.—Plenty of trees and evergreen undergrowth.
Topography.—Good slopes generally, flat in parts.

Soil.—0—6" Granular, loamy soil with organic matter, horizon not well defined.
6—17" Soil a bit clayey with organic matter plenty of roots, friable well drained.
17—30" Reddish soil with some organic matter and small stones, crumby structure.

Note.—Except for the fact that the soil had less organic matter and area was a bit stoney, the general soil structures of compartments 4 and 5 were the same as No. 1.

COORG—*contd.*

PROFILE No. 50.

Location.—1¼ mile from Mercara.

Type of land.—Paisari land, abandoned coffee estate.

Elevation.—3,800 ft.

Aspect.—Mainly South East.

Climate.—Same as Mercara.

Vegetation.—Silver oaks. Not much undergrowth and a little of lantana.

Topography.—Gentle slopes.

Soil.—0—2" Soil with some organic matter, loamy, rather loose, horizon faintly marked.

2—19" Soil with a few pieces of gravel, soil loamy, *viz.*, few roots.

19—48" Weathering rock with plenty of soil. Columnar structure will chain well.

Note.—In certain profiles, lower layers were sandy. These areas are likely to be poor chemically but their physical condition is satisfactory.

PROFILE No. 51.

Location.—6M-3F. on Mercara-Somwerpet Road.

Type of land.—Paisari, old abandoned coffee estate "Haleri Paisari".

Elevation.—About 3,200 feet.

Aspect.—Mainly east.

Climate.—Same as Mercara. No exact data.

Vegetation.—Mainly lantana.

Topography.—Sloping.

Soil.—0—5½" Darkish loamy soil, with some organic matter, granular, loose. Horizon boundary distinct.

5½ to 18" Brown loamy soil with very little organic matter, granular, soft, very few roots. Horizon boundary not distinct.

18—48" Brown soil, columnar, with weathering rock.

PROFILE No. 52.

Location.—7M-6F on Mercara-Somwerpet Road, both sides of the road.

Type of land.—Paisari.

Elevation.—3,500 feet.

Aspect.—East.

Climate.—Same as Mercara. No data.

Vegetation.—Cedrela toona, and Lantana.

Topography.—Gentle slope near the road but better higher up.

Soil.—0—4" Dark loamy soil with plenty of organic matter, granular, horizon boundary not distinct.

4—16" Same type of soil but with less organic matter.

16—46" Reddish colour loamy soil, compact.

46—52" Reddish soil, sandy loam.

COORG—*contd.*

Profile No. 53.

Location.—11 M.-4 F on Mercara-Somwerpet Road.
Type of land.—Paisari.
Elevation.—3,250 feet.
Aspect.—Mainly East.
Climate.—No data.
Vegetation.—Lantana predominates. some bamboos and some trees mentioned in the preceding profile.
Topography.—Good slope.
Soil.—0—9″ Loamy soil rich in organic matter, granular, friable. Horizon boundary not well defined.

9—24″ Loamy soil with only a little organic matter. Nodular, plenty of roots and some small stones.

24—54″ Same as above but with more stones.

Profile No. 54.

Location.—3-M.—4-F. From Mercara on Mercara-Sempage Road.
Type of land.—Paisari.
Elevation.—About 3,200 feet.
Aspect.—North.
Climate.—Same as Mercara. No data.
Vegetation.—Mainly lantana
Topography.—Good slope.
Soil.—0—8″ Darkish soil, loamy, with some organic matter, coarse granular.

8—12″ Loamy soil with a little organic matter, rather loose consistency, a few roots.

12—24″ Brownish soil, loamy, compact with some weathering rock.

24—36″ Mainly weathering rock.

Profile No. 55.

Location.—6-M.-1-F. from Mercara on Mercara-Sempage Road.
Type of land.—Paisari, old abandoned coffee estate.
Elevation.—About 3,000 feet.
Aspect.—Mainly North West and other aspects.
Climate.—Increasing rainfall as we go further from Mercara. No data.
Vegetation.—Lantana and some trees.
Topography.—Good slope, near the road, rather steep higher up.
Soil.—0—4″ Loamy soil, inclined to clayeyness. Some organic matter, friable.

4—24″ Reddish brown soil, clayey loam, very little organic matter.

24—36″ Reddish brown, plenty of disintegrating rock, irregular columnar.

COORG—*contd.*

PROFILE No. 56.

Location.—8-M.-6-F. from Mercara on Mercara-Sempage Road.
Type of land.—Paisari.
Elevation.—About 2,900 feet.
Aspect.—
Climate.—Increasing rainfall but no exact data.
Vegetation.—Lantana predominates.
Topography.—Good Slopes, too steep in parts.
Soil.—0—8″ Coarse granular soil with pieces of rock. Some organic matter. Horizon not defined.

8—18″ Same type of soil as above.

18—30″ More disintegrating rock, Nodular to irregular clod.

30″ Rock afterwards.

PROFILE No. 57.

Location.—10-M.-3-F. from Mercara on Mercara-Sempage Road.
Type of land.—Paisari.
Elevation.—About 2,600 ft.
Aspect.—
Climate.—Rainfall about 160″.
Vegetation.—Lantana, etc.
Topography.—Good slope.
Soil.—0—5″ Loamy soil with some organic matter, coarse.

5—14″ Clayey soil, whitish in colour, soft with pieces of rock.

14—60″ Yellowish brown rock, disintegrating, irregular rock.

PROFILE No. 58.

Location.—2-M.-4 furlongs from the turning point to Bhagamandala.
Type of land.—Forest land.
Elevation.—3,000—3,500 feet.
Aspect.—North mainly, some South.
Climate.—Same as Mercara.
Vegetation.—Lantana and huge trees like Artocarpus, Eugenia and others.
Topography.—Good slopes but some flat pieces.
Soil.—0—8″ Darkish loamy soil, with a fair amount of organic matter, friable, horizon not well marked.

8—13″ Loamy soil with less organic matter, coarse grain with occasion stones.

13—30″ Sandy loam, discoloured, loose, crumbly.

COORG—*contd.*

PROFILE No. 59.

Location.—3-M.-1 furlong from the turning point on Mercara-Bhagamandala Road, left of the road.

Type of land.—Forest.

Elevation.—3,000—3,300 feet.

Aspect.—South and some South-West.

Climate.—Same as Mercara.

Vegetation.—Huge trees, lantana and other vegetation.

Topography.—Mostly good slopes but land flattens out at several places

Soil.—0—5" Loamy soil with plenty of organic matter, friable, horizon not well defined.

5—20" Loamy soil with some infiltered organic matter with some stones, loose.

20—33" Yellowish coloured soil with some decomposing rock, crumbly.

PROFILE No. 60.

Location.—3 furlongs from the turning point on Mercara-Mangalore road towards Bhagamandala.

Type of land.—Paisari.

Elevation.—3,500 feet.

Aspect.—North.

Climate.—Same as Mercara.

Vegetation.—

Topography.—Good slope.

Soil.—0—5" Darkish soil, friable, loamy, horizon well marked.

5—24" Friable soil with some organic matter, loamy, some roots, horizon not marked.

24—36" Reddish colour soil, coarse grain, compact.

PROFILE No. 61.

Location.—4-M.-7-F. from the turning point on Mercara-Bhagamandala Road, right of the road.

Type of land.—Paisari.

Elevation.—About 3,000 feet.

Aspect.—

Climate.—

Vegetation.—Same as mentioned before.

Topography.—Gentle to good slope.

Soil.—0—6" Loamy soil with some organic matter, friable, horizon not marked.

6—22" Soil a little sandy but well compacted with some organic matter.

22—36" Yellowish soil, loamy texture, coarse, nodular.

Note.—This profile also represents conditions at 7-M.-2-F. along the same road.

COORG—*contd.*

PROFILE No. 62.

Location.—12th mile, 2 furlongs from the turning point to Bhagamandala.

Type of land.—Paisari land.

Elevation.—About 3,200 feet.

Aspect.—

Climate.—About 180″ rainfall.

Vegetation.—

Topography.—Rather gentle slopes.

Soil.—0—6″ Loamy soil with fair amount of organic matter, friable, granular.

6—18″ Soil with disintegrating rock. Several times we struck rock at 12″.

Area not worth considering unless further exploration yields better soil. It is not likely because of heavy rainfall.

PROFILE No. 63.

Location.—Along cart road between Haggalle and the main road from Virajpet to Cannanore.

Type of land.—Paisari.

Elevation.—3,000—3,300 feet.

Aspect.—West and some south.

Climate.—About 100″ rainfall, hot during summer.

Vegetation.—Evergreen, Lantana and trees.

Topography.—Good slope.

Soil.—0—7″ Loamy soil, friable, darkish brown with some roots, horizon not distinct.

7—24″ Same as above but inclined to sandiness, fair amount of organic matter.

24—48″ Brown sandy loam with some weathered rock, loose.

48″ Rock or big boulders.

Several sections were taken. This is one typical representative of one.

PROFILE No. 64.

Location.—21 miles, 3 furlongs from Mercara on Mercara-Virajpet Road, ½ mile from Ammatti.

Type of land.—Paisari abandoned coffee estate

Elevation.—

Aspect.—South West.

Climate.—Rainfall about 80″. No exact data.

Vegetation.—Mainly lantana, with a few trees.

Topography.—Flat near the road but sloping inwards.

Soil.—0—4″ Darkish soil, clay loam, compact, horizon distinct.

4—19″ Clayey soil with a little organic matter and containing some weathered rock nodular and a bit hard.

19—42″ Same as above but practically no organic matter, moist.

42″ Reddish soil, irregular columnar, well compacted.

COORG—*contd.*

PROFILE No. 65.

Location.—10-M.-4-F. from Mercara on Mercara-Virajpet road *via* Ammeti.
Type of land.—Paisari.
Elevation.—
Aspect.—West.
Climate.—Rainfall about 80".
Vegetation.—Mainly lantana and evergreen.
Topography.—Good slopes.
Soil.—0—6" Clay loam, with some organic matter, plenty of roots, horizon boundary distinct.

6—20" Clayey loam with some infiltered organic matter and weathered rock.
20—36" Clay loam, columnar, compact, a bit moist.
36" Layered rock.

Province or State.—MYSORE.

PROFILE No. 66.

Location.—Henya State Forest, four miles from Kallurkatti on Shimoga-Kumdapur road.
Type of land.—Forest land.
Elevation.—2,000—2,500 feet.
Aspect.—Mainly West.
Climate.—Rainfall about 100".
Vegetation.—Careya arboria, wild pepper, cinnamon, Mesua ferria, etc.
Topography.—Undulating. Slopes too gradual.
Soil.—0—2" Soil with a little organic matter, loamy in texture and hard. Horizon not defined.

2—24" Reddish soil with furrogenous rock pieces, hard, cubical.
24" Rock but not very hard and was in Layers. Lateritic. Quartz like bits encountered.

PROFILE No. 67.

Location.—Devagange State forest.
Type of land.—Forest land.
Elevation.—2,000—2,500 feet.
Aspect.—Mainly east.
Climate.—80—100" rainfall.
Vegetation.—Same as Henya but bigger trees and better wooded.
Topography.—Slopes good, steep in parts.
Soil.—0—8" Soil with a fair amount of organic matter, loamy, horizon not well marked.

8—20" Clayey soil, reddish in colour with some stones and furrogenous rock pieces, soft.
20—36" Less clay, reddish in colour, with soft rock which breaks easily, practically without any organic matter.

MYSORE—*contd.*

PROFILE No. 68.

Location.—Malandur State forest, seven miles from Narsimrajpur on way to Koppa.
Type of land.—Forest land, evergreen.
Elevation.—2,400 feet.
Aspect.—East mainly but some parts west.
Climate.—Rainfall 60—80". Rather hot in summer.
Vegetation.—Xylia carpe, cinnamon, Maraya, etc.
Topography.—Slopes too gentle.
Soil.—0—7" Soil with some organic matter, loamy. Horizon not marked.

7—16" Clayey loam with less organic matter. Soft with some roots.

16—24" Reddish soil, with practically no organic matter, irregular clod.

24" Red soil.

PROFILE No. 69.

Location.—Kemmangundi (Bababudans).
Type of land.—Forest land, shola where experimental cinchona is growing.
Elevation.—4,600 feet.
Aspect.—East and some north east.
Climate.—120—130" rainfall.
Vegetation.—Cedrela toona, Eugenia, Cinnamon, etc.
Topography.—Good slopes.
Soil.—0—2½" Loamy soil, rich in organic matter, friable, horizon not well-defined.

2½—6" Loamy soil with some infiltered organic matter, crumbly.

6—12" Reddish soil, loamy with some very small stones. Nodular.

12—30" Reddish loamy type as above but more stone pieces.

PROFILE No. 70.

Location.—Kemmangundi (Bababudans).
Type of land.—Forest land, newly cleared area in the same shola.
Elevation.—4,600 feet.
Aspect.—North.
Climate.—120—130" rainfall.
Vegetation.—Same as in the previous area.
Topography.—Good slope.
Soil.—0—7" Loamy soil with some organic matter, friable. Horizon not marked.

7—14" Reddish loam with some infiltered organic matter, friable, a few stones.

14—30" Reddish soil with a few small stones. Nodular, not very hard, well-drained.

MYSORE—*contd.*

PROFILE No. 71.

Location.—Bababudan Hills.

Type of land.—Forest land, 24 miles from Chikmagalur on Chikmagalur-Kemmangundi Road (7 miles from Kemmangundi).

Elevation.—3,700—4,600 feet.

Aspect.—Mainly North.

Climate.—100—130″ rainfall.

Vegetation.—Same as in the preceding area but not so well wooded.

Topography.—Slopes too gentle.

Soil.—0—4″ Loamy soil with plenty of organic matter, friable, horizon not well defined.

4—28″ Clayey loam with small quantity of organic matter, reddish, stones of various sizes, well compacted.

28″ Yellowish highly weathered rock.

PROFILE No. 72.

Location.—Bababudan Hills, 23 miles 5 furlongs from Chikmagalur on Chik-Kemmangundi Road.

Type of land.—Forest Land.

Elevation.—3,700—4,600 feet.

Aspect.—North and North-West.

Climate.—100—130″ rainfall.

Vegetation.—Same as in the preceding area.

Topography.—Good slopes.

Soil.—0—4″ Soil with plenty of organic matter, loamy, friable, granular. Horizon not distinct.

4—12″ Clayey loam, with some organic matter, loose, coarse granular.

12—30″ Reddish loamy soil, with a few small stones, small nodular structure, not hard.

30″ Rock—yellowish.

Though the area was in parts stony, even next to the stone good deep soil was available.

PROFILE No. 73.

Location.—Bababudan Hills, 22 miles 6 furlongs from Chikmagalur on Chik-Kemmangundi road.

Type of land.—Forest land.

Elevation.—3,700—4,200 feet.

Aspect.—Mainly East.

Climate.—100—130″ rainfall.

Vegetation.—Same as in the preceding area.

Topography.—Slopes gradual.

Soil.—0—4″ Clayey loam with some organic matter, friable. Horizon not well defined.

4—11″ Less clay but some small pieces of decomposed rock mixed with soil, compact, some roots. Inclined to cracking.

11—36″ All weathered rock, very little soil crumbly.

Note.—Some yellow ochre was met in certain section beyond 4 ft.

Though this profile shows very shallow soil, there were a number of portions having deeper soil upto 1½ feet of the same horizon type.

MYSORE—*concld.*

PROFILE No. 74.

Location.—Between Kemmangundi and Chikmagalur.
Type of land.—Abandoned coffee estate. 12 miles 7 furlongs from Chikmagalur.
Elevation.—About 3,200 feet.
Aspect.—North.
Climate.—Rainfall about 80″.
Vegetation.—Coffee standing, unattended and uncared.
Topography.—Good slopes in part but generally gradual.
Soil.—0—12″ Loamy, friable soil with a little organic matter. Horizon not marked.
12—24″ Same type of soil with less organic matter.
24—36″ Reddish soil, with pieces of disintegrating rock, coarse grain and compact.

PROFILE No. 75.

Location.—8 miles from Chikmagalur on Kemmangundi Road.
Type of land.—Forest land.
Elevation.—About 3,500 feet.
Aspect.—Mainly North.
Climate.—60—80″ rainfall.
Vegetation.—Same as in Bababudans but thin.
Topography.—Sloping, with many steep portions.
Soil.—0—7″ Loamy soil, with very little organic matter, granular.
7—24″ Gravelly soil, disintegrating rock, not very hard. Nodular structure.
24—36″ More disintegrating rock, very little soil.

Province or State.—TRAVANCORE.

PROFILE No. 76.

Location.—7th mile—2 furlongs from Munnar on Munnar-Alwaye road.

Type of land.—Forest land (Cardamom Hill Reserve).

Elevation.—About 2,700 feet.

Aspect.—South and South West.

Climate.—120—140″ rainfall.

Vegetation.—Well-wooded. Trees and bushes.

Topography.—Good slopes, rolling southwards.

Soil.—0—8″ Darkish soil with fair amount of organic matter, clayey loam, coarse granular. Horizon not defined.

8—23″ Same type of soil but with less organic matter and a few small stones.

23—60″ Reddish soil, clayey loam, no stones, irregular columnar, with some roots.

60″ Rock, furrogenous looking rock, with disintegrating laterite.

TRAVANCORE—*contd.*

Profile No. 76-A.

Location.—18 miles ½ furlong on Munnar-Alwaye Road (below Pullivasal).
Type of land.—Forest land, Malayattur Reserve.
Elevation.—About 2,000 feet.
Aspect.—Mainly South.
Climate.—About 120″ Rainfall.
Vegetation.—Well wooded.
Topography.—Good slopes, steep in parts.
Soil.—0—11″ Loamy, friable soil with plenty of organic matter, Horizon not well marked.
11—24″ Loamy to clay loam, with plenty of organic matter, well drained.
24—48″ Loamy to clay loam, with very little organic matter, with few pieces of disintegrating rock and plenty of roots.
48″ Rock.

Province or State.—COCHIN.

Profile No. 77

Location.—Nelliampathies.
Type of land.—Pulayampara estate abandoned coffee estate.
Elevation.—3,000—4,000 feet.
Aspect.—South mainly.
Climate.—120—140″ rainfall, both monsoon.
Vegetation.—Some silver oaks; Lantana and other evergreens and some trees.
Topography.—Good slopes but plenty of flat pieces.
Soil.—0—4½″ Loamy soil with fair amount of organic matter, granular, friable, horizon defined.
4½—17″ Same type of soil but less organic matter. Some roots.
17—30″ Reddish loamy soil with nodular to irregular prismatic structure, and small pieces of whitish rock. Not hard.
30—40″ Mostly disintegrating rock.

Profile No. 78.

Location.—Nelliampathies.
Type of land.—East Pailala Estate, abandoned coffee estate
Elevation.—About 3,500 feet.
Aspect.—South and South East.
Climate.—120—140″ rainfall both monsoons.
Vegetation.—Same as in the preceding estate
Topography.—Good slopes.
Soil.—0—2″ Loamy soil with plenty of organic matter, coarse grain, friable.
2—10″ Loamy reddish soil with very little organic matter, well-compacted.
10—28″ Soil with some decomposing rocks, porous, crumbly.
28—36″ More decomposing rock with some soil, good drainage.

COCHIN—*contd.*

PROFILE No. 79.

Location.—Nelliampathies.
Type of land.—Forest land, south of Beatrice estate.
Elevation.—3,500—4,000 feet.
Aspect.—South west and other faces too.
Climate.—Same as in the preceding estate.
Vegetation.—Evergreen.
Topography.—Sloping with occasional steep parts.
Soil.—0—5″ Loamy soil with plenty of organic matter, friable, fine grain. Horizon well-defined.

5—18″ Same type with less organic matter, plenty of roots.
18—42″ Soil mixed with disintegrating rock, columnar structure, not hard.

Province or State.—SIKKIM.

PROFILE No. 80.

Location.—Namle Reserve.
Type of land.—Forest land.
Elevation.—2,500—4,000 feet.
Aspect.—Mainly south, partially west.
Climate.—Rainfall about 100″.
Vegetation.—Schima Wallichii, Castanopsis indica, Albizzia, Stipulata, Betula Sp., Callicarpa, Tephrosia Candida, Castanopsis.
Topography.—Good slope generally.
Soil.—0—12″ Loamy soil with plenty of organic matter, dark brown, granular, horizon not marked.

12—24″ Plenty of organic matter even in this layer; soil granular and compact.
24—36″ Loamy soil with only a little organic matter, rather dry. Coarse grain and not hard.

PROFILE No. 81.

Location.—Doreng Reserve.
Type of land.—Forest land.
Elevation.—2 500—4,000 feet.
Aspect.—South mainly.
Climate.—100″ rainfall, Monsoon June to September.
Vegetation.—Schima Wallichii, Michelia, Cinnamomum Cecicodaphne.
Topography.—Sloping.
Soil.—0—10″ Loamy soil with some organic matter, granular, friable.

10—24″ Less organic matter, soil fine and granular, well-compacted.
24—36″ Loamy soil, rather dry, a few nodules, plenty of roots, well-drained.

SIKKIM—*contd.*

PROFILE No. 82.

Location.—Between Doreng and Namle Reserve.
Type of land.—Basty land (Chuba).
Elevation.—2,500—3,500 feet.
Aspect.—East.
Climate.—Same as Doreng and Namle areas.
Vegetation.—Maize and Buckwheat are grown. Poor crops.
Topography.—Sloping with stony areas in plenty.
Soil.—0—12" Loamy soil with practically no organic matter, crumbly, loose.
12—36" Same type of soil but plenty of stones. Generally poor.

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